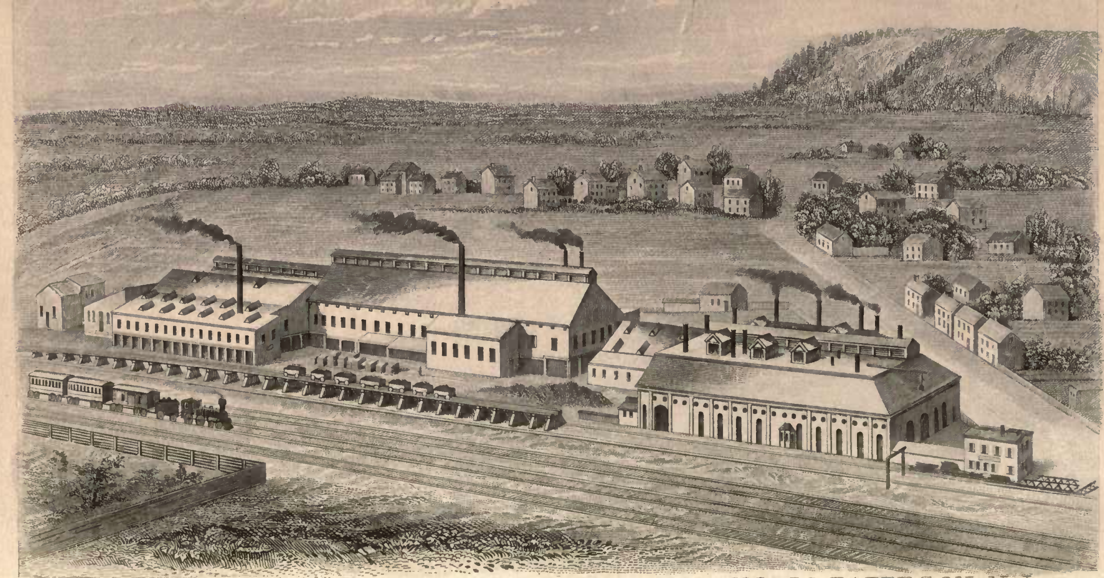

MILLS AND BRIDGEWORKS, PASSAIC ROLLING MILL C^o PATERSON. N.J.

A MANUAL

OF

USEFUL INFORMATION

AND

TABLES

APPERTAINING TO THE USE OF

WROUGHT IRON

AS MANUFACTURED BY

THE PASSAIC ROLLING MILL CO.

PATERSON, N. J.

(New-York Office, Room 45, Astor House.)

FOR

ENGINEERS, ARCHITECTS, AND BUILDERS,

BY

F. A. LEERS, C. E.

1884.

Electrotype Edition. *Price, $1.50.*

Press of THEO. L. DE VINNE & CO. New-York.

OFFICERS.

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JOHN K. COOKE, -	Superintendent.
F. A. LEERS, - -	Engineer.

PREFACE.

THE present edition of the MANUAL *is a new work throughout. It is intended to supply such special information and tables as, it was thought, would prove valuable to workers in wrought iron in general, and the patrons of the publishers,* THE PASSAIC ROLLING MILL CO., *in particular.*

The tables, with a few exceptions, were computed expressly for this work, and some of them are original in both matter and form.

The author hopes that they will be found to possess the qualities of accuracy and reliability.

Such of the tables as were not calculated for this work were obtained from two or more works of presumably independent origin, which were compared for the detection of errors.

The table of weight of a cubic foot and of the ultimate strength of substances was derived mostly from Trautwine.

The list of shapes rolled by THE PASSAIC ROLLING MILLS *will be found increased in number, and some of the sections improved in form. All angle irons are now made with flanges of uniform thickness; the range between the minimum and maximum weight for a number of the shapes has been increased.*

CONTENTS.

PLATE 1

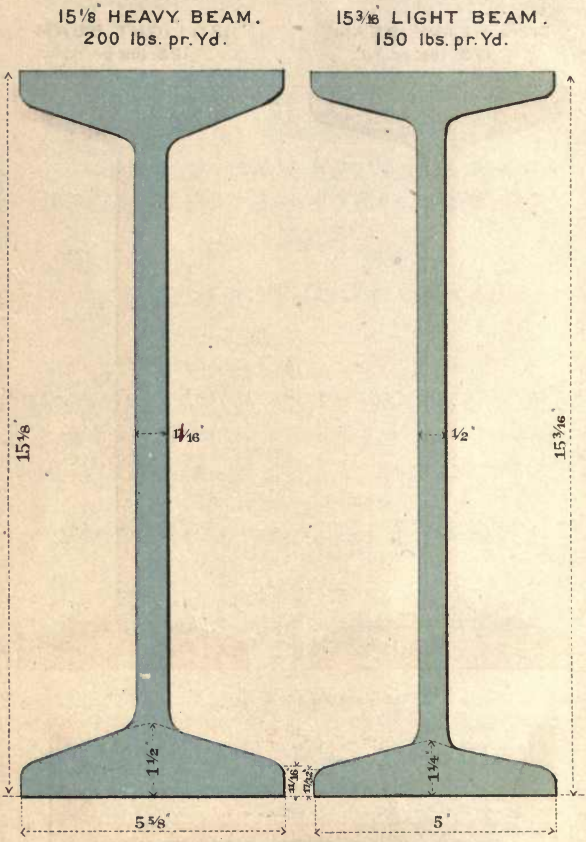
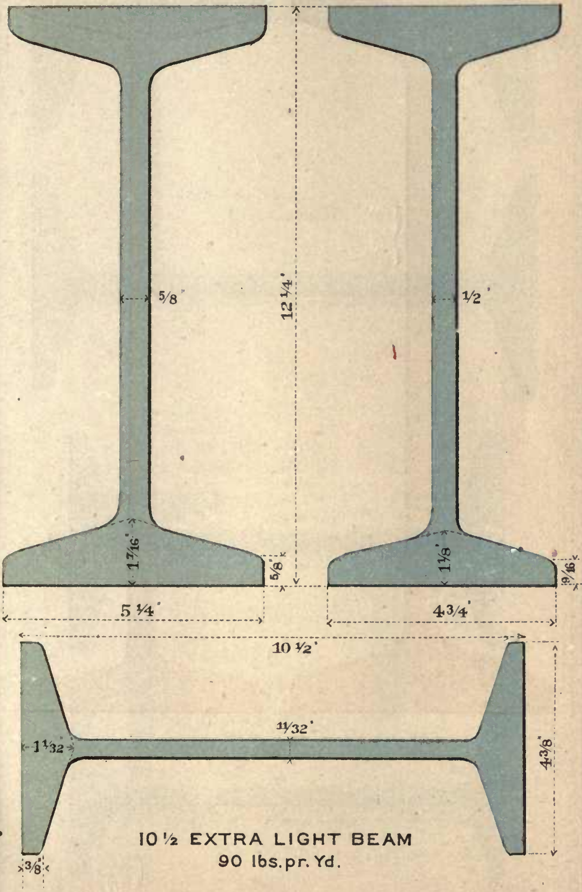

15⅛" HEAVY BEAM.
200 lbs. pr. Yd.
15 3/16" LIGHT BEAM.
150 lbs. pr. Yd.
15⅛"
11/16"
1½
5⅝"
11/16
17/32
½"
1¼"
5"
15 3/16"

PLATE 2

12¼ HEAVY BEAM.
170 lbs. pr. Yd.

12¼ LIGHT BEAM
125 lbs. pr. Yd.



10½ EXTRA LIGHT BEAM
90 lbs. pr. Yd.

PLATE 3

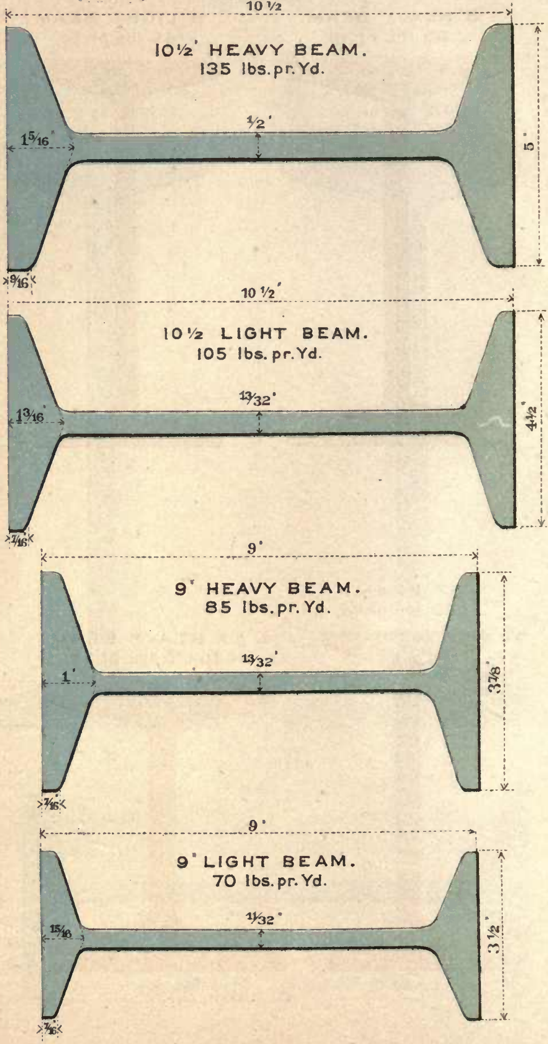
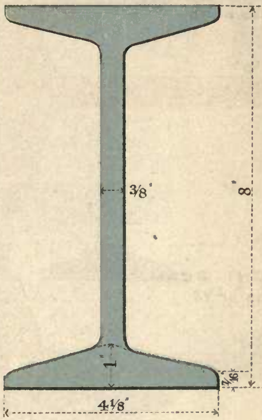
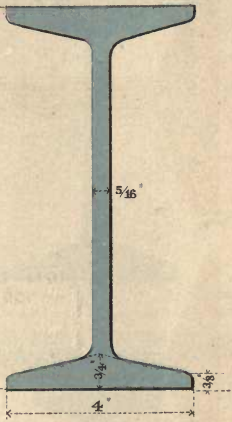

10 ½
10½' HEAVY BEAM.
135 lbs. pr. Yd.
½'
1 5/16"
5"
9/16
10 ½'
10½ LIGHT BEAM.
105 lbs. pr. Yd.
13/32'
1 3/16'
4½'
7/16
9'
9' HEAVY BEAM.
85 lbs. pr. Yd.
13/32'
1'
3 7/8'
7/16
9'
9' LIGHT BEAM.
70 lbs. pr. Yd.
11/32'
15/16
3½'
7/16

PLATE 4

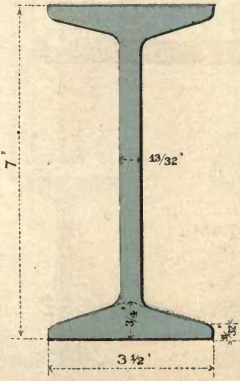
8" HEAVY BEAM.
80 lbs. pr. Yd.



8" LIGHT BEAM.
65 lbs. pr. Yd.



7" BEAM.
60 lbs. pr. Yd.



6" EX. HEAVY BEAM.
90 to 120 lbs. pr. Yd.

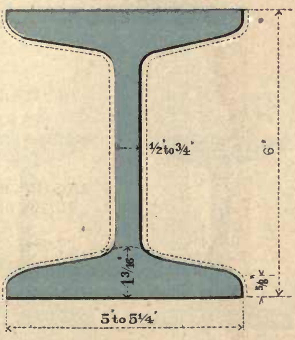


PLATE 5

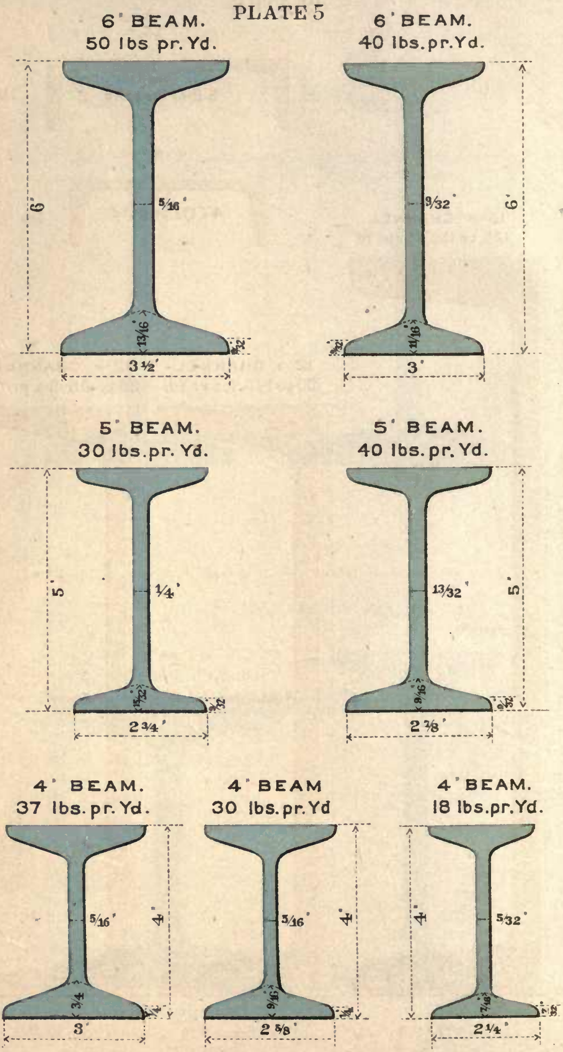

6" BEAM.
50 lbs pr. Yd.
6"
5/16"
13/16
3½"
6" BEAM.
40 lbs. pr. Yd.
9/32"
6"
11/16
3"
5" BEAM.
30 lbs. pr. Yd.
5"
¼"
15/32
2¾"
5" BEAM.
40 lbs. pr. Yd.
13/32"
5"
9/16
2⅞"
4" BEAM.
37 lbs. pr. Yd.
5/16"
4"
3/4
3"
4" BEAM
30 lbs. pr. Yd
5/16"
4"
9/16
2 5/8"
4" BEAM.
18 lbs. pr. Yd.
4"
5/32"
7/16
2¼"

PLATE 6

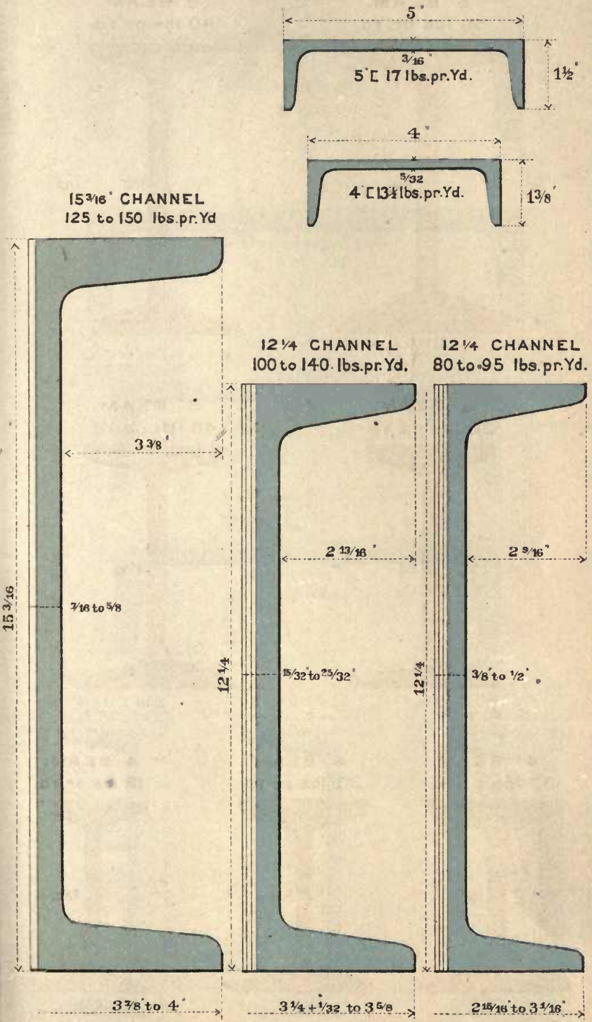

5"
3/16"
5" [17 lbs.pr.Yd.
1½"
4"
5/32
4" [13½ lbs.pr.Yd.
1⅜"
15 3/16" CHANNEL
125 to 150 lbs.pr.Yd
3 3/8"
7/16 to 5/8
15 3/16
3 3/8" to 4"
12 1/4 CHANNEL
100 to 140 lbs.pr.Yd.
2 13/16"
15/32" to 25/32"
12 1/4
3 1/4 + 1/32 to 3 5/8
12 1/4 CHANNEL
80 to 95 lbs.pr.Yd.
2 9/16"
3/8" to 1/2"
12 1/4
2 15/16" to 3 1/16"

PLATE 7

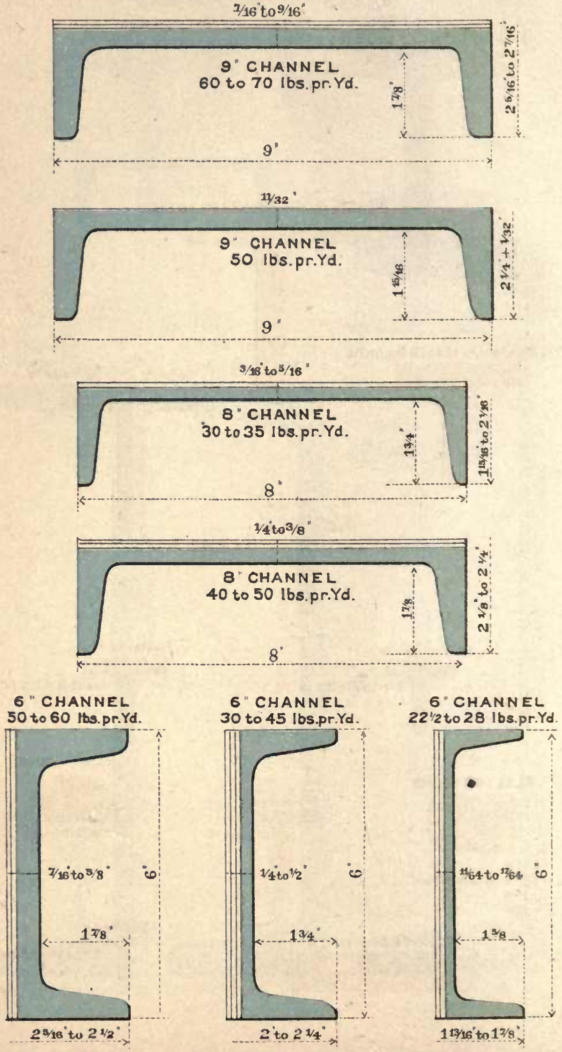

9" CHANNEL
60 to 70 lbs. pr. Yd.
9" CHANNEL
50 lbs. pr. Yd.
8" CHANNEL
30 to 35 lbs. pr. Yd.
8" CHANNEL
40 to 50 lbs. pr. Yd.
6" CHANNEL
50 to 60 lbs. pr. Yd.
6" CHANNEL
30 to 45 lbs. pr. Yd.
6" CHANNEL
22½ to 28 lbs. pr. Yd.

PLATE 8
EQUAL TEE.

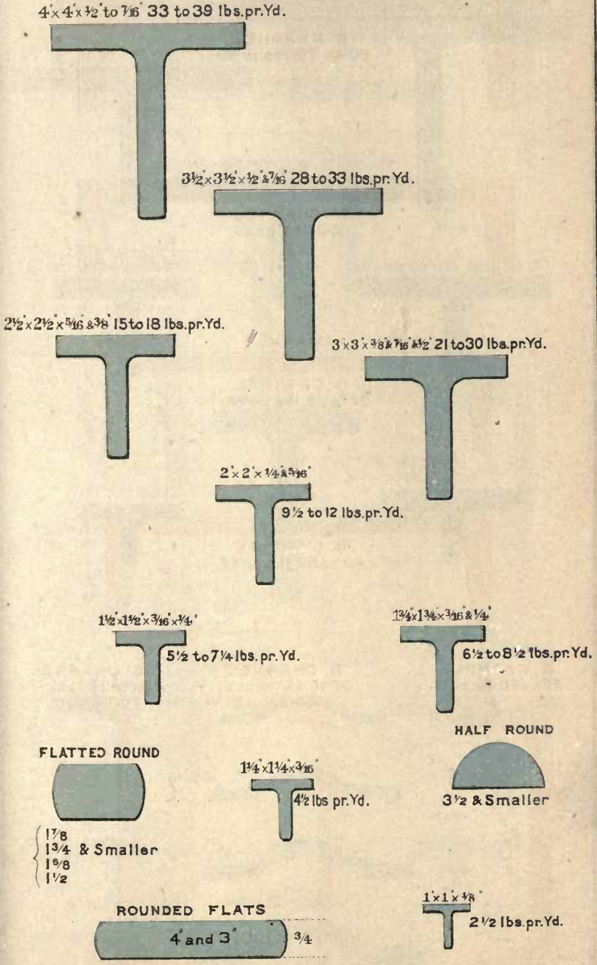
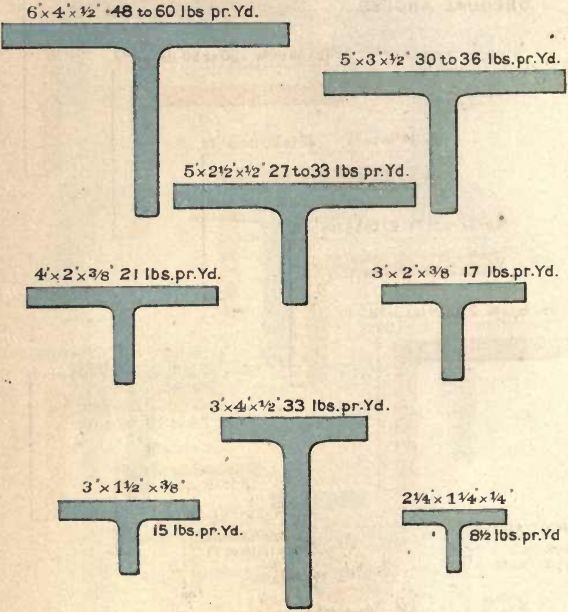


PLATE 9
UNEQUAL TEE.



BEAD IRON.

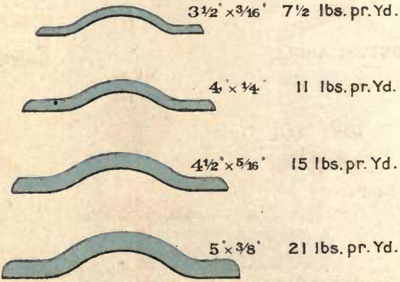


PLATE 10

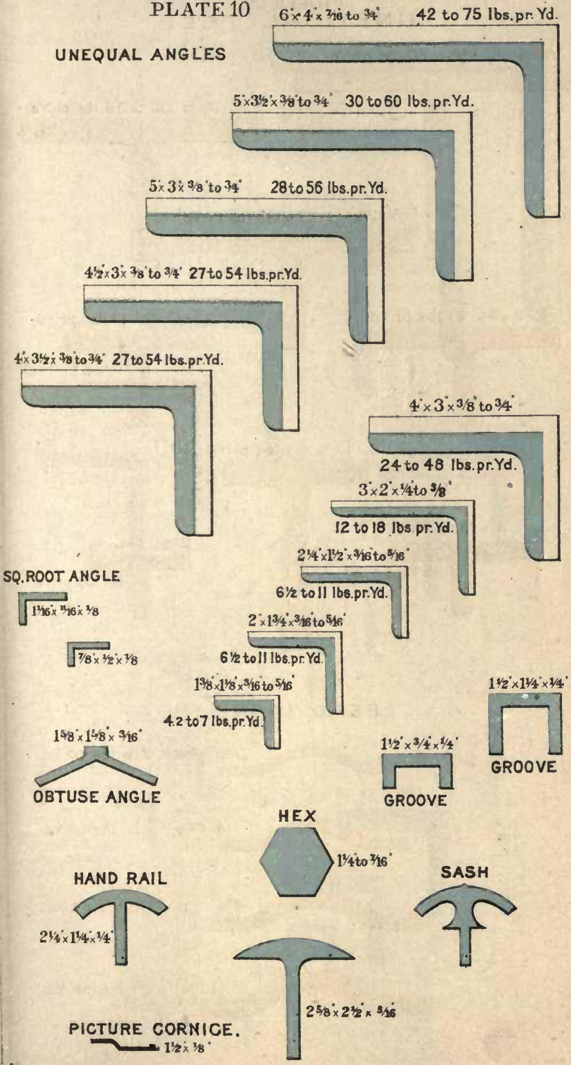
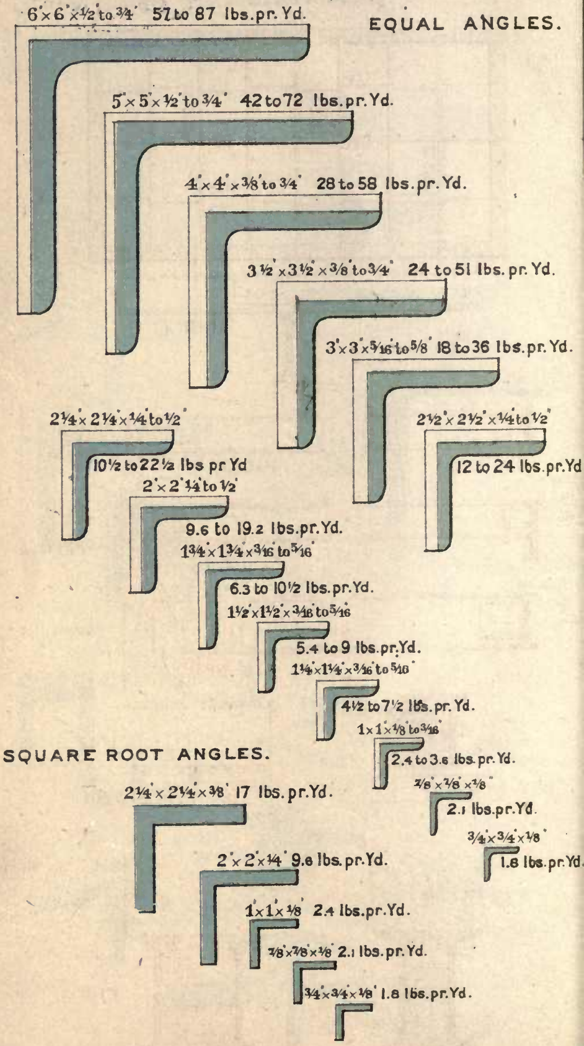

UNEQUAL ANGLES
6"x4"x7/16 to 3/4" 42 to 75 lbs. pr. Yd.
5"x3½"x3/8" to 3/4" 30 to 60 lbs. pr. Yd.
5"x3"x3/8" to 3/4" 28 to 56 lbs. pr. Yd.
4½"x3"x3/8" to 3/4" 27 to 54 lbs. pr. Yd.
4"x3½"x3/8" to 3/4" 27 to 54 lbs. pr. Yd.
4"x3"x3/8" to 3/4"
24 to 48 lbs. pr. Yd.
3"x2"x1/4" to 3/8"
12 to 18 lbs. pr. Yd.
2¼"x1½"x3/16" to 5/16"
6½ to 11 lbs. pr. Yd.
2"x1¾"x3/16" to 5/16"
6½ to 11 lbs. pr. Yd.
1⅜"x1⅛"x3/16" to 5/16"
4.2 to 7 lbs. pr. Yd.
SQ. ROOT ANGLE
1 1/16"x 11/16"x 1/8
7/8"x½"x1/8
1⅝"x1⅝"x3/16"
OBTUSE ANGLE
1½"x1¼"x1/4"
GROOVE
1½"x3/4"x1/4"
GROOVE
HEX
1¼ to 7/16"
SASH
HAND RAIL
2¼"x1¼"x1/4"
2⅝"x2½"x3/16"
PICTURE CORNICE.
1½"x1/8"

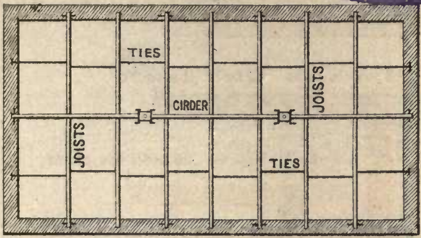
PLATE 11



EQUAL ANGLES.
6"×6"×½" to ¾" 57 to 87 lbs. pr. Yd.
5"×5"×½" to ¾" 42 to 72 lbs. pr. Yd.
4"×4"×⅜" to ¾" 28 to 58 lbs. pr. Yd.
3½"×3½"×⅜" to ¾" 24 to 51 lbs. pr. Yd.
3"×3"×5/16" to ⅝" 18 to 36 lbs. pr. Yd.
2¼"×2¼"×¼" to ½" 10½ to 22½ lbs pr Yd
2½"×2½"×¼" to ½" 12 to 24 lbs. pr. Yd
2"×2" ¼" to ½" 9.6 to 19.2 lbs. pr. Yd.
1¾"×1¾"×3/16" to 5/16" 6.3 to 10½ lbs. pr. Yd.
1½"×1½"×3/16" to 5/16" 5.4 to 9 lbs. pr. Yd.
1¼"×1¼"×3/16" to 5/16" 4½ to 7½ lbs. pr. Yd.
1"×1"×⅛" to 3/16" 2.4 to 3.6 lbs. pr. Yd.
⅞"×⅞"×⅛" 2.1 lbs. pr. Yd.
¾"×¾"×⅛" 1.8 lbs. pr. Yd.
SQUARE ROOT ANGLES.
2¼"×2¼"×⅜" 17 lbs. pr. Yd.
2"×2"×¼" 9.6 lbs. pr. Yd.
1"×1"×⅛" 2.4 lbs. pr. Yd.
⅞"×⅞"×⅛" 2.1 lbs. pr. Yd.
¾"×¾"×⅛" 1.8 lbs. pr. Yd.

PLATE 12

FIG. I.



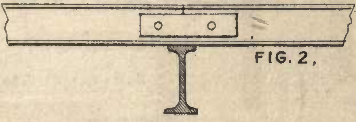


FIG. 2,

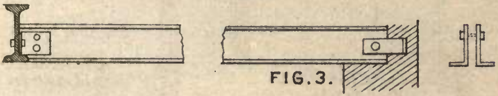


FIG. 3.

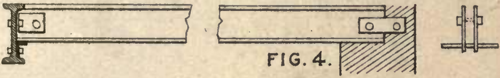


FIG. 4.

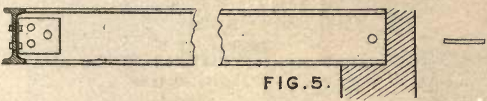
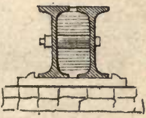


FIG. 5.



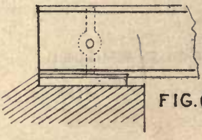


FIG. 6.

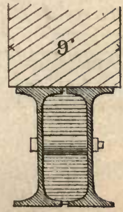


FIG. 7.

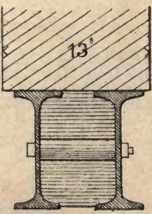


FIG. 8.

PLATE 13

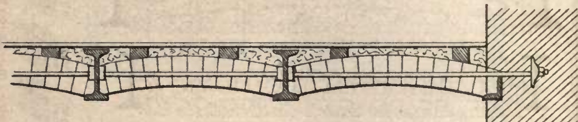


FIG. 9

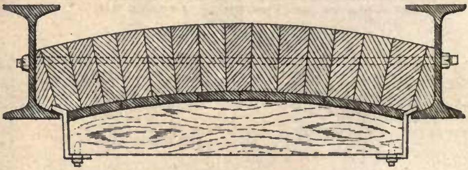
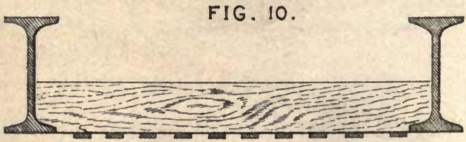
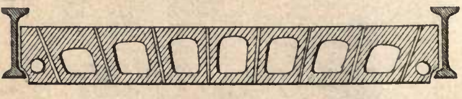


FIG. 10.





THE FIRE PROOF BUILDING COMPANY OF NEW YORK.

Fire Proof Construction with Iron and Hollow Brick.

PLATE 14

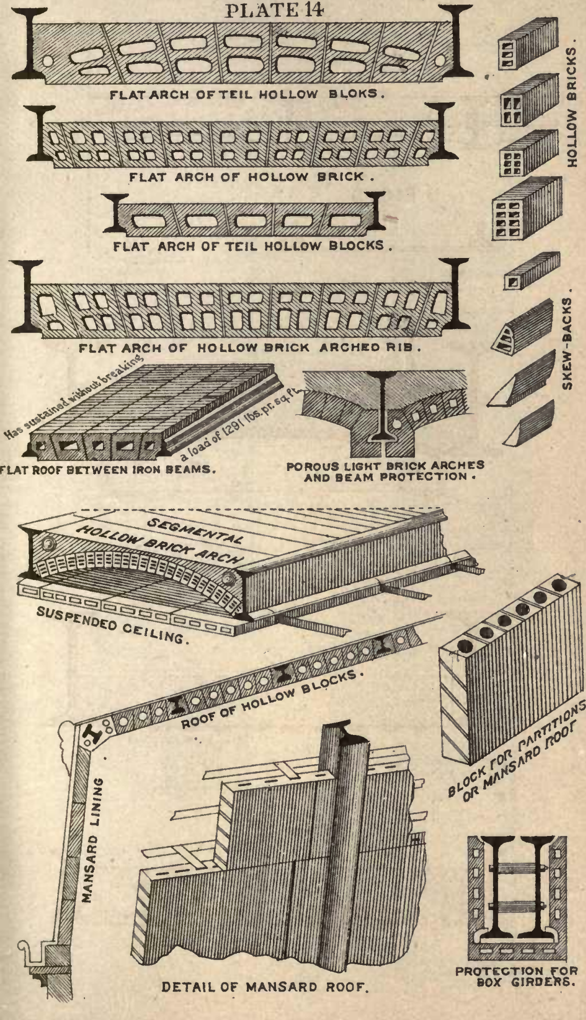


PLATE 15

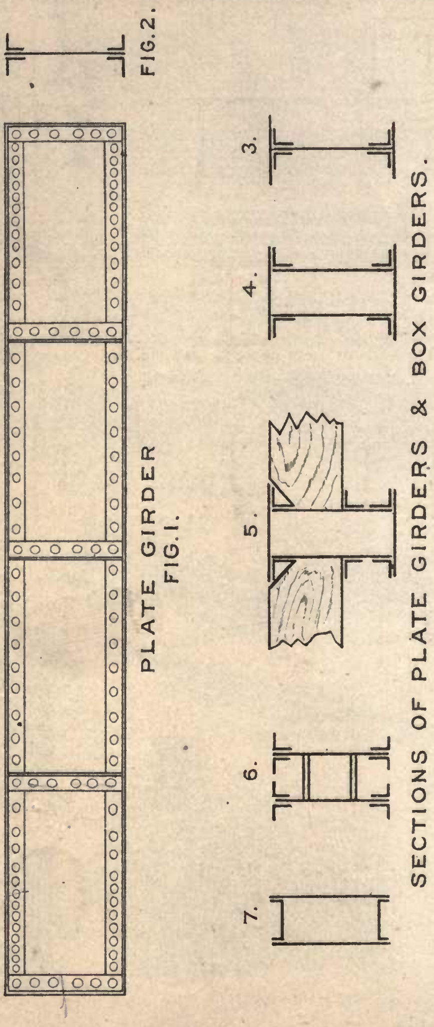


FIG.2.
PLATE GIRDER
FIG.1.
3.
4.
5.
6.
7.
SECTIONS OF PLATE GIRDERS & BOX GIRDERS.

SECTIONS OF COLUMNS
PLATE 16

FIG 1.

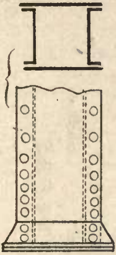


FIG. 2.

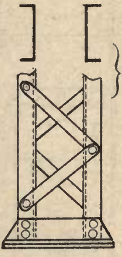


FIG. 3.

FIG. 8.

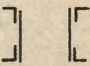


FIG. 4.

FIG. 5.

FIG. 6.

FIG. 7.

FIG. 9.

FIG. 10.

FIG. 11.

FIG. 12.

FIG. 13.

FIG. 14.

FIG. 15.

FIG. 16.

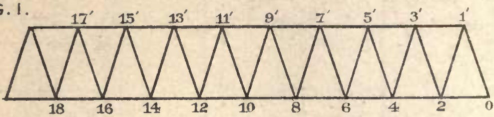
FIG. 17.

FIG. 18.

PLATE 17

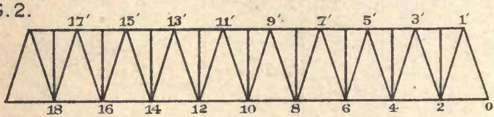
TRIANGULAR OR WARREN TRUSS.

FIG. 1.



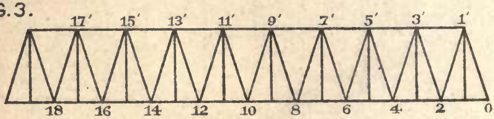
WARREN TRUSS, WITH INTERMEDIATE POSTS.

FIG. 2.



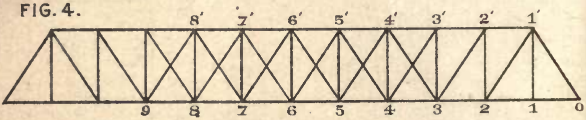
WARREN TRUSS, WITH INTERMEDIATE SUSPENDERS.

FIG. 3.



RECTANGULAR TRUSS, SINGLE INTERSECTION.

FIG. 4.



KING AND QUEEN ROOF TRUSS.

FIG. 5.

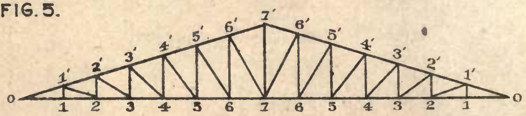


PLATE 18

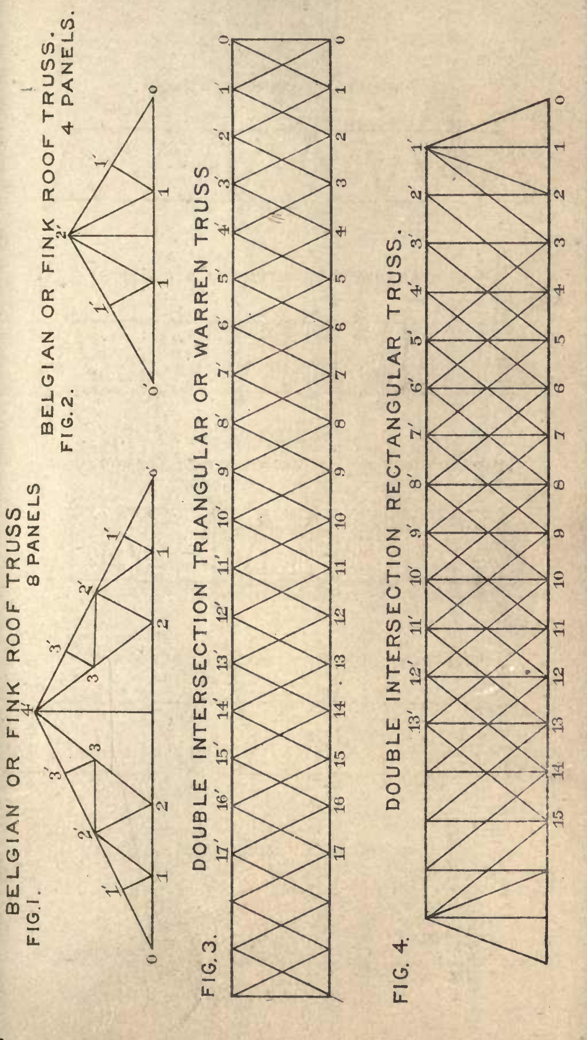
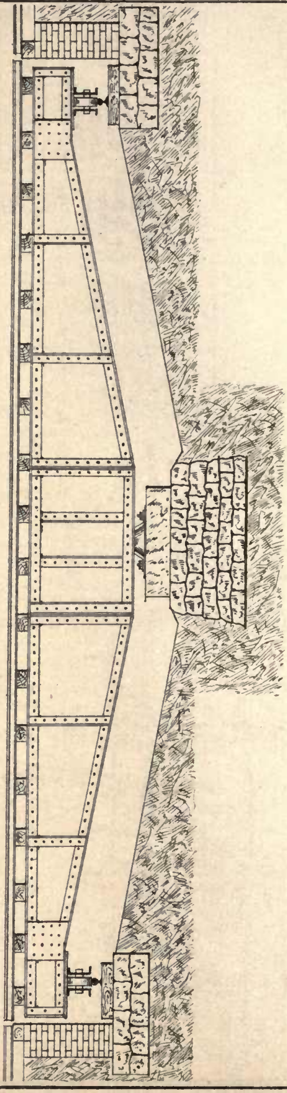


FIG.1.
BELGIAN OR FINK ROOF TRUSS
8 PANELS
FIG.2.
BELGIAN OR FINK ROOF TRUSS.
4 PANELS.
FIG.3.
DOUBLE INTERSECTION TRIANGULAR OR WARREN TRUSS
FIG. 4.
DOUBLE INTERSECTION RECTANGULAR TRUSS.

PLATE 19



STANDARD WROUGHT IRON TURN TABLES,

MANUFACTURED BY

THE PASSAIC ROLLING MILL CO.

PATERSON, N.J.

New York Office
Nº 45 Astor House.

PLATE 20.

CROSS SECTION AND DIMENSIONS OF PASSAIC ROLLING MILLS STANDARD TURN TABLES.

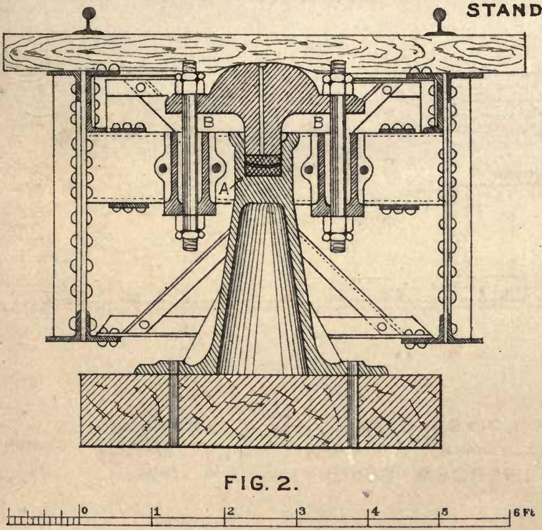


FIG. 2.

Diameter of Pit.		Length of Girder, Out to Out.		Diameter of Circular Track, c. to c. of Rail.		Depth From Top of Rail on Table to Top of Center Stone.		Depth From Top of Rail on Table to Top of Rail of Circular Track.		Ditto for Special Turn-table with Shallow Pit.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
35	0	34	4	31	0	5	0	3	4	2	0
40	0	39	4	36	0	5	0	3	4	2	0
45	0	44	4	41	0	5	0	3	4	2	0
50	0	49	6	46	0	5	6	3	10	2	6
55	0	54	6	51	0	5	6	3	10	2	6
60	0	59	6	56	0	5	6	3	10	2	6

STRENGTH OF BEAMS.

If a beam, supported at its ends, is loaded with a weight, this weight will produce reactions on the two supports, the sum of which is equal to the weight. These are the external forces acting on the beam. Under the influence of these external forces a bending of the beam occurs, the fibers of the upper half of the cross-section are shortened, and those of the lower half are elongated. These changes are the result of a compressive strain in the upper half and of a tensile strain in the lower half of the cross-section of the beam. In the middle of the heights is a place where no shortening or lengthening of the fibers occurs, and this is called the *neutral axis*. In wrought iron, as in other homogeneous substances, this neutral axis is coincident with the center of gravity of the section, and in symmetrical sections, as in **I** beams, this is in the middle of the depth of the beam.

The *moment of inertia* of a cross-section is an expression which is used in the calculation of the strength of beams. The sum of the products of the infinitely small areas of each fiber, by the square of its distance (taken at right angles) from the neutral axis, is its value with respect to this axis.

The *moment of resistance* is the moment of inertia divided by the distance from the neutral axis (or center of gravity of the section) to the most extreme fiber. This is used to determine the maximum strain in the most extreme fiber.

The *radius of gyration* is found by extracting the square root of the moment of inertia divided by the area of the cross-section. If all material were concentrated at this distance from the neutral axis (or center of gravity), it would resist against bending the same as the material distributed over the cross-section.

Twice the radius of gyration may be called the effective depth of the beam.

TERMS USED IN FORMULAS:

W, Load.
l, Length of beam in inches.
A, Area of total cross-section of beam.
h, Depth of beam.
I, Moment of inertia of cross-section.
R, Moment of resistance of cross-section.
e, Distance of the most extreme fiber from the neutral axis (usually $e = \frac{h}{2}$).
d, Deflection in inches.
S, Strain per square inch.
M, Bending-moment produced by the load W in any cross-section.
x, The distance of this cross-section from the support or from the load.

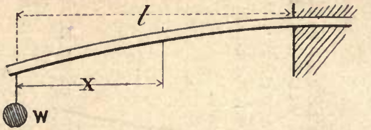
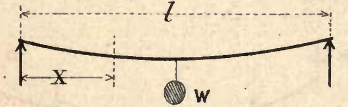
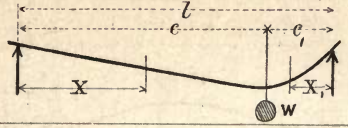
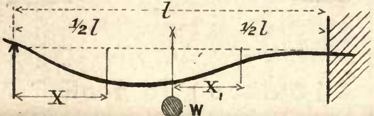
The following tables give general formulas of bending-moments M, maximum loads W, maximum fiber strains S, and deflections d, for beams loaded and supported in different ways. The bending-moments may be calculated with these formulas for any cross-section by substituting the particular value of x, and from the value thus obtained the strain in this cross-section is found by the general formula

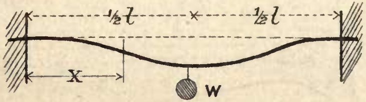
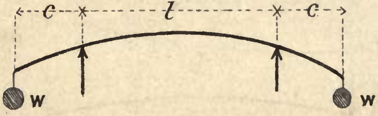
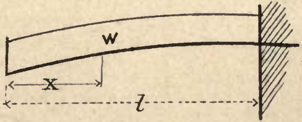
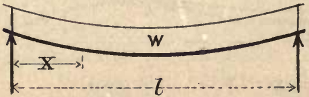
$$S = \frac{M}{\frac{I}{e}} \quad \text{or} \quad S = \frac{M}{R}.$$

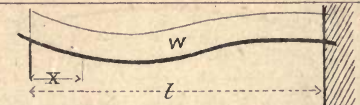
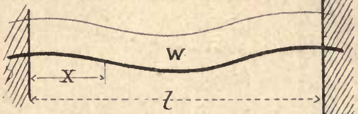
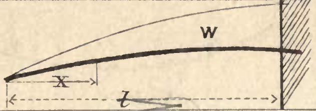
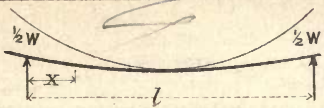
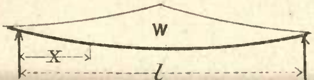
The necessary section of the beam at any place is obtained by reversing this formula, thus:

$$\frac{I}{e} \quad \text{or} \quad R = \frac{M}{S}.$$

This gives the moment of resistance required, and the corresponding beam may be selected from the table giving the different properties of beams and channels.

	MODE OF LOADING	BENDING MOMENT M	LOAD W	STRAIN S	DEFLECTION d
1 ONE END FIRMLY FIXED OTHER END LOADED.		Wx	$\frac{SI}{le}$	$\frac{Wl}{\frac{I}{e}}$	$\frac{W}{IE}\cdot\frac{l^3}{3}$
2 SUPPORTED AT BOTH ENDS LOADED IN CENTRE.		$\frac{Wx}{2}$	$4\frac{SI}{le}$	$\frac{1}{4}\frac{Wl}{\frac{I}{e}}$	$\frac{W}{IE}\frac{l^3}{48}$
3 SUPPORTED AT BOTH ENDS LOADED ANY PLACE.		FOR THE LEFT SIDE $\frac{Wc_1}{l}x$ FOR THE RIGHT SIDE $\frac{Wc}{l}\cdot x_1$	$\frac{l}{cc_1}\frac{SI}{e}$	$\frac{c\,c_1}{l\,l}\frac{Wl}{\frac{I}{e}}$	$\frac{W}{IE}\frac{l^3c^2c_1^2}{3\,l^2\,l^2}$
4 ONE END FIXED OTHER END SUPPORTED LOAD IN CENTRE.		FOR THE LEFT SIDE $\frac{5}{16}Wx$ FOR THE RIGHT SIDE $\frac{11}{32}Wl\left(\frac{5}{11}-\frac{2x_1}{l}\right)$	$\frac{16}{3}\frac{SI}{le}$	$\frac{3}{16}\frac{Wl}{\frac{I}{e}}$	$\frac{W}{IE}\frac{7l^3}{768}$

	MODE OF LOADING	BENDING MOMENT M	LOAD W	STRAIN S	DEFLECTION d
5 BOTH ENDS FIXED LOAD IN CENTRE.		$\frac{Wl}{2}\left(\frac{x}{l}-\frac{1}{4}\right)$	$8\,\frac{SI}{le}$	$\frac{1}{8}\,\frac{Wl}{\frac{I}{e}}$	$\frac{W}{IE}\,\frac{l^3}{192}$
6 LOADED AT EACH END 2 SUPPORTS BETW. ENDS.		Wc FOR THE PART BET. SUPPORTS.	$\frac{SI}{ce}$	$\frac{Wc}{\frac{I}{e}}$	$\frac{W}{IE}\cdot\frac{l^3}{8}\cdot\frac{c}{l}$
7 ONE END FIXED LOAD UNIFORMLY DISTRIBUTED.		$\frac{Wx}{2}\;\frac{x}{l}$	$2\,\frac{SI}{le}$	$\frac{1}{2}\,\frac{Wl}{\frac{I}{e}}$	$\frac{W}{IE}\,\frac{l^3}{8}$
8 BOTH ENDS SUPPORTED LOAD UNIFORMLY DISTRIBUTED.		$\frac{Wx}{2}\left(1-\frac{x}{l}\right)$	$8\,\frac{SI}{le}$	$\frac{1}{8}\,\frac{Wl}{\frac{I}{e}}$	$\frac{W}{IE}\,\frac{5\,l^3}{384}$

	MODE OF LOADING	BENDING MOMENT M	LOAD W	STRAIN S	DEFLECTION d
9 ONE END FIXED OTHER END SUPPORTED UNIFORMLY DISTRIBUTED LOAD.		$\frac{Wx}{2}\left(\frac{3}{4}-\frac{x}{l}\right)$	$8\,\frac{S}{l}\,\frac{I}{e}$	$\frac{1}{8}\,\frac{Wl}{\frac{I}{e}}$	$\frac{W}{IE}\,\frac{l^3}{192}$
10 BOTH ENDS FIXED UNIFORMLY DISTRIBUTED LOAD.		$\frac{Wl}{2}\left(\frac{1}{6}-\frac{x}{l}+\frac{x^2}{l^e}\right)$	$12\,\frac{S}{l}\,\frac{I}{e}$	$\frac{1}{12}\,\frac{Wl}{\frac{I}{e}}$	$\frac{W}{IE}\,\frac{l^3}{384}$
11 ONE END FIXED LOAD DISTRIBUTED INCREASING TOWARDS THE FIXED END.		$\frac{Wx}{3}\quad\frac{x^2}{l^2}$	$3\,\frac{S}{l}\,\frac{I}{e}$	$\frac{1}{3}\,\frac{Wl}{\frac{I}{e}}$	$\frac{W}{IE}\,\frac{l^3}{15}$
12 BOTH ENDS SUPPORTED LOAD DISTRIBUTED DECREASING TOWARDS THE MIDDLE.		$Wx\left(\frac{1}{2}-\frac{x}{l}+\frac{2x^2}{3l^2}\right)$	$12\,\frac{S}{l}\,\frac{I}{a}$	$\frac{1}{12}\,\frac{Wl}{\frac{I}{e}}$	$\frac{W}{IE}\,\frac{3l^3}{320}$
13 BOTH ENDS SUPPORTED LOAD DISTRIBUTED INCREASING TOWARDS THE MIDDLE.		$Wx\left(\frac{1}{2}-\frac{2}{3}\,\frac{x^2}{l^2}\right)$	$6\,\frac{S}{l}\,\frac{I}{a}$	$\frac{1}{6}\,\frac{Wl}{\frac{I}{e}}$	$\frac{W}{IE}\,\frac{l^3}{60}$

Properties of Passaic Rolling Mill's I Beams, Channel Bars, Angles, and Tee Iron.

The following tables give co-efficients, by the use of which the safe, uniformly distributed load for any Beam, Channel, Tee, or Angle Iron can be easily determined. It is only necessary to divide the co-efficient by the span between centers of supports (in feet). This will give the safe, uniformly distributed load in lbs. for a beam simply supported on both ends, as in case 8 (see table of formulas for different modes of loading). For any other way of loading, the result has to be multiplied with a factor which is for

Mode of Loading.

	Mode of Loading	Factor.
1.	One end fixed, other end loaded	$\frac{1}{8}$
2.	Both ends supported, concentrated load in center of span	$\frac{1}{2}$
3.	Both ends supported, concentrated load on any point of beam	
4.	One end fixed, other end supported, concentrated load in center of span	$\frac{2}{3}$
5.	Both ends fixed, concentrated load in center of span	1
6.	Concentrated load at each end, two supports between ends of beam	$\frac{1}{8}$
7.	One end fixed, uniformly distributed load	$\frac{1}{4}$
8.	Both ends supported, uniformly distributed load	1
9.	One end fixed, other end supported, uniformly distributed load	1
10.	Both ends fixed, uniformly distributed load	$\frac{3}{2}$
11.	One end fixed, load distributed, but increasing toward the fixed end	$\frac{3}{8}$
12.	Both ends supported, load distributed, but decreasing toward the middle of the span	$\frac{3}{2}$
13.	Both ends supported, load distributed, but increasing toward the middle of the span	$\frac{3}{4}$

The co-efficients given in the tables for Beams and Channels have been calculated for maximum fiber strains of 12,000 lbs. per square inch and 10,000 lbs. per square inch, but those for Tees and Angle Iron only for 12,000 lbs. per square inch. If it be desired to find the carrying capacity for any other strain per square inch, this is simply done by increasing or decreasing the co-efficient given in the tables in proportion to the strains allowed. These tables have been calculated under the supposition that the beams are sufficiently secured against yielding sideways. Usually, it is assumed that this is the case if the free length of the beam does not exceed twenty times its width. If longer beams are required, it is necessary that they should be stayed at intermediate points, or the safe load has to be reduced as given in the table for beams not secured against yielding sideways.

Beams or Channels in short lengths have to be proportioned so that the section of the web is sufficient to resist the shearing strain. The shearing strain on the web should not be more than the half of the fiber strain allowed on the flanges; that is, 6000 and 5000 lbs. resp. per square inch. This gives for short beams a maximum safe load which such beam may support without buckling or crushing of the web.

The tables show the dimensions and different properties of I Beams, Channels, Tees, and Angle Iron. I Beams are usually rolled heavy, and light weight, as given in the table. Channels and Angle Iron frequently are made of varying weights, but Tee Iron can be rolled only to the weights shown in the lithographed plates.

I BEAMS.

Depth of Beam, in inches...	15⅛	15 3/16	12¼	12¼	10½	10½	10½	9	9	8
Weight, per yard, in lbs........	200	150	170	125	135	105	90	85	70	80
Thickness of web, in inches	0.64	0.50	0.66	0.46	0.53	0.41	0.34	0.41	0.32	0.37
Width of flange, in inches......	5⅝	5	5¼	4¾	4 15/16	4½	4⅜	3⅞	3½	4⅛
Moment of inertia, } neutral axis square to center-line of web,	708.	520.	385.	297.	227.	182.	163.	104.5	89.0	81.5
" resistance, }	93.2	68.8	63.0	48.6	43.2	34.6	31.0	23.3	19.8	20.4
Radius of gyration, }	5.95	5.89	4.75	4.87	4.1	4.16	4.26	3.50	3.56	3.19
Square of rad. " }	35.4	34.7	22.6	23.7	16.8	17.4	18.1	12 3	12.7	10.2
Safe load = co-efficient / length in feet, for fiber strain of 12,000 lbs. p. □″	746,000	550,000	504,000	388,000	345,000	277,000	248,000	186,000	158,000	163,000
Safe load = co-efficient / length in feet, for fiber strain of 10,000 lbs. p. □″	622,000	458,000	419,000	323,000	287,000	230,000	206,000	155,000	132,000	136,000
Mom't of inertia, } axis coincid't with center-line of web,	27.2	14.4	20.9	12.2	16.1	9.23	7.91	6.34	3.55	7.00
Rad. of gyration, }	1.17″	0.98	1.11	0.99	1.09	0.94	0.94	0.87	0.71	0.94

I BEAMS—*Continued.*

Depth of Beam, in inches	8	7	6	6	6	5	5	4	4	4
Weight, per yard, in lbs.	65	60	90	50	40	40	30	37	30	18
Thickness of web, in inches	0.31	0.40	0.57	0.39	0.27	0.41	0.23	0.31	0.30	0.15
Width of flange, in inches	4	$3\frac{1}{2}$	$4\frac{7}{8}$	$3\frac{1}{2}$	$2\frac{15}{16}$	$2\frac{7}{8}$	$2\frac{3}{4}$	3	$2\frac{5}{8}$	$2\frac{3}{16}$
Moment of inertia, (neutral axis square to center-line of web)	71.0	45.0	51.2	29.0	23.2	15.1	12.7	9.2	7.6	5.1
" resistance, (neutral axis square to center-line of web)	17.7	12.9	17.1	9.66	7.73	6.02	5.06	4.60	3.80	2.55
Radius of gyration, (neutral axis square to center-line of web)	3.30	2.74	2.38	2.41	2.40	1.95	2.06	1.58	1.59	1.68
Square of rad. " (neutral axis square to center-line of web)	10.9	7.5	5.7	5.8	5.8	3.78	4.23	2.50	2.52	2.82
Safe load $= \frac{\text{co-efficient}}{\text{length in feet}}$ for fiber strain of 12,000 lbs. p. □″	142,000	103,000	137,000	77,400	62,000	48,300	40,600	36,800	30,400	20,400
Safe load $= \frac{\text{co-efficient}}{\text{length in feet}}$ for fiber strain of 10,000 lbs. p. □″	118,000	85,600	114,000	64,500	51,600	40,200	33,800	30,600	25,300	17,000
Mom't of inertia, (axis coincid't with center-line of web)	5.03	3.15	10.7	2.74	1.69	1.45	1.15	1.74	1.07	0.45
Rad. of gyration, (axis coincid't with center-line of web)	0.88″	0.73	1.09	0.74	0.65	0.60	0.62	0.69	0.60	0.50

[BARS.

Depth of Channel, in inches	$15\frac{3}{16}$	$15\frac{3}{16}$	$12\frac{1}{4}$	$12\frac{1}{4}$	$12\frac{1}{4}$	9	9
Weight per yard, in lbs.	180	150	140	100	80	70	50
Width of flange, in inches	4.17	3.97	3.60	3.28	2.95	2.44	2.30
Thickness of web, in inches	0.82	0.62	0.78	0.46	0.39	0.53	0.33
Increase for 10 lbs. weight	0.07	0.07	0.08	0.08	0.08	0.11	0.11
Moment of inertia, axis horizontal	524.0	467.5	264.2	214.3	168.9	69.7	56.4
Increase for 10 lbs. weight, axis horizontal	18.7	18.7	12.4	12.4	12.4	6.75	6.75
Moment of resistance, axis horizontal	70.0	62.3	43.2	35.0	27.7	15.49	12.53
Increase for 10 lbs. weight, axis horizontal	2.5	2.5	2.0	2.0	2.0	1.50	1.50
Radius of gyration, r, axis horizontal	5.40	5.60	4.34	4.63	4.60	3.16	3.36
" " r^2, axis horizontal	29.2	31.3	18.9	21.4	21.1	10.0	11.3
Safe load = co-efficient / length in ft. (fiber strain 12,000 lbs. p. □″)	560,000	500,000	345,000	280,000	221,000	124,000	100,000
Increase of co-efficient for 10 lbs. weight	20,000	20,000	16,300	16,300	16,300	12,000	12,000
Safe load = co-efficient / length in ft. (fiber strain 10,000 lbs. p. □″)	466,000	416,000	288,000	233,000	184,000	103,000	83,300
Increase of co-efficient for 10 lbs. weight	16,700	16,700	13,600	13,600	13,600	10,000	10,000
Moment of inertia, axis vertical	21.6	19.7	12.0	8.93	5.44	2.82	1.94
Center of grav. from back of [, axis vertical	1.06	1.09	0.92	0.86	0.73	0.61	0.57
Radius of gyration, axis vertical	1.10	1.15	0.93	0.94	0.82	0.63	0.62

⊏ BARS—*Continued.*

Depth of Channel, in inches	8	8	6	6	6	5	4
Weight per yard, in lbs	50	30	60	48	24	17	13½
Width of flange, in inches	2.25	1.94	2.50	2.25	1.85	1.44	1.44
Thickness of web, in inches	0.38	0.21	0.61	0.53	0.21	0.19	0.17
Increase for 10 lbs. weight	0.12	0.12	0.17	0.17	0.17	0.20	0.25
Moment of inertia, (axis horizontal)	43.4	27.8	27.6	21.9	13.3	6.20	3.25
Increase for 10 lbs. weight, (axis horizontal)	5.3	5.3	3.0	3.0	3.0	2.09	1.33
Moment of resistance, (axis horizontal)	10.85	6.95	9.30	7.30	4.43	2.48	1.62
Increase for 10 lbs. weight, (axis horizontal)	1.33	1.33	1.00	1.00	1.00	0.84	0.67
Radius of gyration, r (axis horizontal)	2.95	3.05	2.15	2.14	2.35	1.91	1.55
" " r^2 (axis horizontal)	8.70	9.30	4.60	4.57	5.55	3.65	3.41
Safe load $= \frac{\text{co-efficient}}{\text{length in ft.}}$ (fiber strain 12,000 lbs. p. □″)	86,800	55,600	73,600	58,400	35,400	19,900	13,000
Increase of co-efficient for 10 lbs. weight	10,600	10,600	8,000	8,000	8,000	6,700	5,300
Safe load $= \frac{\text{co-efficient}}{\text{length in ft.}}$ (fiber strain 10,000 lbs. p. □″)	72,200	46,300	61,300	48,600	29,500	16,600	10,800
Increase of co-efficient for 10 lbs. weight	8,800	8,800	6,700	6,700	6,700	5,600	4,400
Moment of inertia, (axis vertical)	2.03	1.01	2.86	1.70	0.74	0.31	0.23
Center of grav. from back of ⊏, (axis vertical)	0.61	0.53	0.77	0.61	0.54	0.45	0.38
Radius of gyration, (axis vertical)	0.64	0.58	0.69	0.60	0.55	0.43	0.41

T IRON.

The Co-efficients of Strength are calculated for a maximum strain of 12,000 lbs. per sq. inch in the most extreme fiber.

Size of T	Area in sq. inches.	Weight per ft. Lbs.	Distance of Center of Gravity from top.	Neutral Axis parallel to flange.				Neutral Axis square to flange.			
				Mom't of Inertia.	Mom't of Resist'ce.	Co-effic. of Strength.	Radius of Gyration.	Mom't of Inertia.	Mom't of Resist'ce.	Co-effic. of Strength.	Radius of Gyration.
6 × 4 × 1/2	4.75	16.	0.99	6.25	2.07	16,560	1.15	9.04	3.01	24,080	1.41
5 × 3 × 1/2	3.75	12.5	0.75	2.58	1.10	8,800	0.83	5.23	2.10	16,800	1.18
5 × 2 1/2 × 1/2	3.50	11.7	0.61	1.53	0.81	6,480	0.66	5.20	2.08	16,640	1.22
4 × 4 × 1/2	3.75	12.5	1.19	5.51	1.97	15,760	0.72	2.70	1.35	10,800	0.85
4 × 2 × 3/8	2.09	7.0	0.48	0.58	0.37	2,960	0.54	2.02	1.01	8,080	0.98
3 1/2 × 3 1/2 × 1/2	3.25	11.	1.06	3.63	1.50	12,000	1.06	1.82	1.04	8,320	0.75
3 × 4 × 1/2	3.25	11.	1.33	5.01	1.88	15,040	1.24	1.16	0.77	6,160	0.60
3 × 3 × 1/2	2.75	9.	0.93	2.22	1.08	8,640	0.90	1.15	0.77	6,160	0.65
3 × 2 × 3/8	1.70	5.7	0.55	0.53	0.36	2,880	0.56	0.86	0.57	4,560	0.71
3 × 2 1/2 × 3/8	1.51	5.	0.40	0.22	0.20	1,600	0.34	0.57	0.455	3,640	0.62
2 1/2 × 2 1/2 × 3/8	1.72	5.7	0.77	0.97	0.56	4,480	0.75	0.50	0.400	3,200	0.54
2 1/4 × 1 1/4 × 1/4	0.81	2.7	0.32	0.09	0.097	776	0.105	0.24	0.214	1,712	0.55
2 × 2 × 5/16	0.95	3.2	0.59	0.35	0.25	2,000	0.61	0.17	0.170	1,360	0.42
1 3/4 × 1 3/4 × 1/4	0.82	2.7	0.52	0 235	0.192	1,536	0.54	0.11	0.125	1,000	0.37
1 1/2 × 1 1/2 × 1/4	0.68	2.3	0.47	0.138	0.144	1,152	0.45	0.073	0.099	792	0.105
1 1/4 × 1 1/4 × 3/16	0.48	1.6	0.35	0.064	0.102	816	0.365	0.031	0.050	400	.084
1 × 1 × 1/8	0.23	0.8	0.29	0.022	0.031	248	0.31	0.011	0.022	176	.071

WEIGHTS AND PROPERTIES OF ANGLE IRON.

ANGLES WITH EQUAL LEGS.

Size.	Weights per yard for different thicknesses.											Moment of Inertia, axis through Center of Gravity.	Distance of Cent. of Grav. from outside of flange. Inches.	Radius of Gyrat. Inches.	Co-efficient of Strength, max. strain 10,000 lbs. per sq. inch.
Inches.	1/8″	3/16″	1/4″	5/16″	3/8″	7/16″	1/2″	9/16″	5/8″	11/16″	3/4″				
6 × 6							57.5	65.	72.	80.	87.	20.0 – 32.0	1.68 – 1.83	1.89	31,000 – 48,000
5 × 5						42.	48.	54.	60.	66.	72.	9.4 – 18.4	1.40 – 1.59	1.56	17,400 – 33,500
4 × 4					28.	33.	39.	43.	48.	53.	58.	4.35 – 9.50	1.14 – 1.35	1.25	10,100 – 21,700
3½ × 3½					24.	28½	33.	37.5	42.			2.87 – 6.38	1.01 – 1.14	1.10	7,700 – 16,300
3 × 3				18.	21.	24.5	28.	31.5	35.			1.50 – 3.35	0.86 – 1.04	0.94	4,800 – 10,200
2½ × 2½			12.	15.	18.	21.	24.					0.85 – 1.50	0.71 – 0.85	0.77	3,400 – 5,500
2¼ × 2¼			10.5	13.5	16.5	19.5	22.5					0.50 – 1.15	0.66 – 0.79	0.70	2,100 – 4,500
2 × 2			9.6	12.	14.4	16.8	19.2					0.35 – 0.78	0.59 – 0.73	0.62	1,700 – 3,400
1¾ × 1¾		6.3	8.4	10.5	12.6	14.8						0.18 – 0.48	0.51 – 0.64	0.55	1,050 – 2,650
1½ × 1½		5.4	7.2	9.0	10.8							0.11 – 0.25	0.44 – 0.55	0.47	730 – 1,520
1¼ × 1¼	3.0	4.5	6.0	7.5								0.044 – 0.123	0.35 – 0.46	0.39	
1 × 1	2.4	3.6	4.8									0.022 – 0.035	0.30 – 0.33	0.30	
⅞ × ⅞	2.1	3.2										0.014 – 0.021			
¾ × ¾	1.8	2.7										0.009 – 0.014			

WEIGHTS AND PROPERTIES OF ANGLE IRON.

ANGLES WITH UNEQUAL LEGS.

Size	Weights per yard for different thicknesses.										Moment of Inertia, axis through Center of Gravity.	Distance of Cent. of Grav. from outside of flange. Inches.	Radius of Gyrat. In.	Co-efficient of Strength, max. strain 10,000 lbs. per sq. inch.
Inches.	3/16″	1/4″	5/16″	3/8″	7/16″	1/2″	9/16″	5/8″	11/16″	3/4″				
6 × 4					42.	48.	54.	60.	66.	72.	15.5 – 28.2	1.96 – 2.14	1.95	25,300 – 44,500
											5.6 – 10.5	0.96 – 1.14	1.20	12,000 – 22,000
5 × 3½				30.	35.	40.	45.	50.	55.	60.	7.78 – 16.7	1.61 – 1.82	1.60	15,300 – 31,200
											3.18 – 7.09	0.86 – 1.07	1.05	8,000 – 16,600
5 × 3				28.	33.	37½	42.	47.	51.	56.	7.37 – 15.9	1.70 – 1.90	1.60	14,600 – 30,600
											2.04 – 4.66	0.70 – 0.90	0.86	5,900 – 12,600
4½ × 3				26.	30½	35.	39½	44.	48.	52½	5.10 – 12.2	1.44 – 1.68	1.45	11,600 – 26,500
											1.98 – 4.52	0.74 – 0.94	0.88	6,200 – 13,100
4 × 3½				26.	30½	35.	39½	44.	48.	52½	4.18 – 9.14	1.20 – 1.40	1.27	9,900 – 20,600
											2.99 – 6.65	0.96 – 1.16	1.08	7,800 – 16,600
4 × 3				24.	28.	32.	36.	40.	44.	48.	3.96 – 8.70	1.28 – 1.49	1.28	9,700 – 20,000
											1.92 – 4.38	0.78 – 0.99	0.90	5,800 – 12,000
3 × 2		12.	15.	18.	21.	24.					1.09 – 2.36	0.99 – 1.13	0.97	3,600 – 7,400
											0.39 – 0.89	0.49 – 0.63	0.58	1,700 – 3,600
2¼ × 1½	6.5	8.7	11.											
2 × 1¾	6.5	8.7	11.											
1⅜ × 1⅛	4.2	5.6	7.											

I BEAMS.

THE following tables are designed for practical use, to guide the selection of the most economical beam, by simple inspection, when the load and the span between centers of supports are given. The maximum fiber strain assumed is 12,000 lbs. per square inch, which is sufficient for all building purposes. Where beams have to carry moving loads, as in bridges, etc., this maximum fiber strain should be reduced; but for entirely permanent and dead loads, it may be increased with safety up to 16,000 lbs. per square inch, as the limit of elasticity is at least fifty per cent. larger than this. The corresponding bearing capacity of beams can be easily found by simply multiplying the safe loads given in the table by the proportion of maximum strain allowed. The deflections for each greater load are always in proportion to the loads.

Another table has been calculated for the safe loads which may be carried by beams not supported sideways. This table is calculated from Rankine's formula,

$$b = \frac{a}{1 + \frac{l^2}{5000\,w^2}}$$

in which $a =$ the strain allowed in beams braced sideways, $l =$ length in inches, and $w =$ width in inches.

I BEAMS.

Safe Loads, in tons of 2000 lbs. uniformly distributed, and corresponding DEFLECTIONS in inches for maximum fiber strains of 12,000 lbs. per sq. inch (beams being secured against yielding sideways).

Depth	15″		15″		12¼″		12¼″		10½″		10½″		10½″		9″		9″		8″	
Weight per yd. in lbs.	200		150		170		125		135		105		90		85		70		80	
Span in feet.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.
	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.
5	73.0	0.02	52.0	0.02	50.4	0.03	38.8	0.03	34.5	0.03	27.7	0.03	24.0	0.03	18.6	0.04	15.8	0.04	16.3	0.04
6	62.2	0.03	45.9	0.03	42.0	0.04	32.3	0.04	28.8	0.05	23.1	0.05	20.7	0.05	15.5	0.06	13.2	0.06	13.6	0.06
7	53.4	0.05	39.4	0.05	36.0	0.06	27.0	0.06	24.7	0.07	19.8	0.07	17.7	0.07	13.3	0.08	11.3	0.08	11.6	0.09
8	46.6	0.06	34.4	0.06	31.5	0.07	24.3	0.07	21.6	0.08	17.3	0.08	15.5	0.08	11.6	0.10	9.9	0.10	10.2	0.11
9	41.5	0.07	30.6	0.07	28.1	0.09	21.6	0.09	19.2	0.11	15.5	0.11	13.8	0.11	10.4	0.13	8.8	0.13	9.1	0.14
10	37.3	0.09	27.5	0.09	25.6	0.11	19.4	0.11	17.3	0.13	13.9	0.13	12.4	0.13	9.3	0.15	7.9	0.15	8.1	0.17
11	34.0	0.11	25.1	0.11	23.0	0.14	17.7	0.14	15.7	0.16	12.6	0.16	11.3	0.16	8.5	0.19	7.2	0.19	7.4	0.21
12	31.1	0.13	23.0	0.13	21.0	0.16	16.2	0.16	14.4	0.19	11.6	0.19	10.4	0.19	7.7	0.22	6.6	0.22	6.8	0.25
13	28.8	0.15	21.2	0.15	19.5	0.19	15.0	0.19	13.3	0.22	10.7	0.22	9.6	0.22	7.2	0.26	6.1	0.26	6.3	0.29
14	26.7	0.18	19.7	0.18	18.0	0.22	13.9	0.22	12.4	0.26	9.9	0.26	8.9	0.26	6.7	0.30	5.6	0.30	5.8	0.34
15	24.8	0.21	18.3	0.21	16.8	0.25	12.9	0.25	11.5	0.30	9.2	0.30	8.3	0.30	6.2	0.35	5.2	0.35	5.4	0.39
16	23.4	0.23	17.2	0.23	15.8	0.29	12.1	0.29	10.8	0.34	8.7	0.34	7.8	0.34	5.8	0.39	4.9	0.39	5.1	0.44
17	22.0	0.26	16.2	0.26	14.9	0.33	11.4	0.33	10.1	0.39	8.1	0.39	7.3	0.39	5.5	0.45	4.6	0.45	4.8	0.50
18	20.7	0.30	15.3	0.30	14.0	0.37	10.8	0.37	9.6	0.43	7.7	0.43	6.9	0.43	5.2	0.50	4.4	0.50	4.5	0.56
19	19.6	0.33	14.5	0.33	13.3	0.41	10.2	0.41	9.1	0.48	7.3	0.48	6.5	0.48	4.9	0.56	4.2	0.56	4.3	0.63

I BEAMS—*Continued.*

Safe Loads, in tons of 2000 lbs. uniformly distributed, and corresponding DEFLECTIONS in inches for maximum fiber strains of 12,000 lbs. per sq. inch (beams being secured against yielding sideways).

Depth	8″		7″		6″		6″		6″		5″		5″		4″		4″		4″	
Weight per yd. in lbs.	65		60		90		50		40		40		30		37		30		18	
Span in feet.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.
	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.
5	14.2	0.04	10.3	0.05	13.7	0.06	7.74	0.06	6.20	0.06	4.83	0.07	4.06	0.07	3.68	0.08	3.04	0.08	2.04	0.08
6	11.8	0.06	8.6	0.07	11.4	0.08	6.5	0.08	5.17	0.08	4.02	0.10	3.88	0.10	3.06	0.12	2.53	0.12	1.70	0.12
7	10.2	0.09	7.4	0.09	9.8	0.11	5.5	0.11	4.4	0.11	3.45	0.14	2.90	0.14	2.63	0.17	2.18	0.17	1.46	0.17
8	8.9	0.11	6.4	0.13	8.5	0.15	4.8	0.15	3.88	0.15	3.02	0.18	2.55	0.18	2.30	0.22	1.90	0.22	1.28	0.22
9	7.9	0.14	5.7	0.16	7.6	0.19	4.3	0.19	3.46	0.19	2.69	0.22	2.26	0.22	2.05	0.28	1.70	0.28	1.13	0.28
10	7.1	0.17	5.1	0.20	6.8	0.23	3.9	0.23	3.10	0 23	2.41	0.28	2.03	0.28	1.84	0.35	1.52	0.35	1.02	0.35
11	6.5	0.21	4.7	0.24	6.2	0.28	3.5	0.28	2.83	0.28	2.20	0.33	1.85	0.33	1.68	0.42	1.39	0.42	0.93	0.42
12	5.9	0.25	4.3	0.29	5.7	0.33	3.2	0.33	2.59	0.33	2.02	0.40	1.70	0.40	1.54	0.50	1.27	0.50	0.85	0.50
13	5.5	0.29	4.0	0.34	5.3	0.39	3.0	0.39	2.40	0.39	1.86	0.47	1.56	0.47	1.42	0.59	1.17	0.59	0.78	0.59
14	5.1	0.34	3.7	0.39	4.9	0.45	2.8	0.45	2.22	0.45	1.73	0.54	1.45	0.54	1.32	0.68	1.09	0.68	0.74	0.68
15	4.7	0.39	3.4	0.45	4.6	0.52	2.6	0.52	2.07	0.52	1.61	0.62	1.35	0.62	1.23	0.78	1.01	0.78	0.68	0.78
16	4.4	0.44	3.2	0.51	4.3	0.59	2.4	0.59	1.94	0.59	1.52	0.71	1.27	0.71	1.15	0.89	0.95	0.89	0.64	0.89
17	4.2	0.50	3.0	0.57	4.0	0.67	2.3	0.67	1.83	0.67	1.42	0.80	1.20	0.80	1.08	1.00	0.89	1.00	0.60	1.00
18	3.9	0.56	2.9	0.64	3.8	0.75	2.15	0.75	1.73	0.75	1.34	0.90	1.13	0.90	1.02	1.13	0.84	1.13	0.57	1.13
19	3.7	0.63	2.7	0.72	3.6	0.84	2 0	0.84	1.64	0.84	1.27	1.00	1.07	1.00	0.97	1.25	0.80	1.25	0.54	1.25

I BEAMS—*Continued.*

Safe Loads, in tons of 2000 lbs. uniformly distributed, and corresponding DEFLECTIONS in inches for maximum fiber strains of 12,000 lbs. per sq. inch (beams being secured against yielding sideways).

Depth	$15\frac{1}{8}''$		$15\frac{3}{16}''$		$12\frac{1}{4}''$		$12\frac{1}{4}''$		$10\frac{1}{2}''$		$10\frac{1}{2}''$		$10\frac{1}{2}''$		$9''$		$9''$		$8''$	
Weight per yd. in lbs.	200		150		170		125		135		105		90		85		70		80	
Span in feet.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.
	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.
20	18.7	0.37	13.8	0.37	12.6	0.45	9.7	0.45	8.7	0.53	6.9	0.53	6.2	0.53	4.7	0.62	4.0	0.62	4.1	0.69
21	17.8	0.40	13.1	0.40	12.0	0.50	9.2	0.50	8.3	0.59	6.6	0.59	5.8	0.59	4.4	0.68	3.7	0.68	3.9	0.77
22	17.0	0.44	12.5	0.44	11.5	0.55	8.8	0.55	7.9	0.65	6.3	0.65	5.6	0.65	4.2	0.75	3.6	0.75	3.7	0.84
23	16.2	0.48	12.0	0.48	11.0	0.60	8.4	0.60	7.5	0.71	6.0	0.71	5.4	0.71	4.0	0.82	3.4	0.82	3.5	0.92
24	15.5	0.52	11.5	0.52	10.5	0.65	8.1	0.65	7.2	0.77	5.8	0.77	5.2	0.77	3.9	0.89	3.3	0.89	3.4	1.00
25	14.9	0.57	11.0	0.57	10.1	0.71	7.8	0.71	6.9	0.83	5.5	0.83	5.0	0.83	3.7	0.96	3.1	0.96	3.3	1.09
26	14.4	0.62	10.6	0.62	9.7	0.77	7.5	0.77	6.7	0.90	5.3	0.90	4.8	0.90	3.6	1.04	3.0	1.04	3.1	1.17
27	13.8	0.67	10.2	0.67	9.3	0.83	7.2	0.83	6.4	0.97	5.1	0.97	4.6	0.97	3.4	1.13	2.9	1.13	3.0	1.27
28	13.4	0.72	9.8	0.72	9.0	0.89	6.9	0.89	6.2	1.04	4.9	1.04	4.4	1.04	3.3	1.21	2.8	1.21	2.9	1.36
29	12.9	0.77	9.5	0.77	8.7	0.95	6.7	0.95	6.0	1.12	4.8	1.12	4.3	1.12	3.2	1.30	2.7	1.30	2.8	1.46
30	12.4	0.82	9.2	0.82	8.4	1.02	6.5	1.02	5.8	1.19	4.6	1.19	4.1	1.19	3.1	1.39	2.6	1.39	2.7	1.56
31	12.0	0.88	8.9	0.88	8.1	1.09	6.3	1.09	5.6	1.27	4.5	1.27	4.0	1.27	3.0	1.49	2.55	1.49	2.6	1.67
32	11.7	0.93	8.6	0.93	7.9	1.16	6.1	1.16	5.4	1.36	4.3	1.36	3.9	1.36	2.9	1.50	2.5	1.50	2.5	1 78
33	11.3	0.99	8.3	0.99	7.6	1.24	5.9	1.24	5.2	1.44	4.2	1.44	3.8	1.44	2.8	1.69	2.4	1.69	2.5	1.89
34	11.0	1.05	8.1	1.05	7.4	1.31	5.7	1.31	5.1	1.53	4.1	1.53	3.6	1.53	2.7	1.79	2.32	1.79	2.40	2.00

I BEAMS—*Continued.*

Safe Loads, in tons of 2000 lbs. uniformly distributed, and corresponding DEFLECTIONS in inches for maximum fiber strains of 12,000 lbs. per sq. inch (beams being secured against yielding sideways).

Depth	8″		7″		6″		6″		6″		5″		5″		4″		4″		4″	
Weight per yd. in lbs.	65		60		90		50		40		40		30		37		30		18	
Span in feet.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.	Load	Defl.
	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.	Tons	In.
20	3.6	0.69	2.6	0.79	3.4	0.93	1.9	0.93	1.56	0.93	1.2	1.11	1.00	1.11	0.92	1.39	0.76	1.39	0.51	1.39
21	3.4	0.77	2.4	0.87	3.2	1.02	1.8	1.02	1.47	1.02	1.15	1.22	0.96	1.22	0.87	1.53	0.72	1.53	0.48	1.53
22	3.2	0.84	2.3	0.96	3.1	1.12	1.8	1.12	1.4	1.12	1.1	1.34	0.92	1.34	0.84	1.68	0.69	1.68	0.46	1.68
23	3.1	0.92	2.2	1.05	3.0	1.23	1.7	1.23	1.35	1.23	1.05	1.47	0.88	1.47	0.80	1.84	0.66	1.84	0.44	1.84
24	3.0	1.00	2.1	1.14	2.8	1.34	1.6	1.34	1.3	1.34	1.0	1.60	0.84	1.60	0.77	2.00	0.63	2.00	0.42	2.00
25	2.8	1.09	2.1	1.24	2.7	1.45	1.55	1.45	1.25	1.45	0.97	1.73	0.81	1.73	0.74	2.17	0.61	2.17	0.41	2.17
26	2.7	1.17	2.0	1.34	2.6	1.57	1.5	1.57	1.2	1.57	0.93	1.87	0.78	1.87	0.71	2.35	0.58	2.35	0.39	2.35
27	2.6	1.27	1.9	1.45	2.5	1.69	1.4	1.69	1.15	1 69	0.90	2.02	0.75	2.02	0.68	2.53	0.56	2.53	0.38	2.53
28	2.5	1.36	1.85	1.56	2.4	1.82	1.4	1.82	1.1	1.82	0.86	2.17	0.73	2.17	0.66	2.72	0.54	2.72	0.36	2.72
29	2.45	1.46	1.8	1.67	2.4	1.95	1.33	1.95	1.07	1.95	0.83	2.33	0.70	2.33	0.63	2.92	0.52	2.92	0.35	2.92
30	2.4	1.56	1.7	1.79	2.3	2.09	1.3	2.09	1.03	2.09	0.81	2.49	0.68	2.49	0.61	3.12	0.51	3.12	0.34	3.12
31	2.3	1.67	1.67	1.91	2.2	2.23	1.25	2.23	1.00	2.23	0.78	2.67	0.66	2.67	0.59	3.33	0.49	3.33	0.33	3.33
32	2.2	1.78	1.6	2.03	2.1	2.37	1.21	2.37	0.97	2.37	0.75	2.83	0.63	2.83	0.57	3.55	0.47	3.55	0.32	3.55
33	2.15	1.89	1.57	2.16	2.07	2.52	1.18	2.52	0.94	2.52	0.73	3.01	0.62	3.01	0.56	3.78	0.46	3.78	0.31	3.78
34	2.10	2.00	1.52	2.30	2.00	2.68	1.14	2.68	0 91	2.68	0.71	3.20	0.60	3.20	0.54	4.00	0.46	4.00	0.30	4.00

BEAMS UNSUPPORTED SIDEWAYS

Are liable to fail under a much lighter load than given in the previous tables, by yielding laterally.

Safe Load, in tons, for Beams unsupported sideways.

Span in feet.	15″ × 200	15″ × 150	12¼″ × 170	12¼″ × 125	10½″ × 135	10½″ × 105	10½″ × 90	9″ × 85	9″ × 70	8″ × 80	8″ × 65	7″ × 60	6″ × 90	6″ × 50	6″ × 40	5″ × 40	5″ × 30	4″ × 37	4″ × 30	4″ × 18
6															4.7	3.8	3.4	2.8	2.2	1.4
8						15.9	14.2	10.2	8.6	8.9	7.8	5.6		4.2	3.2	2.6	2.0	1.9	1.5	.93
10		24.8	23.3	17.2	15.6	12.2	10.9	7.9	6.4	6.9	6.0	4.2	6.1	3.2	2.3	1.8	1.5	1.35	1.1	.64
12	27.5	19.9	18.3	13.8	12.4	9.7	8.1	6.1	5.0	5.4	4.7	3.2	4.9	2.4	1.8	1.4	1.1	1.05	.82	.46
14	22.6	16.2	14.9	11.1	10.2	7.7	7.0	5.0	3.8	4.3	3.8	2.5	4.0	1.9	1.4	1.1	.82	.82	.62	
16	19.1	13.4	12.5	9.1	8.4	6.4	5.7	4.0	3.1	3.5	3.0	2.0	3.3	1.5	1.1	.85	.63	.64		
18	16.1	11.2	10.5	7.7	7.0	5.3	4.7	3.3	2.5	2.9	2.5	1.65	2.8	1.2	.85	.66	.5			
20	13.8	9.4	8.9	6.4	6.0	4.4	3.9	2.8	2.1	2.4	2.1	1.35	2.3	1.0	.66	.53				
22	11.8	8.1	7.6	5.5	5.1	3.7	3.3	2.3	1.7	2.0	1.8	1.1	2.0	.85	.55					
24	10.2	6.9	6.6	4.7	4.3	3.2	2.9	1.9	1.4	1.7	1.5	.9	1.7	.70						
26	8.9	6.0	5.7	4.0	3.8	2.7	2.5	1.6	1.15	1.4	1.2	.8	1.5							
28	7.8	5.2	4.9	3.5	3.3	2.3	2.1	1.4	1.0	1.2	1.0	.7								
30	6.9	4.5	4.3	3.0	2.9	2.0	1.8	1.2	.8	1.0	.9									
32	6.1	4.0	3.8	2.7	2.5	1.8	1.6	1.0	.7	.9										
34	5.4	3.5	3.4	2.3	2.2	1.6	1.4	.9	.6											

This table is calculated by Rankine's formula,

$$b = \frac{a}{1 + \frac{l^2}{5000\, w^2}}$$

l = length. w = width.

FLOORS.

ROLLED iron beams are extensively used in the construction of fire-proof floors. For the selection of the required beams, it is first necessary to ascertain the load to be carried per square foot of floor. This may vary considerable, according to the purposes for which the building is intended. The weight of a fire-proof floor one-half brick in thickness is from 60 to 70 lbs. per square foot. For halls, theaters, churches, etc., an additional load from 70 to 80 lbs. per square foot should be added. This is the weight of a closely packed crowd of people. Generally, the same load will be sufficient for factories. Floors of warehouses have frequently very large loads, from 200 lbs. per square foot up to even 400 lbs. per square foot, according to the nature of the merchandise stored.

The beams used in floors should not only be strong enough to carry the superimposed loads, but also sufficiently rigid to prevent vibration. The deflection should not exceed one-thirtieth of an inch per foot of span. A good rule is to have no beam of less depth than one twenty-fourth of the clear span, or the beams should have a depth of one-half inch for each foot of span. If it is necessary to use shallower beams, the strains should be reduced so that the deflection is no larger than stated above. Generally, of two beams of the same carrying capacity, the deeper beam is the most economical and the stiffer one also.

The plates 12, 13, and 14 show several connections of beams and girders forming floors.

The beams used as joists are frequently laid on top of the girders and walls. If the lower sides of the joists and girders have to be flush, the joists are framed or coped into the girders, so that they rest on their bottom flange. In this case they are connected to the web of the girders by angle iron flanges or knees, which are riveted or bolted to both girder and joist. The same connections are used in the construction of openings for stair-ways, hatch-ways, etc. The ends of joists or beams should rest on bearing-plates, either of iron or of stone, so as to distribute the pressure over the brick-work; also, anchors have to be connected to the ends in the wall. Tie-rods, three-fourths to one inch in diameter, are used to tie the joists together and take up the thrust of the arches. Concrete is frequently used instead of brick arches. Corrugated iron is placed between the joists, resting on the lower flanges, and concrete is laid top of it. Also, hollow bricks and blocks of different shapes have been used for fire-proof floors. These have the advantage of reducing the dead load considerably. They may be used for flat or segmental arches.

Girders consisting of two or more beams are used when single beams do not give the necessary strength. Usually, they are bolted together with cast-iron separators. For carrying walls, it is necessary to have girders consisting of at least two beams, so as to give sufficient width. The beams should have separators near the supports, and besides these, from five to seven feet apart. A table of the weight of Cast-Iron Separators is given here below.

Approximate Weights of Separators and Bolts.

Size of Beam.	Weight of Sep. and one Bolt, Flanges being ¼″ apart.	Increase in Wt. for 1″ increase in width of Sep.	Size of Beam.	Weight of Sep. and one Bolt, Flanges being ¼″ apart.	Increase in Wt. for 1″ increase in width of Sep.
15″ × 200	20½ lbs.	3¾ lbs.	9″ × 85	9½ lbs.	2⅜ lbs.
15″ × 150	18½ "	3¾ "	9″ × 70	9 "	2½ "
12¼″ × 170	14½ "	2¾ "	8″ × 80	9¼ "	2⅛ "
12¼″ × 125	14½ "	3 "	8″ × 65	10 "	2⅜ "
10½″ × 135	13¼ "	2⅝ "	7″ × 60	7¾ "	2 "
10½″ × 105	12¼ "	2⅝ "	6″ × 90	8¾ "	1¾ "
10½″ × 90	12¾ "	2¾ "	6″ × 50	7¼ "	2 "
			6″ × 40	6¼ "	1⅞ "

I BEAMS, USED AS FLOORING JOISTS.

Load, 70 lbs. per □ ft.

Clear Span.	3′ apart.	3½′ apart.	4′ apart.	4½′ apart.	5′ apart.	5½′ apart.	6′ apart.
10 ft.	30 □′	35 □′	40 □′	45 □′	50 □′	55 □′	60 □′
Load, ℔	2,100	2,450	2,800	3,150	3,500	3,850	4,200
I	5 × 30	5 × 30	5 × 30	5 × 30	5 × 30	5 × 30	6 × 40
12 ft.	36 □′	42 □′	48 □′	54 □′	60 □′	66 □′	72 □′
Load, ℔	2,520	2,940	3,360	3,780	4,200	4,620	5,040
I	5 × 30	5 × 30	5 × 30	6 × 40	6 × 40	6 × 40	6 × 40
14 ft.	42 □′	49 □′	56 □′	63 □′	70 □′	77 □′	84 □′
Load, ℔	2,940	3,430	3,920	4,410	4,900	5,390	5,880
I	5 × 30	6 × 40	6 × 40	6 × 40	6 × 50	6 × 50	7 × 60
16 ft.	48 □′	56 □′	64 □′	72 □′	80 □′	88 □′	96 □′
Load, ℔	3,360	3,920	4,480	5,040	5,600	6,160	6,720
I	6 × 40	6 × 40	6 × 50	7 × 60	7 × 60	7 × 60	8 × 65
18 ft.	54 □′	63 □′	72 □′	81 □′	90 □′	99 □′	108 □′
Load, ℔	3,780	4,410	5,040	5,670	6,300	6,930	7,560
I	6 × 50	7 × 60	7 × 60	7 × 60	8 × 65	8 × 65	8 × 65
20 ft.	60 □′	70 □′	80 □′	90 □′	100 □′	110 □′	120 □′
Load, ℔	4,200	4,900	5,600	6,300	7,000	7,700	8,400
I	7 × 60	7 × 60	8 × 65	8 × 65	8 × 65	9 × 70	9 × 85
22 ft.	66 □′	77 □′	88 □′	99 □′	110 □′	121 □′	132 □′
Load, ℔	4,620	5,390	6,160	6,930	7,700	8,470	9,240
I	7 × 60	8 × 65	8 × 65	9 × 70	9 × 85	9 × 85	10½ × 90
24 ft.	72 □′	84 □′	96 □′	108 □′	120 □′	132 □′	144 □′
Load, ℔	5,040	5,880	6,720	7,560	8,400	9,240	10,080
I	8 × 65	8 × 65	9 × 70	9 × 85	10½ × 90	10½ × 90	10½ × 90
26 ft.	78 □′	91 □′	104 □′	117 □′	130 □′	143 □′	156 □′
Load, ℔	5,460	6,370	7,280	8,190	9,100	10,010	10,920
I	8 × 65	9 × 85	9 × 85	10½ × 90	10½ × 90	10½ × 105	12¼ × 125
28 ft.	84 □′	98 □′	112 □′	126 □′	140 □′	154 □′	168 □′
Load, ℔	5,880	6,860	7,840	8,820	9,800	10,780	11,760
I	9 × 85	10½ × 90	10½ × 90	10½ × 90	10½ × 105	12¼ × 125	12¼ × 125
30 ft.	90 □′	105 □′	120 □′	135 □′	150 □′	165 □′	180 □′
Load, ℔	6,300	7,350	8,400	9,450	10,500	11,550	12,600
I	10½ × 90	10½ × 90	10½ × 105	12¼ × 125	12¼ × 125	12¼ × 125	12¼ × 125

I BEAMS, USED AS FLOORING JOISTS.

Load, 100 lbs. per □ ft.

Clear Span.	3′ apart.	3½′ apart.	4′ apart.	4½′ apart.	5′ apart.	5½′ apart.	6′ apart.
10 ft.	30 □′	35 □′	40 □′	45 □′	50 □′	55 □′	60 □′
Load, lb	3,000	3,500	4,000	4,500	5,000	5,500	6,000
I	5 × 30	5 × 30	5 × 30	6 × 40	6 × 40	6 × 40	6 × 40
12 ft.	36 □′	42 □′	48 □′	54 □′	60 □′	66 □′	72 □′
Load, lb	3,600	4,200	4,800	5,400	6,000	6,600	7,200
I	6 × 40	6 × 40	6 × 40	6 × 50	6 × 50	7 × 60	7 × 60
14 ft.	42 □′	49 □′	56 □′	63 □′	70 □′	77 □′	84 □′
Load, lb	4,200	4,900	5,600	6,300	7,000	7,700	8,400
I	6 × 40	6 × 50	6 × 50	7 × 60	7 × 60	8 × 65	8 × 65
16 ft.	48 □′	56 □′	64 □′	72 □′	80 □′	88 □′	96 □′
Load, lb	4,800	5,600	6,400	7,200	8,000	8,800	9,600
I	6 × 50	7 × 60	7 × 60	8 × 65	8 × 65	8 × 65	9 × 70
18 ft.	54 □′	63 □′	72 □′	81 □′	90 □′	99 □′	108 □′
Load, lb	5,400	6,300	7,200	8,100	9,000	9,900	10,800
I	7 × 60	8 × 65	8 × 65	9 × 70	9 × 85	9 × 85	10½ × 90
20 ft.	60 □′	70 □′	80 □′	90 □′	100 □′	110 □′	120 □′
Load, lb	6,000	7,000	8,000	9,000	10,000	11,000	12,000
I	8 × 65	8 × 65	9 × 70	9 × 85	10½ × 90	10½ × 90	10½ × 90
22 ft.	66 □′	77 □′	88 □′	99 □′	110 □′	121 □′	132 □′
Load, lb	6,600	7,700	8,800	9,900	11,000	12,100	13,200
I	9 × 70	9 × 85	10½ × 90	10½ × 90	10½ × 90	10½ × 105	12¼ × 125
24 ft.	72 □′	84 □′	96 □′	108 □′	120 □′	132 □′	144 □′
Load, lb	7,200	8,400	9,600	10,800	12,000	13,200	14,400
I	9 × 85	10½ × 90	10½ × 90	10½ × 105	12¼ × 125	12¼ × 125	12¼ × 125
26 ft.	78 □′	91 □′	104 □′	117 □′	130 □′	143 □′	156 □′
Load, lb	7,800	9,100	10,400	11,700	13,000	14,300	15,600
I	10½ × 90	10½ × 90	10½ × 105	12¼ × 125	12¼ × 125	12¼ × 125	15 × 150
28 ft.	84 □′	98 □′	112 □′	126 □′	140 □′	154 □′	168 □′
Load, lb	8,400	9,800	11,200	12,600	14,000	15,400	16,800
I	10½ × 90	10½ × 105	12¼ × 125	12¼ × 125	15 × 150	15 × 150	15 × 150
30 ft.	90 □′	105 □′	120 □′	135 □′	150 □′	165 □′	180 □′
Load, lb	9,000	10,500	12,000	13,500	15,000	16,500	18,000
I	10½ × 105	12¼ × 125	12¼ × 125	15 × 150	15 × 150	15 × 150	15 × 150

I BEAMS, USED AS FLOORING JOISTS.

Load, 150 lbs. per □ ft.

Clear Span.	3′ apart.	3½′ apart.	4′ apart.	4½′ apart.	5′ apart.	5½′ apart.	6′ apart.
10 ft.	30 □′	35 □′	40 □′	45 □′	50 □′	55 □′	60 □′
Load, lb	4,500	5,250	6,000	6,750	7,500	8,250	9,000
I	6 × 40	6 × 40	6 × 40	6 × 50	6 × 50	7 × 60	7 × 60
12 ft.	36 □′	42 □′	48 □′	54 □′	60 □′	66 □′	72 □′
Load, lb	5,400	6,300	7,200	8,100	9,000	9,900	10,800
I	6 × 50	6 × 50	7 × 60	7 × 60	8 × 65	8 × 65	8 × 65
14 ft.	42 □′	49 □′	56 □′	63 □′	70 □′	77 □′	84 □′
Load, lb	6,300	7,350	8,400	9,450	10,500	11,550	12,600
I	7 × 60	7 × 60	8 × 65	8 × 65	9 × 70	9 × 85	9 × 85
16 ft.	48 □′	56 □′	64 □′	72 □′	80 □′	88 □′	96 □′
Load, lb	7,200	8,400	9,600	10,800	12,000	13,200	14,400
I	8 × 65	8 × 65	9 × 70	9 × 85	10½ × 90	10½ × 90	10½ × 90
18 ft.	54 □′	63 □′	72 □′	81 □′	90 □′	99 □′	108 □′
Load, lb	8,100	9,450	10,800	12,150	13,500	14,850	16,200
I	9 × 70	9 × 85	10½ × 90	10½ × 90	10½ × 90	10½ × 105	12¼ × 125
20 ft.	60 □′	70 □′	80 □′	90 □′	100 □′	110 □′	120 □′
Load, lb	9,000	10,500	12,000	13,500	15,000	16,500	18,000
I	9 × 85	10½ × 90	10½ × 90	10½ × 105	12¼ × 125	12¼ × 125	12¼ × 125
22 ft.	66 □′	77 □′	88 □′	99 □′	110 □′	121 □′	132 □′
Load, lb	9,900	11,550	13,200	14,850	16,500	18,150	19,800
I	10½ × 90	10½ × 105	12¼ × 125	12¼ × 125	12¼ × 125	15 × 150	15 × 150
24 ft.	72 □′	84 □′	96 □′	108 □′	120 □′	132 □′	144 □′
Load, lb	10,800	12,600	14,400	16,200	18,000	19,800	21,600
I	10½ × 105	12¼ × 125	12¼ × 125	12¼ × 125	15 × 150	15 × 150	15 × 150
26 ft.	78 □′	91 □′	104 □′	117 □′	130 □′	143 □′	156 □′
Load, lb	11,700	13,650	15,600	17,550	19,500	21,450	23,400
I	12¼ × 125	12¼ × 125	15 × 150	15 × 150	15 × 150	15 × 150	15 × 200
28 ft.	84 □′	98 □′	112 □′	126 □′	140 □′	154 □′	168 □′
Load, lb	12,600	14,700	16,800	18,900	21,000	23,100	25,200
I	12¼ × 125	15 × 150	15 × 150	15 × 150	15 × 200	15 × 200	15 × 200
30 ft.	90 □′	105 □′	120 □′	135 □′	150 □′	165 □′	180 □′
Load, lb	13,500	16,250	18,000	20,250	22,500	24,750	27,000
I	15 × 150	15 × 150	15 × 150	15 × 200	15 × 200	15 × 200	2–15 × 150

I BEAMS, USED AS FLOORING JOISTS.

Load, 200 lbs. per □ ft.

Clear Span.	3′ apart.	3½′ apart.	4′ apart.	4½′ apart.	5′ apart.	5½′ apart.	6′ apart.
10 ft.	30□′	35□′	40□′	45□′	50□′	55□′	60□′
Load, ℔	6,000	7,000	8,000	9,000	10,000	11,000	12,000
I	6 × 40	6 × 50	7 × 60	7 × 60	7 × 60	8 × 65	8 × 65
12 ft.	36□′	42□′	48□′	54□′	60□′	66□′	72□′
Load, ℔	7,200	8,400	9,600	10,800	12,000	13,200	14,400
I	7 × 60	7 × 60	8 × 65	8 × 65	9 × 70	9 × 70	9 × 85
14 ft.	42□′	49□′	56□′	63□′	70□′	77□′	84□′
Load, ℔	8,400	9,800	11,200	12,600	14,000	15,400	16,800
I	8 × 65	8 × 65	9 × 70	9 × 85	10½×90	10½ × 90	10½ × 90
16 ft.	48□′	56□′	64□′	72□′	80□′	88□′	96□′
Load, ℔	9,600	11,200	12,800	14,400	16,000	17,600	19,200
I	9 × 70	9 × 85	10½×90	10½×90	10½×105	10½ × 105	10½ × 135
18 ft.	54□′	63□′	72□′	81□′	90□′	99□′	108□′
Load, ℔	10,800	12,600	14,400	16,200	18,000	19,800	21,600
I	10½×90	10½×90	10½×105	12¼×125	12¼×125	12¼ × 125	12¼ × 125
20 ft.	60□′	70□′	80□′	90□′	100□′	110□′	120□′
Load, ℔	12,000	14,000	16,000	18,000	20,000	22,000	24,000
I	10½ × 90	12¼×125	12¼×125	12¼×125	15×150	15 × 150	15 × 150
22 ft.	66□′	77□′	88□′	99□′	110□′	121□′	132□′
Load, ℔	13,200	15,400	17,600	19,800	22,000	24,200	26,400
I	12¼×125	12¼×125	12¼×125	15×150	15×150	15 × 150	15 × 200
24 ft.	72□′	84□′	96□′	108□′	120□′	132□′	144□′
Load, ℔	14,400	16,800	19,200	21,600	24,000	26,400	28,800
I	12¼×125	15×150	15×150	15×150	15×200	15 × 200	15 × 200
26 ft.	78□′	91□′	104□′	117□′	130□′	143□′	156□′
Load, ℔	15,600	18,200	20,800	23,400	26,000	28,600	31,200
I	15×150	15×150	15×150	15×200	15×200	15 × 200	2–15 × 150
28 ft.	84□′	98□′	112□′	126□′	140□′	154□′	168□′
Load, ℔	16,800	19,600	22,400	25,200	28,000	30,800	33,600
I	15×150	15×150	15×200	15×200	2-15×150	2–15 × 150	2–15 × 150
30 ft.	90□′	105□′	120□′	135□′	150□′	165□′	180□′
Load, ℔	18,000	21,000	24,000	27,000	30,000	33,000	36,000
I	15×150	15×200	15×200	2-15×150	2-15×150	2–15 × 150	2–15 × 150

RIVETED GIRDERS.

RIVETED girders are used where rolled beams are not sufficiently strong for carrying the load. Sometimes it may be more economical to use a deeper built beam instead of a solid rolled beam, but generally the rolled beam is the cheaper one, if it can be had strong enough to carry the weight. Plate girders have either single or double webs. The latter ones, box girders, have more stiffness sideways; and plain plate girders, with single webs, are somewhat cheaper. The width of the top flange of the girders should be at least one-twentieth of the span, or the section of the top flange should be increased accordingly. For girders not protected against yielding sideways, box girders are preferable, as they have greater stiffness laterally. Shearing strains in the web should never be more than half of the strains allowed in the flanges; and if the depth is considerable, stiffeners should be used to prevent buckling of the web-plates. A good rule is to have stiffeners if the depth of the web-plate exceeds eighty times its thickness. Angle irons are better as stiffeners than Tee iron on account of having larger flanges, which allow more space for rivets. The stiffeners should always reach over the vertical sides of the angles forming the chords of the girder, and there should be filling pieces between the stiffening angles and the web-plate. In every case, whether there are web-stiffeners used or not, there should be a reinforcing by angles or plates at the ends of the girders where they rest on columns or on the wall, so that the reaction of the support may be resisted by an increased section of the web. In larger girders, one, two, or more cover-plates are required to make up the necessary section of the chords or flanges. Frequently all these cover-plates are made the whole length of the girder, but this is only a waste of material, as the outer cover-plates are only required for a part of the length. Plate girders should never be made too shallow, on account of the deflection; they should have at least a depth of one twenty-fourth of the clear span; if built shallower, more material should be put in the flanges and webs, so as to reduce the strain per square inch, and the deflection in proportion.

CALCULATION OF A RIVETED GIRDER.

Box girder, to carry a wall 20 inches wide.
Span, 30 feet between centers of supports = 360 inches.
Total weight to be carried, 100 tons = 200,000 lbs.
Depth available, 36″.
Load on each support, $\frac{1}{2} \times 200{,}000 = 100{,}000$ lbs.

Web section required, $\frac{100{,}000 \text{ lbs.}}{5{,}000 \text{ lbs.}} = 20$ □″.

Two web-plates, $34'' \times \frac{3}{8}'' = 25\frac{1}{2}$ □″.
Bending moment in middle of span,
$\frac{1}{8} \times 200{,}000 \times 360 = 9{,}000{,}000$ inch lbs.
Depth of girders bet. centers of chords or flanges, about 34″.

Maximum chord strain, $\frac{9{,}000{,}000}{34} = 264{,}700$ lbs.

Chord section required, $\frac{264{,}700}{10{,}000} = 26\frac{1}{2}$ □″.

This section is made up as follows:	$\frac{1}{6}$ of the web-plates..............	$4\frac{1}{4}$ □″
	2 L iron, $6'' \times 4'' \times \frac{1}{2}$.............	$9\frac{3}{4}$ □″
	1 cover plate, $20'' \times \frac{5}{8}$.............	$12\frac{1}{2}$ □″
		$26\frac{1}{2}$ □″

STIFFENERS.—Angle iron, $3'' \times 3'' \times \frac{3}{8}''$, placed about 4 to 5 feet apart.

By the use of the following table, it is easy to find the section required in the chords of riveted girders, if the load and span are given. This table is calculated for a maximum strain of 10,000 lbs. per square inch of gross section. If a higher strain per square inch is admissible,—as in case of strictly permanent loads for structures which are not exposed to vibrations and sudden applications of heavy weights,—it is only necessary to reduce the result obtained in proportion to the higher strain per square inch allowed.

Plate No. 15, fig. 1, shows an elevation of a plain plate girder, built of a web-plate, and four angle irons, stiffened with angle-iron stiffeners.

Fig. 2. Section of plain plate girder, without cover-plate.

Fig. 3. Section of plate girder, with top and bottom cover-plates.

Fig. 4. Section of ordinary box girder, with two web-plates, two cover-plates, and four angle irons in chords.

Fig. 5. Same with extra angle irons riveted to the side of the web-plate. The floor joists, either iron or wood, are carried on these angles.

Fig. 6. Compound girder, consisting of two ordinary plain plate girders, connected together at intervals with wrought or cast iron separators.

Fig. 7. Box girder, composed of two vertical plates and two horizontal channel irons.

RIVETED GIRDERS.

Multiply by the load in tons of 2000 lbs., uniformly distributed, and divide by 1000. The result is the gross area in square inches required for each flange, allowing a maximum fiber strain of 10,000 lbs. per □ inch.

Span in feet.	DEPTH OUT TO OUT OF WEB IN INCHES.												
	18	20	22	24	26	28	30	32	34	36	38	40	42
10	167	150	136	125	115	107	100	94	88	83	79	75	71
11	183	165	150	138	127	118	110	103	97	92	87	83	79
12	200	180	164	150	138	129	120	113	106	100	95	90	86
13	217	195	177	163	150	139	130	122	115	108	102	98	93
14	233	210	191	175	162	150	140	131	124	117	110	105	100
15	250	225	205	188	173	161	150	141	132	125	118	113	107
16	267	240	218	200	185	171	160	150	141	133	126	120	114
17	283	255	232	213	196	182	170	159	150	142	134	128	121
18	300	270	245	225	208	193	180	169	159	150	142	135	129
19	317	285	259	238	219	204	190	178	168	158	150	143	136
20	333	300	273	250	231	214	200	188	176	167	158	150	143
21	350	315	286	263	242	225	210	197	185	175	165	158	150
22	367	330	300	275	254	236	220	206	194	183	173	165	157
23	383	345	314	288	265	246	230	216	203	192	181	173	164
24	400	360	327	300	277	257	240	225	212	200	189	180	171
25	417	375	341	313	288	268	250	234	221	208	197	188	179
26	433	390	355	325	300	279	260	244	229	217	205	195	186
27	450	405	368	338	312	289	270	253	238	225	213	203	193
28	467	420	382	350	323	300	280	263	247	233	221	210	200
29	483	435	395	363	335	311	290	272	256	242	229	218	207
30	500	450	409	375	346	321	300	281	265	250	236	225	214
31	517	465	423	388	358	332	310	291	274	258	244	233	221
32	533	480	436	400	369	343	320	300	282	267	252	240	228
33	550	495	450	413	381	354	330	309	291	275	260	248	236
34	567	510	464	425	392	364	340	319	300	283	268	255	243
35	583	525	477	438	404	375	350	328	309	292	276	263	250
36	600	540	491	450	415	386	360	338	318	300	284	270	257
37	617	555	505	463	427	396	370	347	326	308	292	278	264
38	633	570	518	475	438	407	380	356	335	317	299	285	271
39	650	585	532	488	450	418	390	366	344	325	307	293	278
40	667	600	546	500	461	429	400	375	353	333	315	300	286

STRENGTH OF WOODEN BEAMS.

The following table is calculated for rectangular beams one inch thick, and for different spans and depth of beams.

Maximum fiber strain allowed, 1000 lbs. per square inch. Beams to be braced sideways. For a factor of safety of 5 multiply by—

1.0 for ash.
1.0 — 1.3 for spruce.
1.44 — 1.8 for white oak.
1.0 — 1.12 for white pine.
1.6 for long leaf yellow pine.

Span in feet.	DEPTH IN INCHES.										
	6	7	8	9	10	11	12	13	14	15	16
5	800	1090	1420	1800	2220	2690	3200	3980	4380	5000	5690
6	670	910	1190	1500	1850	2240	2670	3220	3650	4170	4740
7	570	780	1020	1290	1590	1920	2290	2840	3130	3570	4060
8	500	680	890	1130	1390	1680	2000	2490	2740	3130	3560
9	440	610	790	1000	1230	1490	1780	2210	2430	2780	3160
10	400	540	710	900	1110	1340	1600	1990	2190	2500	2840
11	360	495	650	820	1010	1220	1450	1810	1990	2270	2590
12	330	450	590	750	930	1120	1330	1660	1820	2080	2370
13	310	420	550	690	860	1030	1230	1530	1690	1930	2200
14	290	390	510	640	800	960	1150	1430	1570	1790	2040
15	270	360	480	600	740	900	1070	1330	1460	1670	1900
16	250	340	450	560	700	840	1000	1250	1370	1570	1780
17	240	320	420	530	650	790	940	1170	1290	1470	1680
18	220	300	400	500	620	750	890	1110	1220	1390	1590
19	210	290	380	480	590	710	840	1050	1150	1320	1500
20	200	272	360	450	560	670	800	990	1090	1250	1420
21	190	260	340	430	530	640	760	950	1040	1190	1360
22	180	248	325	410	510	610	730	910	1000	1140	1300
23	175	237	310	390	480	590	700	870	950	1090	1240
24	167	228	297	380	460	560	670	830	910	1040	1190
25	160	218	285	360	450	540	640	800	880	1000	1140
26	154	210	275	350	430	520	620	770	840	960	1100
27	149	202	265	330	410	500	590	740	810	930	1060
28	143	195	255	315	400	480	570	710	780	890	1020
29	138	188	246	307	380	465	550	690	750	860	980
30	134	182	237	297	370	450	530	660	730	830	950

COLUMNS, POSTS AND STRUTS.

THE following tables of strength of columns are calculated for safe working strains, and not for the ultimate strength, as it is of greater consequence to know what load a column will support with safety, than to know under what load it will fail.

The first table is copied from a paper read by Mr. Theodore Cooper, before the A. S. of C. E., and it is based on experiments made on full size columns at the Watertown Arsenal. The allowed working strains are calculated so that they are in proportion to the limit of elasticity (0.44 of it). For posts which are liable to be struck by passing bodies as f: i, the web-posts in through-bridges, smaller working strains are given.

The second table shows strains per square inch as allowed by the specifications of the New York, Lake Erie and Western Railroad, which have been adopted by a great many roads all through the United States, and on which base a great number of structures have been designed and executed. The values of ratio of length to diameter for different shapes of struts, are only approximate, but they are sufficient for ordinary use.

Both of these tables are calculated for moving loads; for steady loads, as in buildings, the safe working strains may be increased 25 per cent.

The table of safe loads on rolled I beams used as columns or struts is intended for steady loads only. Such columns are frequently used in buildings, and give very satisfactory results if the length is not too great. If two I beams, well braced together, are used, they will carry a larger load. The co-efficients, as given for box columns, may be used for such columns without great error.

Plate 16 shows sections of different types of columns.

Fig. 1. Box column, composed of two channels and two plates.

Fig. 2. Box column, composed of four angle irons and four plates.

Fig. 3. Open column, composed of two channels connected with lattice bars or lacing.

Fig. 4. Open column, built of two plates and four angle irons, connected with lattice bars.

Fig. 5. Open column, built of two I beams, connected with lattice bars.

Figs. 6 and 7. Columns built of two [and one I beam, or of three I beams.

Fig. 8. Columns of similar section; in place of solid rolled beams and channels, angles and plates are used.

Fig. 11. Column consisting of two plain bars riveted together with an I beam.

Fig. 12. Plain I beam used as column.

Fig. 9. Two I beams connected with cast-iron separators and bolts or rivets.

Fig. 10. Two channel bars connected in the same way.

Fig. 18. Two flat bars connected in the same way.

Fig. 13. Open column, built of four angle irons, latticed.

Fig. 14. Four angles connected with solid web-plate, or latticed.

Figs. 15 and 17. Two T irons or four angle irons riveted together in star shape.

Fig. 16. Similar column. The angles are separated by cast-iron thimbles.

TABLE OF

ALLOWED WORKING STRAINS ON WROUGHT-IRON COLUMNS.

Calculated by Mr. TH. COOPER, C. E., M. A. S. C. E., based on Experiments made at the Watertown Arsenal.

	Ratio of Length to Diameter.	Phœnix Columns.		American Co's Col.		Box Columns.		Open Columns.		REMARKS.
		a. Lbs. per sq. inch.	b. Lbs. per sq. inch.	a. Lbs. per sq. inch.	b. Lbs. per sq. inch.	a. Lbs. per sq. inch.	b. Lbs. per sq. inch.	a. Lbs. per sq. inch.	b. Lbs. per sq. inch.	
SQUARE-ENDED Columns.	10	9,96[illegible]	8,853	7,521	6,686	7,790	6,924	9,452	8,482	The values given in Columns *b* should be used where the posts are subject to be struck transversely by passing bodies (Web-posts in Through Bridges).
	20	8,661	6,928	6,666	5,333	6,828	5,462	8,337	6,670	
	30	8,300	6,037	6,455	4,700	6,510	4,735	8,000	5,818	
	40	7,968	5,312	5,700	3,800	6,364	4,243	7,690	5,126	
	50	7,115	4,380	4,640	2,855	5,866	3,610	6,540	4,024	
	60	6,037	3,450	3,646	2,084	5,153	2,945	5,867	3,352	
PIN-ENDED Columns.	10	8,314	7,390	6,600	5,867	6,520	5,797	8,012	7,122	
	20	8,250	6,600	6,212	4,970	6.395	5,116	7,798	6,238	
	30	7,313	5,318	5,280	3,840	5,929	4,312	7,074	5,145	
	40	6,256	4,170	4,224	2,816	5,229	3,486	6,075	4,050	
	50	5,182	3,189	3,300	2,031	4,463	2,746	5,052	3,109	
	60	4,234	2,419	2,575	1,471	3,743	2,139	4,143	2,367	

TABLE OF

ALLOWED WORKING STRAINS ON WROUGHT-IRON COLUMNS.

Calculated from formulas of the N. Y., Lake Erie, and W. R. R.

For Square Ends.	Pin and Square Ends.	Pin Ends.
$\dfrac{8{,}000}{1+\dfrac{L^2}{40{,}000\ R^2}}$	$\dfrac{8{,}000}{1+\dfrac{L^2}{30{,}000\ R^2}}$	$\dfrac{8{,}000}{1+\dfrac{L^2}{20{,}000\ R^2}}$

L = length in inches. R = radius of gyration in inches.
For dead loads, as in buildings, allow 25% more.

Ratio of Length to Rad. of Gyr. $\frac{L}{R}$	Working Strains per sq. inch.			Ratio of L to Diameter.				
	Square. Lbs. per sq. in.	Pin and Square. Lbs. per sq. in.	Pin. Lbs. per sq. in.	Phœnix Col.	American Col.	Box Col.	Open Col.	╬ Col.
30	7,820	7,770	7,660	10.9	10.	12.3	11.1	6.1
35	7,760	7,690	7,540	12.8	11.7	14.3	13.	7.2
40	7,700	7,590	7,410	14.6	13.3	16.4	14.8	8.2
45	7,620	7,500	7,260	16.4	15.	18.5	16.7	9.2
50	7,530	7,380	7,110	18.2	16.7	20.5	18.6	10.2
55	7,440	7,260	6,950	20.0	18.3	22.6	20.5	11.2
60	7,340	7,140	6,780	21.9	20.	24.6	22.3	12.2
65	7,230	7,010	6,610	23.7	21.7	26.7	24.2	13.3
70	7,130	6,880	6,420	25.5	23.3	28.7	26.	14.3
75	7,020	6,740	6,250	27.3	25.	30.8	27.8	15.3
80	6,900	6,590	6,060	29.2	26.7	32.8	29.7	16.4
85	6,780	6,450	5,880	31.0	28.3	34.9	31.5	17.4
90	6,660	6,300	5,700	32.8	30.0	36.9	33.4	18.4
95	6,530	6,150	5,510	34.6	31.7	39.0	35.2	19.4
100	6,400	6,000	5,330	36.4	33.3	41.0	37.1	20.5
105	6,270	5,860	5,160	38.2	35.0	43.1	39.	21.5
110	6,140	5,700	4,980	40.0	36.7	45.1	40.8	22.5
115	6,010	5,550	4,820	41.9	38.3	47.2	42.6	23.5
120	5,880	5,410	4,650	43.7	40.0	49.2	44.5	24.5
125	5,750	5,260	4,490	45.5	41.7	51.3	46.4	25.5
130	5,620	5,120	4,340	47.3	43.3	53.3	48.2	26.6
135	5,500	4,980	4,180	49.2	45.0	55.4	50.1	27.6
140	5,370	4,840	4,040	51.0	46.7	57.4	52.	28.6
145	5,240	4,700	3,900	52.8	48.3	59.5	53.9	29.6
150	5,120	4,570	3,770	54.6	50.0	61.5	55.7	30.6
155	5,000	4,440	3,630	56.4	51.7	63.6	57.5	31.7
160	4,880	4,320	3,510	58.2	53.3	65.6	59.4	32.7

TABLE OF SAFE LOADS FOR ROLLED I BEAMS USED AS COLUMNS OR STRUTS.

Both ends flat and fixed.
This Table is to be used for dead loads only.
For moving loads deduct 20%.

Calculated from formula $\dfrac{10{,}000}{1 + \dfrac{L^2}{40{,}000\, r^2}}$ per sq. inch.

Depth of Beam.	15	15	12¼	12¼	10½	10½	10½	9″	9	8	8	7	6	6	6	5	5	4	4	4
Wgt. per yd.	200	150	170	125	135	105	90	85	70	80	65	60	90	50	40	40	30	37	30	18
Length of Post. Feet.	Safe Load, in tons of 2000 lbs. (factor safety, 4).																			
4	96	71	81	59	63	49	42	39	32	38	30	27	42	23	17.5	17.2	13.0	16.5	12.9	7.3
5	94	69	79	57	61	47	40	38	30	36	29	26	41	21	16.5	16.0	12.2	15.6	12.0	6.6
6	91	66	77	55	60	46	39	36	28	35	27	24	40	20	15.3	14.7	11.2	14.6	11.0	5.8
7	89	64	74	53	58	44	38	34	26	34	26	22	39	19	14.1	13.4	10.3	13.5	10.1	5.2
8	85	61	72	51	56	42	36	33	24	32	25	21	37	17	12.9	12.2	9.4	12.5	9.1	
9	82	59	69	49	54	40	34	31	22	30	24	19	36	16	11.9	11.2	8.6	11.5	8.4	
10	79	55	67	46	52	37	32	29	21	28	22	18	35	15	10.9	10.2	7.9	10.6	7.6	
11	76	52	63	43	49	35	30	27	19	27	21	16	33	14	9.5	9.2	7.2	9.7	6.9	
12	72	49	60	41	47	33	28	25	17	25	19	15	31	12						
13	69	47	57	39	44	31	26	23	16	24	18	14	29	11						
14	66	44	54	37	42	29	25	22	14	22	17	12	28	10						
15	63	41	51	34	40	27	23	20	12	21	15	11	27	09						

TABLE OF SAFE LOADS
FOR
HOLLOW CYLINDRICAL CAST AND WROUGHT IRON COLUMNS.

CAST-IRON COLUMNS, with factor of safety 6.

Square Bearing.	Pin and Square.	Pin Bearing.
$\dfrac{13333}{1+\dfrac{L^2}{800\,d^2}}$	$\dfrac{13333}{1+\dfrac{L^2}{533\,d^2}}$	$\dfrac{13333}{1+\dfrac{L^2}{400\,d^2}}$

WROUGHT-IRON COLUMNS, with factor of safety 4.

Square Bearing.	Pin and Square.	Pin Bearing.
$\dfrac{10000}{1+\dfrac{L^2}{3000\,d^2}}$	$\dfrac{10000}{1+\dfrac{L^2}{2000\,d^2}}$	$\dfrac{10000}{1+\dfrac{L^2}{1500\,d^2}}$

L, length of columns in inches.
d, diameter of columns in inches.

This table is calculated only for dead loads. For moving loads, deduct 20% for wrought-iron columns and 25% for cast-iron columns.

CAST-IRON COLUMNS. Safe Loads, in lbs. per □ in.				WROUGHT-IRON COLUMNS. Safe Loads, in lbs. per □ in.			
$\frac{L}{d}$	Square.	Square and Pin.	Pin.	$\frac{L}{d}$	Square.	Square and Pin.	Pin.
12	11,300	10,500	9,800	12	9,540	9,330	9,125
15	10,410	9,380	8,530	15	9,300	8,990	8,700
18	9,490	8,300	7,370	18	9,020	8,600	8,220
21	8,600	7,600	6,350	21	8,720	8,190	7,730
24	7,750	6,410	5,460	24	8,390	7,770	7,220
27	6,890	5,630	4,730	27	8,050	7,320	6,730
30	6,270	4,960	4,100	30	7,690	6,900	6,250
33	5,650	4,380	3,580	33	7,320	6,480	5,800
36	5,090	3,890	3,140	36	6,980	6,070	5,360
39	3,760	3,460	2,780	39	6,640	5,680	4,970

TABLE OF

SAFE LOADS FOR RECTANGULAR TIMBER POSTS, SEASONED.

This table is calculated for a factor of safety of 5 from the following formulas:

Square Bearing.	Pin and Square Bearing.	Pin Bearing.
$\frac{1120}{1 + \frac{L^2}{550\, d^2}}$	$\frac{1120}{1 + \frac{L^2}{378\, d^2}}$	$\frac{1120}{1 + \frac{L^2}{275\, d^2}}$

Deducted from Lemande's experiments with posts of French oak, and may be used for American white pine of best quality.

Ratio of Length to Least Side. $\frac{L}{d}$	Safe Loads, in lbs. per □ inch of Section.		
	Square Ends.	Square and Pin Ends.	Pin Ends.
12	890	804	736
15	795	695	616
18	704	594	514
21	623	509	431
24	548	436	362
27	482	375	307
30	424	324	262
33	376	282	226
36	334	246	196
39	297	218	172
42	266	192	152
45	239	172	134

L, length of post in inches.
d, width of smallest side in inches.

ROOFS.

THE most frequent types of Roof trusses are shown in plates 17 and 18. The strains in the different members of these trusses are easily found by the use of the following tables. They may be built of iron, or of wood and iron combined. If iron only is used in the construction, the rafters are made of two channel-bars, with an iron cover-plate, or properly latticed together. This is the best mode of constructing the rafter. For smaller spans or lighter roofs a single I beam makes a good rafter. If the purlins are supported only at the joints, a T iron or two angle-irons make a satisfactory rafter; but if the purlins have to be carried on points between the joints of the truss, the bending strains produced are usually too large to be carried on a rafter of this cross section. The bottom end of the rafters usually has a shoe riveted on, or rests on a pin which is supported by a separate shoe. The top connection of the two main rafters is also either a riveted one (the two rafters being cut so as to bear one against the other), or the connection is made by having both rafters bearing against a pin. If the roof is pin-connected throughout, the latter connection at the peak (with the pin simply) is the better one, and the roof is more easily erected.

The tension members are either flat bars with forged eyes, bored for iron pins, or round or square rods with loop-welded eyes.

The struts are made in very many different ways. A good construction is to use two light channel-bars connected together to form a strut, which has a pin-hole at its lower end to connect with the bottom chord and the tension braces.

Sometimes these trusses are built with wooden main-rafters and struts. In this case, the ends of these members are usually fitted to cast-iron pin-boxes, and the tension members constructed in the same way as in all iron trusses.

LOADS ON ROOFS—SPANS 75 FEET AND LESS.

Roof covered with corrugated iron, unboarded	8 lbs. per □ ft.	
" " " " " on boards	11 "	"
" " " slate unboarded or on laths	13 "	"
" " " " on boards $1\frac{1}{4}''$ thick	16 "	"
" " " shingles on laths	10 "	"
If plastered below the rafters or tie-beam, add	10 "	"
For the weight of iron construction, add	4 "	"
For snow and wind, add	20 "	"

The velocity and pressure of wind against surfaces at right angles to the direction of the wind is, as given by Smeaton:

Vel. in miles per hour.	Vel. in feet. per sec.	Pressure per square foot.	
10	14.67	0.5	
12½	18.33	0.78	Fresh breeze.
15	22.	1.12	
20	29.33	2.	
25	36.67	3.12	Brisk wind.
30	44.	4.5	Strong wind.
40	58.67	8.	High wind.
50	73.33	12.5	Storm.
60	88.	18.	Violent storm.
80	117.3	32.	Hurricane.
100	146.7	50.	Violent hurricane.

It seems sufficient to calculate for a wind pressure of 30 lbs. per square foot; but, as the roofs are built with a slope, only that component of the 30 lbs. which acts vertical to the surface of the roof comes into account. In most cases it will be sufficient to calculate simply for a load of 20 lbs. per square foot for wind and snow together.

MAXIMUM STRAINS IN KING AND QUEEN ROOF TRUSSES.

Plate 17, Fig. 5.

To find the maximum strains in any member of these trusses, multiply the co-efficients given here below.

1. For rafters, by the panel load . . . . $\times \frac{\text{length of rafter}}{\text{depth of truss}}$
2. For bottom chord, " . . . . $\times \frac{\frac{1}{2}\text{ span of truss}}{\text{depth of truss}}$
3. For inclined struts, " . . . . $\times \frac{\text{length of strut}}{\text{length of rod}}$
4. For vertical rod, " . . . . $\times$ 1

Multiply by	Member.	14 Panel.	12 Panel.	10 Panel.	8 Panel.	6 Panel.	4 Panel.
Panel load $\times \frac{\frac{1}{2}\text{ span}}{\text{depth of truss}}$	0 2	6.5	5.5	4.5	3.5	2.5	1.5
	2 3	6.	5.	4.	3.	2.	
	3 4	5.5	4.5	3.5	2.5		
	4 5	5.	4.	3.			
	5 6	4.5	3.5				
	6 7	4.					
Panel load $\times \frac{\text{length of rafter}}{\text{depth of truss}}$	0 1′	6.5	5.5	4.5	3.5	2.5	1.5
	1′ 2′	6.	5.	4.	3.	2.	1.
	2′ 3′	5.5	4.5	3.5	2.5	1.5	
	3′ 4′	5.	4.	3.	2.		
	4′ 5′	4.5	3.5	2.5			
	5′ 6′	4.	3.				
	6′ 7′	3.5					
Panel load $\times \frac{\text{length of strut}}{\text{length of rod}}$	1′ 2	0.5	0.5	0.5	0.5	0.5	0.5
	2′ 3	1.0	1.0	1.0	1.0	1.0	
	3′ 4	1.5	1.5	1.5	1.5		
	4′ 5	2.0	2.0	2.0			
	5′ 6	2.5	2.5				
	6′ 7	3.0					
Panel load $\times$ 1	1 1′	0	0	0	0	0	0
	2 2′	0.5	0.5	0.5	0.5	0.5	1.
	3 3′	1.0	1.0	1.0	1.0	2.	
	4 4′	1.5	1.5	1.5	3.		
	5 5′	2.0	2.0	4.			
	6 6′	2.5	5.				
	7 7′	6.					

MAXIMUM STRAINS IN BELGIAN OR FINK ROOF TRUSSES.

Plate 18, Figs. 1 and 2.

To find the maximum strain in any member of these trusses, multiply the co-efficients given in the table below with the panel load.

Ratio of depth to length of span.			0.333 $\frac{1}{3}$	0.289 $\frac{1}{3.464}$	0.250 $\frac{1}{4}$	0.200 $\frac{1}{5}$	0.167 $\frac{1}{6}$	0.125 $\frac{1}{8}$
Inclinat'n of rafters.			41° 49′	30°	26° 34′	21° 48′	18° 26′	14° 2′
8-panel truss.	Bottom chord.	0 1	5.25	6.06	7.00	8.75	10.50	14.00
		1 2	4.50	5.19	6.00	7.50	9.00	12.00
		2 2	3.00	3.46	4.00	5.00	6.00	8.00
	Top chord.	0 1′	6.30	7.00	7.83	9.42	11.08	14.44
		1′2′	5.75	6.50	7.38	9.05	10.76	14.20
		2′3′	5.20	6.00	6.93	8.68	10.45	13.95
		3′4′	4.65	5.50	6.48	8.31	10.13	13.71
	Tension braces.	2 3	1.50	1.73	2.00	2.50	3.00	4.00
		3 4′	2.25	2.60	3.00	3.75	4.50	6.00
		12′ & 32′	0.75	0.87	1.00	1.25	1.50	2.00
	Struts.	11′ & 33′	0.83	0.87	0.89	0.93	0.95	0.97
		2 2′	1.66	1.73	1.78	1.86	1.90	1.94
4-panel truss.	Bottom chord.	0 1	2.25	2.60	3.00	3.75	4.50	6.00
		1 2	1.50	1.73	2.00	2.50	3.00	4.00
	Top chord.	0 1′	2.70	3.00	3.35	4.04	4.75	6.19
		1′2′	2.15	2.50	2.90	3.67	4.44	5.95
	Rod	1 2′	0.75	0.87	1.00	1.25	1.50	2.00
	strut.	1 1′	0.83	0.87	0.89	0.93	0.95	0.97

MAXIMUM STRAINS IN RECTANGULAR AND TRIANGULAR TRUSSES.

By using the following tables, it will be found easy to determine the maximum strains in different trusses or girders with parallel chords, if the dead and moving loads are given. In many cases it will be sufficient to consider only a uniform dead load and a uniform moving load. The third columns give the influence of a heavier load in front of a uniform load; f. i., a locomotive ahead of a train of cars.

The panel points are numbered, beginning with 0 at the abutment, those of the bottom chord with plain numbers, and those of the top chord with a prime ($'$), so as to indicate the position of the different members without its being necessary to refer to the diagram.

In the calculation of a double intersection rectangular truss, it is necessary to treat the truss as a combination of two single intersection trusses; and if the number of panels is an odd one, there exists some uncertainty in which way the full load is transmitted to the abutments. Sometimes it is assumed that the counter-rods are without strain under full load, and this gives somewhat smaller strains in the top chord and larger strains in the bottom chord than those given in the table.

But generally the counter-rods are made adjustable, and have always some initial strain, so that it is more consistent to assume that the trusses under full load, as well as under partial loads, act like two separate single intersection trusses. The difference in the results in either case is of no practical importance.

In calculating these tables, the loads were supposed to be concentrated at the bottom chord joints for through-bridges, and at the top-chord joints for deck-bridges. In through-bridges, the strains in the web-members under compression (web-posts) obtained this way should be increased by the weight of a panel of top-chord and top-lateral bracing.

EXAMPLE OF APPLICATION OF TABLE.

Warren Truss, Deck Bridge with Intermediate Posts.

Span, 150′; depth, 20′.

Number of panels 10, of 15′ each.

Dead load, 1,200 lbs. per lin. ft.

Live load, 2,400 " " "

D = Dead load = 9,000 lbs. per panel and 1 truss.

L = Live " = 18,000 " " " " 1 "

E = Excess of locomotive weight = 10,000 lbs. for 1 truss.

$$l = \frac{18,000}{10} = 1,800$$

$$e = \frac{10,000}{10} = 1,000$$

Length of diagonal members, 25′

$$\text{Sec.} = \frac{25}{20} = 1.25 \qquad \text{Tang.} = \frac{15}{20} = 0.75$$

Strain in middle piece of bottom chord 4 – 6

$$12.5\,(D + L) = 337,500$$
$$5\,e = 5,000$$
$$342,500 \times \text{tang.} = 256,875$$

Compressive strain in brace, 45′.

$$0.5\,D = 4,500$$
$$15.\ l = 27,000$$
$$5.\ e = 5,000$$
$$36,500 \times \text{sec.} = 45,625$$

Tensile strain in brace, 5′ 6,

$$-0.5\,D = -4,500$$
$$10.\ l = 18,000$$
$$4.\ e = 4,000$$
$$17,500 \times \text{sec.} = 21,875$$

It will be observed that, by beginning with o at the left-hand abutment, the compression member 45′ becomes the tension member 5′ 6, and the maximum strains change from 45,625 compression to 21,875 tension. The strains in the other members are found in similar way.

MAXIMUM STRAINS PRODUCED BY DEAD AND LIVE LOADS IN SINGLE INTERSECTION RECTANGULAR TRUSSES.

(Fig. 4, plate 17.) END-POSTS INCLINED, EQUAL PANELS, THROUGH AND DECK BRIDGES.

Member.			12 Panel Truss.			11 Panel Truss.			10 Panel Truss.			9 Panel Truss.			8 Panel Truss.			7 Panel Truss.			6 Panel Truss.			5 Panel Truss.			4 Panel Truss.		
Thro'gh Post.	Deck Post.	Diag.	D	l	e	D	l	e	D	l	e	D	l	e	D	l	e	D	l	e	D	l	e	D	l	e	D	l	e
		0 1′	5.5	66	11	5	55	10	4.5	45	9	4	36	8	3.5	28	7	3	21	6	2.5	15	5	2	10	4	1.5	6	3
	2 2′	2 1′	4.5	55	10	4	45	9	3.5	36	8	3	28	7	2.5	21	6	2	15	5	1.5	10	4	1	6	3	0.5	3	2
2 2′	3 3′	3 2′	3.5	45	9	3	36	8	2.5	28	7	2	21	6	1.5	15	5	1	10	4	0.5	6	3	0	3	2	-0.5	1	1
3 3′	4 4′	4 3′	2.5	36	8	2	28	7	1.5	21	6	1	15	5	0.5	10	4	0	6	3	-0.5	3	2	-1	1	1			
4 4′	5 5′	5 4′	1.5	28	7	1	21	6	0.5	15	5	0	10	4	-0.5	6	3	-1	3	2	-1.5	1	1						
5 5′	6 6′	6 5′	0.5	21	6	0	15	5	-0.5	10	4	-1	6	3	-1.5	3	2												
6 6′		7 6′	-0.5	15	5	-1	10	4	-1.5	6	3																		
		8 7′	-1.5	10	4	-2	6	3																					
		9 8′	-2.5	6	3																								
	Top.	Bott.	D	L	e	D	L	e	D	L	e	D	L	e	D	L	e	D	L	e	D	L	e	D	L	e	D	L	e
		0 2	5.5	5.5	11	5	5	10	4.5	4.5	9	4	4	8	3.5	3.5	7	3	3	6	2.5	2.5	5	2	2	4	1.5	1.5	3
	1′ 2′	2 3	10.	10.	10	9	9	9	8.	8.	8	7	7	7	6.	6.	6	5	5	5	4.	4.	4	3	3	3	2.	2.	2
	2′ 3′	3 4	13.5	13.5	9	12	12	8	10.5	10.5	7	9	9	6	7.5	7.5	5	6	6	4	4.5	4.5	3						
	3′ 4′	4 5	16.	16.	8	14	14	7	12.	12.	6	10	10	5	8.	8.	4												
	4′ 5′	5 6	17.5	17.5	7	15	15	6	12.5	12.5	5				C														
	5′ 6′		18.	18.	6																								

$l = \frac{L}{n}$

$e = \frac{E}{n}$

Diagonals: multiply by Sec.
Posts: multiply by 1.
Chords: multiply by Tang.

n = No. of panels.
D = Dead load per panel.
L = Live load per panel.
E = Excess of engine load over general live load on 1 panel.

$$\text{Sec.} = \frac{\text{Length of inclined member}}{\text{Depth of truss}} \qquad \text{Tang.} = \frac{\text{Length of panel}}{\text{Depth of truss}}$$

MAXIMUM STRAINS PRODUCED BY DEAD AND LIVE LOADS IN DOUBLE INTERSECTION RECTANGULAR TRUSSES.

(Fig. 4, Plate 18.)

WITH INCLINED END-POSTS, EQUAL PANELS, FOR THROUGH AND DECK BRIDGES.

Vertical Members.		Inclined Memb'rs.		18 Panels.			17 Panels.			16 Panels.			15 Panels.			14 Panels.			13 Panels.			12 Panels.			11 Panels.			10 Panels.		
Through.	Deck.			*d*	*l*	*e*	*d*	*l*	*e*	*d*	*l*	*e*	*d*	*l*	*e*	*d*	*l*	*e*	*d*	*l*	*e*	*d*	*l*	*e*	*d*	*l*	*e*	*d*	*l*	*e*
		0	1′	153	153	17	136	136	16	120	120	15	105	105	14	91	91	13	78	78	12	66	66	11	55	55	10	45	45	9
	2 2′	2	1′	72	72	16	63	64	15	56	56	14	48	49	13	42	42	12	35	36	11	30	30	10	24	25	9	20	20	8
	3 3′	3	1′	63	64	15	56	56	14	48	49	13	42	42	12	35	36	11	30	30	10	24	25	9	20	20	8	15	16	7
2 2′	4 4′	4	2′	54	56	14	46	49	13	40	42	12	33	36	11	28	30	10	22	25	9	18	20	8	13	16	7	10	12	6
3 3	5 5′	5	3′	45	49	13	39	42	12	32	36	11	27	30	10	21	25	9	17	20	8	12	16	7	9	12	6	5	9	5
4 4′	6 6′	6	4′	36	42	12	29	36	11	24	30	10	18	25	9	14	20	8	9	16	7	6	12	6	2	9	5	0	6	4
5 5′	7 7′	7	5′	27	36	11	22	30	10	16	25	9	12	20	8	7	16	7	4	12	6	0	9	5	–2	6	4	–5	4	3
6 6′	8 8′	8	6′	18	30	10	12	25	9	8	20	8	3	16	7	0	12	6	–4	9	5	–6	6	4	–9	4	3	–10	2	2
7 7′	9 9′	9	7′	9	25	9	5	20	8	0	16	7	–3	12	6	–7	9	5	–9	6	4	–12	4	3	–13	2	2			
8 8′		10	8′	0	20	8	–5	16	7	–8	12	6	–12	9	5	–14	6	4	–17	4	3									
9 9′		11	9′	–9	16	7	–12	12	6	–16	9	5	–18	6	4															
		12	10′	–18	12	6	–22	9	5	–24	6	4																		

n = Number of panels.
D = Dead load per panel.
L = Live load per panel.
E = Excess of engine load over general live load on first panel loaded.

Multiply for inclined members by Sec.
" " vertical " " one.

$d = \frac{D}{n}$ $l = \frac{L}{n}$ $e = \frac{E}{n}$

MAXIMUM STRAINS PRODUCED BY DEAD AND LIVE LOADS IN DOUBLE INTERSECTION RECTANGULAR TRUSSES—*Continued.*

Top Chord	Bottom Chord.	18 Panels.		17 Panels.		16 Panels.		15 Panels.		14 Panels.		13 Panels.		12 Panels.		11 Panels.		10 Panels.	
		D+L	*e*	*d* + *l*	*e*	D+L	*e*	*d* + *l*	*e*	D+L	*e*	*d*+*l*	*e*	D+L	*e*	*d*+*l*	*e*	D+L	*e*
	0 2	8.5	17	136	16	7.5	15	105	14	6.5	13	78	12	5.5	11	55	10	4.5	9
	2 3	12.5	16	199	15	11	14	153	13	9.5	12	113	11	8	10	79	9	6.5	8
1′ 2′	3 4	19.5	15	311	14	17.	13	237	12	14.5	11	173	10	12	9	119	8	9.5	7
2′ 3′	4 5	25.5	14	403	13	22	12	303	11	18.5	10	217	9	15	8	145	7	11.5	6
3′ 4′	5 6	30.5	13	481	12	26	11	357	10	21.5	9	251	8	17	7	163*	6	12.5	5
4′ 5′	6 7	34.5	12	539	11	29	10	393	9	23.5	8	269*	7	18	6	167	5		
5′ 6′	7 8	37.5	11	583	10	31	9	417*	8	24.5	7	277	6					4′ 5′=	3′ 4′
6′ 7′	8 9	39.5	10	607*	9	32	8	423	7					5 6′=	4′ 5′	*56=			
7′ 8′		40.5	9	617	8			*78	=	6′ 7′=	5′ 6′	*67=				159	6		
		8′ 9′=	7′ 8′	8′ 9′=	7′ 8′	7′ 8′=	6′ 7′	411	8			261	7						
				*89=															
				597	9														

$$\text{Sec.} = \frac{\text{Length of inclined member}}{\text{Depth of truss}}$$

Chords: multiply by Tang.

$$\text{Tang.} = \frac{\text{Length of panel}}{\text{Depth of truss}}$$

Maximum Strains Produced by Dead and Live Loads in Single Intersection Triangular or Warren Through Trusses.

(Fig 1, Plate 17.)

Multiply by Secans.

Members. Comp.		Tens.		20 Panels. D	l	e	18 Panels. D	l	e	16 Panels. D	l	e	14 Panels. D	l	e	12 Panels. D	l	e	10 Panels. D	l	e	8 Panels. D	i	e	6 Panels. D	l	e	4 Panels. D	l	e
0	1′	1′	2	4.5	90	18	4	72	16	3.5	56	14	3	42	12	2.5	30	10	2	20	8	1.5	12	6	1	6	4	0.5	2	2
2	3′	3′	4	3.5	72	16	3	56	14	2.5	42	12	2	30	10	1.5	20	8	1	12	6	0.5	6	4	0	2	2			
4	5′	5′	6	2.5	56	14	2	42	12	1.5	30	10	1	20	8	0.5	12	6	0	6	4	−0.5	2	2						
6	7	7′	8	1.5	42	12	1	30	10	0.5	20	8	0	12	6	−0.5	6	4	−1	2	2									
8	9′	9′	10	0.5	30	10	0	20	8	−0.5	12	6	−1	6	4	−1.5	2	2												
10	11′	11′	12	−0.5	20	8	−1	12	6	−1.5	6	4	−2	2	2															
12	13′	13′	14	−1.5	12	6	−2	6	4	−2.5	2	2																		
14	15′	15′	16	−2.5	6	4	−3	2	2																					

n = Number of panels.
D = Dead load per double panel.
L = Live load per double panel.
E = Excess of engine load over general live load.

$$\text{Sec.} = \frac{\text{Length of braces}}{\text{Depth of truss}}$$

Multiply by Tang.

Chords.		20 Panels. D+L	e	18 Panels. D+L	e	16 Panels. D+L	e	14 Panels. D+L	e	12 Panels. D+L	e	10 Panels. D+L	e	8 Panels. D+L	e	6 Panels. D+L	e	4 Panels. D+L	e
0	2	4.5	18	4	16	3.5	14	3	12	2.5	10	2	8	1.5	6	1	4	0.5	2
1′	3′	9	17	8	15	7	13	6	11	5.	9	4	7	3.	5	2	3	1.0	1
2	4	12.5	16	11	14	9.5	12	8	10	6.5	8	5	6	3.5	4	2	2		
3′	5′	16	15	14	13	12	11	10	9	8.	7	6	5	4.	3				
4	6	18.5	14	16	12	13.5	10	11	8	8.5	6	6	4						
5′	7′	21	13	18	11	15	9	12	7	9.	5								
6	8	22.5	12	19	10	15.5	8	12	6										
7′	9′	24	11	20	9	16	7												
8	10	24.5	10	20	8														
9′	11′	25	9																

$$\text{Tang.} = \frac{\text{Length of panel}}{\text{Depth of truss}} \qquad l = \frac{L}{n} \qquad e = \frac{E}{n}$$

MAXIMUM STRAINS PRODUCED BY DEAD AND LIVE LOADS IN SINGLE INTERSECTION TRIANGULAR OR WARREN DECK TRUSSES. (Fig. 1, Plate 17.)

	Members.				20 Panels.			18 Panels.			16 Panels.			14 Panels.			12 Panels.			10 Panels.			8 Panels.			6 Panels.			4 Panels.		
	Tens.		Compr.		D	*l*	*e*	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*
Multiply by Sec.			0	1′	5	100	19	4.5	81	17	4	64	15	3.5	49	13	3	36	11	2.5	25	9	2	16	7	1.5	9	5	1	4	3
	1′	2	2	3′	4	81	17	3.5	64	15	3	49	13	2.5	36	11	2	25	9	1.5	16	7	1	9	5	0.5	4	3	0	1	1
	3′	4	4	5′	3	64	15	2.5	49	13	2	36	11	1.5	25	9	1	16	7	0.5	9	5	0	4	3	-0.5	1	1			
	5′	6	6	7′	2	49	13	1.5	36	11	1	25	9	0.5	16	7	0	9	5	-0.5	4	3	-1	1	1						
	7′	8	8	9′	1	36	11	0.5	25	9	0	16	7	-0.5	9	5	-1	4	3	-1.5	1	1									
	9	10	10	11′	0	25	9	-0.5	16	7	-1	9	5	-1.5	4	3	-2	1	1												
	11′	12	12	13′	-1	16	7	-1.5	9	5	-2	4	3	-2.5	1	1															
	13	14	14	15′	-2	9	5	-2.5	4	3	-3	1	1																		
	15	16	16	17′	-3	4	3																								
	Chords.				D+L		*e*	D+L		*e*	D+L		*e*	D+L		*e*	D+L		*e*	D+L		*e*	D+L		*e*	D+L		*e*	D+L		*e*
Multiply by Tang.	0	2			5		19	4.5		17	4		15	3.5		13	3.		11	2.5		9	2.		7	1.5		5	1.		3
	1	3			9		18	8.		16	7		14	6.		12	5		10	4.5		8	3		6	2		4	1		2
	2	4			13		17	11.5		15	10.		13	8.5		11	7		9	5.5		7	4		5	2.5		3			
	3′	5′			16		16	14.		14	12		12	10.		10	8		8	6.		6	4		4						
	4	6			19		15	16.5		13	14		11	11.5		9	9		7	6.5		5									
	5′	7′			21		14	18.		12	15		10	12.		8	9		6												
	6	8			23		13	19.5		11	16		9	12.5		7															
	7′	9			24		12	20.		10	16		8																		
	8	10			25		11	20.5		9																					
	9′	11′			25		10																								

MAXIMUM STRAINS PRODUCED BY DEAD AND LIVE LOADS IN SINGLE INTERSECTION TRIANGULAR OR WARREN GIRDERS,

THROUGH OR DECK BRIDGES, WITH INTERMEDIATE SUSPENDERS OR POSTS (Figs. 2 and 3, Plate 17), WITH INCLINED END-POSTS AND EQUAL PANELS.

Members.		20 Panels.			18 Panels.			16 Panels.			14 Panels.			12 Panels.			10 Panels.			8 Panels.			6 Panels.			4 Panels.		
Compr.	Tens.	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*	D	*l*	*e*
0 1′		9.5	190	19	8.5	153	17	7.5	120	15	6.5	91	13	5.5	66	11	4.5	45	9	3.5	28	7	2.5	15	5	1.5	6	3
	1′ 2	8.5	171	18	7.5	136	16	6.5	105	14	5.5	78	12	4.5	55	10	3.5	36	8	2.5	21	6	1.5	10	4	0.5	3	2
2 3′		7.5	153	17	6.5	120	15	5.5	91	13	4.5	66	11	3.5	45	9	2.5	28	7	1.5	15	5	0.5	6	3	-0.5	1	1
	3′ 4	6.5	136	16	5.5	105	14	4.5	78	12	3.5	55	10	2.5	36	8	1.5	21	6	0.5	10	4	-0.5	3	2			
4 5′		5.5	120	15	4.5	91	13	3.5	66	11	2.5	45	9	1.5	28	7	0.5	15	5	-0.5	6	3	-1.5	1	1			
	5′ 6	4.5	105	14	3.5	78	12	2.5	55	10	1.5	36	8	0.5	21	6	-0.5	10	4	-1.5	3	2						
6 7′		3.5	91	13	2.5	66	11	1.5	45	9	0.5	28	7	-0.5	15	5	-1.5	6	3	-2.5	1	1						
	7′ 8	2.5	78	12	1.5	55	10	0.5	36	8	-0.5	21	6	-1.5	10	4	-2.5	3	2									
8 9′		1.5	66	11	0.5	45	9	-0.5	28	7	-1.5	15	5	-2.5	6	3	-3.5	1	1									
	9′ 10	0.5	55	10	-0.5	36	8	-1.5	21	6	-2.5	10	4	-3.5	3	2												
10 11′		-0.5	45	9	-1.5	28	7	-2.5	15	5	-3.5	6	3	-4.5	1	1												
	11′ 12	-1.5	36	8	-2.5	21	6	-3.5	10	4	-4.5	3	2															
12 13′		-2.5	28	7	-3.5	15	5	-4.5	6	3	-5.5	1	1															
	13′ 14	-3.5	21	6	-4.5	10	4	-5.5	3	2																		
14 15′		-4.5	15	5	-5.5	6	3	-6.5	1	1																		
	15′ 16	-5.5	10	4	-6.5	3	2																					
16 17′		-6.5	6	3	-7.5	1	1																					

Inclined Members, multiply by Sec.

SINGLE INTERSECTION TRIANGULAR OR WARREN GIRDERS— *Continued.*

Chords, multiply by Tang.

Memb's	20 Panels.		18 Panels		16 Panels.		14 Panels.		12 Panels.		10 Panels.		8 Panels.		6 Panels.		4 Panels.	
Chords.	D+L	e	D+L	e	D+L	e	D+L	e	D+L	e	D+L	e	D+L	e	D+L	e	D+L	e
0 2	9.5	19	8.5	17	7.5	15	6.5	13	5.5	11	4.5	9	3.5	7	2.5	5	1.5	3
1′ 3′	18.	18	16.	16	14.	14	12.	12	10.	10	8.	8	6.	6	4.	4	2.	2
2 4	25.5	17	22.5	15	19.5	13	16.5	11	13.5	9	10.5	7	7.5	5	4.5	3		
3′ 5′	32.	16	28.	14	24.	12	20.	10	16.	8	12.	6	8.	4				
4 6	37.5	15	32.5	13	27.5	11	22.5	9	17.5	7	12.5	5						
5′ 7′	42.	14	36.	12	30.	10	24.	8	18.	6								
6 8	45.5	13	38.5	11	31.5	9	24.5	7										
7′ 9′	48.	12	40.	10	32.	8												
8 10	49.5	11	40.5	9														
9′ 11′	50.	10																

n = No. of panels
D = Dead load per panel.
L = Live load per panel.
E = Excess of engine load over general live load, for 1 panel.

$$l = \frac{L}{n} \qquad e = \frac{E}{n}$$

$$\text{Sec.} = \frac{\text{Length of inclined member}}{\text{Depth of truss}}$$

$$\text{Tang.} = \frac{\text{Length of panel}}{\text{Depth of truss}}$$

MAXIMUM STRAINS PRODUCED BY DEAD AND LIVE LOADS IN DOUBLE INTERSECTION TRIANGULAR OR WARREN GIRDERS,

THROUGH OR DECK BRIDGES. (Fig. 3, Plate 18.)

Members. Deck. Compr.	Deck. Tens.	Through. Compr.	Through. Tens.	20 Panels. D	20 Panels. l	20 Panels. e	18 Panels. D	18 Panels. l	18 Panels. e	16 Panels. D	16 Panels. l	16 Panels. e	14 Panels. D	14 Panels. l	14 Panels. e	12 Panels. D	12 Panels. l	12 Panels. e	10 Panels. D	10 Panels. l	10 Panels. e	8 Panels. D	8 Panels. l	8 Panels. e	6 Panels. D	6 Panels. l	6 Panels. e	4 P'ls. D	4 P'ls. l	4 P'ls. e
1′ 0			0′ 1	5	100	19	4.5	81	17	4	64	15	3.5	49	13	3	36	11	2.5	25	9	2.	16	7	1.5	9	5	1	4	3
2′ 1	1 0′	0 1′	1′ 2	4.5	90	18	4	72	16	3.5	56	14	3	42	12	2.5	30	10	2	20	8	1.5	12	6	1	6	4	0.5	2	2
3′ 2	2 1′	1 2	2′ 3	4	81	17	3.5	64	15	3	49	13	2.5	36	11	2	25	9	1.5	16	7	1	9	5	0.5	4	3	0	1	1
4′ 3	3 2′	2 3′	3′ 4	3.5	72	16	3	56	14	2.5	42	12	2	30	10	1.5	20	8	1	12	6	0.5	6	4	0	2	2			
5′ 4	4 3′	3 4′	4′ 5	3	64	15	2.5	49	13	2	36	11	1.5	25	9	1	16	7	0.5	9	5	0	4	3	-0.5	1	1			
6′ 5	5 4′	4 5′	5′ 6	2.5	56	14	2	42	12	1.5	30	10	1	20	8	0.5	12	6	0	6	4	-0.5	2	2						
7′ 6	6 5′	5 6′	6′ 7	2	49	13	1.5	36	11	1	25	9	0.5	16	7	0	9	5	-0.5	4	3	-1	1	1						
8′ 7	7 6′	6 7′	7′ 8	1.5	42	12	1	30	10	0.5	20	8	0	12	6	-0.5	6	4	-1	2	2									
9′ 8	8 7′	7 8′	8′ 9	1	36	11	0.5	25	9	0	16	7	-0.5	9	5	-1	4	3	-1.5	1	1									
10′ 9	9 8′	8 9′	9′ 10	0.5	30	10	0	20	8	-0.5	12	6	-1	6	4	-1.5	2	2												
11′ 10	10 9′	9 10′	10′ 11	0	25	9	-0.5	16	7	-1	9	5	-1.5	4	3	-2	1	1												
12′ 11	11 10′	10 11′	11′ 12	-0.5	20	8	-1.0	12	6	-1.5	6	4	-2	2	2															
13′ 12	12 11′	11 12′	12′ 13	-1	16	7	-1.5	9	5	-2	4	3	-2.5	1	1															
14′ 13	13 12′	12 13′	13′ 14	-1.5	12	6	-2	6	4	-2.5	2	2																		
15′ 14	14 13′	13 14′	14′ 15	-2	9	5	-2.5	4	3	-3.5	1	1																		
16′ 15	15 14′	14 15′	15′ 16	-2.5	6	4	-3	2	2																					
17′ 16	16 15′	15 16′	16′ 17	-3	4	3	-3.5	1	1																					

For Inclined End-posts 1′ 1 = 0′ 1, multiplied by 1. The Strains in End-posts are:

Deck. Compr.	Deck. Tens.	Through. Compr.	Through. Tens.	20 Panels. D	20 Panels. l	20 Panels. e	18 Panels. D	18 Panels. l	18 Panels. e	16 Panels. D	16 Panels. l	16 Panels. e	14 Panels. D	14 Panels. l	14 Panels. e	12 Panels. D	12 Panels. l	12 Panels. e	10 Panels. D	10 Panels. l	10 Panels. e	8 Panels. D	8 Panels. l	8 Panels. e	6 Panels. D	6 Panels. l	6 Panels. e	4 P'ls. D	4 P'ls. l	4 P'ls. e
0 1′		0 1′		9.5	190	19	8.5	153	17	7.5	120	15	6.5	91	13	5.5	66	11	4.5	45	9	3.5	28	7	2.5	15	5	1.5	6	3

n = Number of panels.
D = Dead load per panel.
L = Live load per panel.
E = Excess of engine load over general live load for 1 panel.

$$l = \frac{L}{n} \qquad e = \frac{E}{n}$$

DOUBLE INTERSECTION WARREN GIRDERS — *Continued.*

Chords. Deck. Top.	Deck. Bottom.	Through. Top.	Through. Bottom.	20 Panels. D+L	e	18 Panels. D+L	e	16 Panels. D+L	e	14 Panels. D+L	e	12 Panels. D+L	e	10 Panels. D+L	e	8 Panels. D+L	e	6 Panels. D+L	e	4 Panels. D+L	e
0′ 1′			0 1	4.5	18	4	16	3.5	14	3	12	2.5	10	2	8	1.5	6	1	4	0.5	2
	0 1	0′ 1′		5	19	4.5	17	4	15	3.5	13	3	11	2.5	9	2	7	1.5	5	1	3
1′ 2′			1 2	13.5	18	12	16	10.5	14	9	12	7.5	10	6	8	4.5	6	3	4	1.5	2
	1 2	1′ 2′		14	19	12.5	17	11	15	9.5	13	8	11	6.5	9	5	7	3.5	5	2	3
2′ 3′			2 3	21.5	18	19	16	16.5	14	14	12	11.5	10	9	8	6.5	6	4	4		
	2 3	2′ 3′		22	17	19.5	15	17	13	14.5	11	12	9	9.5	7	7	5	4.5	3		
3′ 4′			3 4	28.5	16	25	14	21.5	12	18	10	14.5	8	11	6	7.5	4				
	3 4	3′ 4′		29	17	25.5	15	22	13	13.5	11	15	9	11.5	7	8	5				
4′ 5′			4 5	34.5	16	30	14	25.5	12	21	10	16.5	8	12	6						
	4 5	4′ 5′		35	15	30.5	13	26	11	21.5	9	17	7	12.5	5						
5′ 6′			5 6	39.5	14	34	12	28.5	10	23	8	17.5	6								
	5 6	5′ 6′		40	15	34.5	13	29	11	23.5	9	18	7								
6′ 7′			6 7	43.5	14	37.0	12	30.5	10	24	8										
	6 7	6′ 7′		44	13	37.5	11	31	9	24.5	7										
7′ 8′			7 8	46.5	12	39	10	31.5	8												
	7 8	7′ 8′		47	13	39.5	11	32	9												
8′ 9′			8 9	48.5	12	40	10														
	8 9	8′ 9′		49	11	40.5	9														
9′ 10′			9 10	49.5	10																
	9 10	9′ 10′		50	11																
For Inclined End-posts:																					
	0 1		0 1	9.5	19	8.5	17	7.5	15	6.5	13	5.5	11	4.5	9	3.5	7	2.5	5	1.5	3

Multiply diagonals by Sec.
" chords by Tang.
" vertical members by one.

$$\text{Sec.} = \frac{\text{Length of inclined member}}{\text{Depth of truss}} \qquad \text{Tang.} = \frac{\text{Length of panel}}{\text{Depth of truss}}$$

RIVETS AND PINS.

IN proportioning riveted work it is customary not to take into account the friction between the shapes or plates connected. The rivets have to resist the whole strain which has to be transmitted from one part to the other by their resistance against shearing. The bearing surfaces of the rivets and of the connected parts must be large enough to avoid damage by crushing. Therefore, it will be always necessary to calculate the rivet connections for shear as well as for bearing. The following tables give shearing and bearing values of rivets of different diameters for shearing strains of 6,000 lbs. and 7,500 lbs. per square inch section, and for bearing values of 12,000 lbs. and 15,000 lbs. per square inch. The smaller values should be used for moving loads, and the larger values may be used for steady loads.

Pins are subject to strains by shearing, bearing, and bending. The corresponding values for these three different strains are—

	SHEARING.	BEARING.	BENDING.
For R. R. bridges and iron pins	7,500	12,000	15,000
" " " " steel pins	11,250	18,000	22,500
For steady loads and highway bridges } iron pins	9,000	14,400	18,000

SHEARING AND BEARING VALUES AND MAXIMUM BENDING MOMENTS OF PINS.

Diameter of Pin. Inches.	Area of Pin. Sq. inches	Maximum Bending Moments.			Bearing Values for 1′ Thickness of Plate.			Shearing Values.		
		S = 15,000 lbs. per □ in.	S = 18,000 lbs. per □ in.	S = 22,500 lbs. per □ in.	At 12,000 lbs. per □ in.	At 14,400 lbs. per □ in.	At 18,000 lbs. per □ in.	At 7,500 lbs. per □ in.	At 9,000 lbs. per □ in.	At 11,250 lbs. per □ in.
$1\frac{7}{16}$	1.62	4,370	5,240	6,550	17,200	20,700	25,900	12,150	14,600	18,200
$1\frac{11}{16}$	2.24	7,070	8,480	10,610	20,200	24,300	30,400	16,800	20,200	25,200
$1\frac{15}{16}$	2.95	10,700	12,840	16,050	23,200	27,900	34,900	22,100	26,550	33,200
$2\frac{3}{16}$	3.76	15,400	18,480	23,110	26,200	31,500	39,400	28,200	33,800	42,300
$2\frac{7}{16}$	4.67	21,310	25,580	31,970	29,200	35,100	43,900	35,000	42,000	52,500
$2\frac{11}{16}$	5.67	28,570	34,280	42,850	32,200	38,700	48,400	42,500	51,000	63,800
$2\frac{15}{16}$	6.78	37,310	44,770	55,960	35,200	42,300	52,900	50,850	61,000	76,300
$3\frac{3}{16}$	7.98	47,670	57,200	71,500	38,200	45,900	57,400	59,850	71,800	89,800
$3\frac{7}{16}$	9.28	59,790	71,750	89,680	41,200	49,500	61,900	69,600	83,500	104,400
$3\frac{11}{16}$	10.68	73,810	88,570	110,710	44,200	53,100	66,400	80,100	96,100	120,150
$3\frac{15}{16}$	12.18	89,860	107,830	134,790	47,200	56,700	70,900	91,350	109,600	137,000
$4\frac{3}{8}$	15.03	123,300	147,960	185,000	52,500	63,000	78,750	112,700	135,300	169,100
$4\frac{7}{8}$	18.66	170,600	204,700	255,900	58,500	70,200	87,750	140,000	167,900	209,900
$5\frac{3}{8}$	22.69	228,700	274,400	343,000	64,500	77,400	96,750	170,150	204,200	255.200
$5\frac{7}{8}$	27.11	298,600	358,300	447,900	70,500	84,600	105,750	203,300	244,000	305,000

SHEARING AND BEARING VALUE OF RIVETS.

Diameter of Rivet.	Area of Rivet.	Single Shear at 6000 lbs. per □″	Bearing Value at 12,000 Lbs. per □″ for Different Thicknesses of Plate.										
			$\frac{1}{4}$″	$\frac{5}{16}$″	$\frac{3}{8}$″	$\frac{7}{16}$″	$\frac{1}{2}$″	$\frac{9}{16}$″	$\frac{5}{8}$″	$\frac{11}{16}$″	$\frac{3}{4}$″	$\frac{13}{16}$″	$\frac{7}{8}$″
$\frac{3}{8}$	.110	660	1120										
$\frac{7}{16}$	.150	900	1310	1640									
$\frac{1}{2}$	.196	1180	1500	1880	2250								
$\frac{9}{16}$	.249	1490	1690	2110	2530	2950							
$\frac{5}{8}$	.307	1840	1860	2320	2790	3250	3720						
$\frac{11}{16}$	.371	2230	2060	2570	3090	3600	4120						
$\frac{3}{4}$	.442	2650	2250	2810	3370	3940	4500	5060					
$\frac{13}{16}$	.519	3110	2440	3050	3660	4270	4870	5480	6090				
$\frac{7}{8}$	.601	3610	2630	3280	3940	4590	5250	5910	6560	7220			
$\frac{15}{16}$	.690	4140	2810	3520	4220	4920	5620	6330	7030	7730			
1	.785	4710	3000	3750	4500	5250	6000	6750	7500	8250	9000		
$1\frac{1}{16}$	.887	5320	3190	3980	4780	5580	6370	7170	7970	8770	9560	10360	

SHEARING AND BEARING VALUE OF RIVETS — *Continued.*

Diameter of Rivet.	Area of Rivet.	Single Shear at 7500 lbs. per □″	Bearing Value at 15,000 Lbs. per □″ for Different Thicknesses of Plate.										
			$\frac{1}{4}$″	$\frac{5}{16}$″	$\frac{3}{8}$″	$\frac{7}{16}$″	$\frac{1}{2}$″	$\frac{9}{16}$″	$\frac{5}{8}$″	$\frac{11}{16}$″	$\frac{3}{4}$″	$\frac{13}{16}$″	$\frac{7}{8}$″
$\frac{3}{8}$	.110	830	1410										
$\frac{7}{16}$	.150	1130	1640	2050									
$\frac{1}{2}$	.196	1470	1880	2340	2810								
$\frac{9}{16}$	.249	1860	2110	2640	3160	3690							
$\frac{5}{8}$	.307	2300	2340	2930	3520	4100							
$\frac{11}{16}$	.371	2780	2580	3220	3870	4510	5160						
$\frac{3}{4}$	.442	3310	2810	3520	4220	4920	5630	6330					
$\frac{13}{16}$	.519	3890	3050	3810	4570	5330	6090	6860	7620				
$\frac{7}{8}$	.601	4510	3280	4100	4920	5740	6560	7380	8200				
$\frac{15}{16}$	.690	5180	3520	4390	5270	6150	7030	7910	8790	9670			
1	.785	5890	3750	4690	5620	6560	7500	8440	9380	10310	11250		
$1\frac{1}{16}$	.887	6650	3980	4980	5980	6970	7970	8960	9960	10960	11950	12950	

IRON RIVETS.

Weight per 100.

Length Under Head.	DIAMETERS. $\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1
1	1.895	4.848	9.66	16.79	26.49	39.3	55.2
$\frac{1}{8}$	2.067	5.235	10.34	17.86	27.99	41.4	57.9
$\frac{1}{4}$	2.238	5.616	11.04	18.96	29.61	43.5	60.7
$\frac{3}{8}$	2.410	6.003	11.73	20.03	31.13	45.6	63.4
$\frac{1}{2}$	2.582	6.402	12.43	21.04	32.74	47.8	66.2
$\frac{5}{8}$	2.754	6.789	13.12	22.11	34.25	49.9	68.9
$\frac{3}{4}$	2.926	7.179	13.81	23.21	35.86	52.0	71.7
$\frac{7}{8}$	3.098	7.566	14.50	24.28	37.37	54.1	74.4
2	3.269	7.956	15.19	25.48	38.99	56.3	77.2
$\frac{1}{8}$	3.441	8.343	15.88	26.56	40.40	58.4	79.9
$\frac{1}{4}$	3.613	8.733	16.57	27.65	42.11	60.5	82.7
$\frac{3}{8}$	3.785	9.120	17.26	28.73	43.67	62.6	85.4
$\frac{1}{2}$	3.957	9.511	17.95	29.82	45.24	64.8	88.2
$\frac{5}{8}$	4.129	9.898	18.64	30.90	46.80	66.9	90.9
$\frac{3}{4}$	4.301	10.29	19.33	31.99	48.36	69.0	93.7
$\frac{7}{8}$	4.473	10.67	20.02	33.08	49.92	71.1	96.4
3	4.644	11.06	20.71	34.18	51.49	73.3	99.2
$\frac{1}{8}$	4.816	11.44	21.40	35.27	53.05	75.4	101.9
$\frac{1}{4}$	4.988	11.84	22.09	36.35	54.61	77.5	104.7
$\frac{3}{8}$	5.160	12.23	22.78	37.44	56.17	79.6	107.4
$\frac{1}{2}$	5.332	12.62	23.48	38.52	57.74	81.8	110.2
$\frac{5}{8}$	5.504	13.01	24.17	39.60	59.30	83.9	112.9
$\frac{3}{4}$	5.676	13.39	24.86	40.69	60.86	86.0	116.7
$\frac{7}{8}$	5.848	13.78	25.55	41.78	62.42	88.1	119.4
4	6.019	14.17	26.24	42.87	63.99	90.3	121.2
$\frac{1}{8}$	6.191	14.56	26.93	43.94	65.55	92.4	123.9
$\frac{1}{4}$	6.363	14.95	27.62	45.01	67.11	94.5	126.6
100 Heads.	.519	1.74	4.14	8.10	13.99	22.27	33.15

UPSET SCREW ENDS FOR ROUND AND SQUARE BARS.

STANDARD DIMENSIONS OF THE PASSAIC ROLLING MILL COMPANY.

Diameter of O Rods. Inches.	Diameter of □ Rods. Inches.	Diameter of Upset Rod. Inches.	Length of Sleeve Nut. Inches.	Smallest Diam. of Hexagon Part.	Number of Threads per Inch.	Weights of 1 Sleeve Nut. Lbs.	Weights of 2 O Ends 1 ft. long. Lbs.	Weights of 2 □ Ends 1 ft long. Lbs.
3/4	5/8	1	7	2 1/8	8	4	3.9	3.3
7/8	3/4	1 1/8	7 3/4	2 3/16	7	5	5.	4.9
1	7/8	1 3/8	9	2 7/16	6	6	7.1	7.
1 1/8	1	1 1/2	9	2 3/4	6	8	8.7	8.8
1 1/4	1 1/8	1 5/8	9	2 3/4	5 1/2	9	10.5	10.6
1 3/8	1 1/4	1 3/4	9	3	5	11	12 1/4	12.8
1 1/2	1 3/8	2	9 1/4	3 1/8	4 1/2	12	15.5	16.1
1 5/8	1 1/2	2 1/4	9 1/4	3 3/4	4 1/2	16 1/2	19.	19.7
1 3/4		2 1/4	9 1/4	3 3/4	4 1/2	16 1/2	20.3	
1 7/8	1 5/8	2 1/2	9 1/2	4	4	17 1/2	24.3	23.8
2	1 3/4	2 1/2	9 1/2	4	4	17 1/2	25.8	25.5
2 1/8	1 7/8	2 1/2	9 1/2	4	4	17 1/2	27.4	27.2
2 1/4	2	2 3/4	10 1/4	4 5/8	4		31.9	32.
2 1/2	2 1/4	3	10 1/4	5 1/4	3 1/2		38.8	39.4
		1 1/4	9	2 1/4	7	5 1/2		

AREAS AND WEIGHTS OF SQUARE AND ROUND WROUGHT-IRON BARS.

Thickness, Inches.	□		○		Thickness, Inches.	□		○	
	Area.	W'ght per ft.	Area.	W'ght per ft.		Area.	W'ght per ft.	Area.	W'ght per ft.
0					2	4.00	13.33	3.14	10.47
1/16	0.004	0.013	0.003	0.010	1/16	4.25	14.18	3.34	11.14
1/8	.016	.052	.012	.041	1/8	4.52	15.05	3.55	11.82
3/16	.035	.117	.028	.092	3/16	4.78	15.95	3.76	12.53
1/4	.062	.208	.049	.164	1/4	5.06	16.88	3.98	13.25
5/16	.098	.326	.077	.256	5/16	5.35	17.83	4.20	14.00
3/8	.141	.469	.110	.368	3/8	5.64	18.80	4.43	14.77
7/16	.191	.638	.150	.501	7/16	5.94	19.80	4.67	15.55
1/2	.250	.833	.196	.654	1/2	6.25	20.83	4.91	16.36
9/16	.316	1.06	.248	.828	9/16	6.57	21.89	5.16	17.19
5/8	.391	1.30	.307	1.02	5/8	6.89	22.97	5.41	18.04
11/16	.473	1.58	.371	1.24	11/16	7.22	24.08	5.67	18.91
3/4	.562	1.87	.442	1.47	3/4	7.56	25.21	5.94	19.80
13/16	.660	2.20	.518	1.73	13/16	7.91	26.37	6.21	20.71
7/8	.766	2.55	.601	2.00	7/8	8.27	27.55	6.49	21.64
15/16	.879	2.93	.690	2.30	15/16	8.63	28.76	6.78	22.59
1	1.00	3.33	.785	2.62	3	9.00	30.00	7.07	23.56
1/16	1.13	3.76	.887	2.95	1/16	9.38	31.26	7.37	24.55
1/8	1.27	4.22	.994	3.31	1/8	9.77	32.55	7.67	25.57
3/16	1.41	4.70	1.110	3.69	3/16	10.16	33.87	7.98	26.60
1/4	1.56	5.21	1.23	4.09	1/4	10.56	35.21	8.30	27.65
5/16	1.72	5.74	1.35	4.51	5/16	10.97	36.58	8.62	28.73
3/8	1.89	6.30	1.48	4.95	3/8	11.39	37.97	8.95	29.82
7/16	2.07	6.89	1.62	5.41	7/16	11.82	39.39	9.28	30.94
1/2	2.25	7.50	1.77	5.89	1/2	12.25	40.83	9.62	32.07
9/16	2.44	8.14	1.92	6.39	9/16	12.69	42.30	9.97	33.23
5/8	2.64	8.80	2.07	6.91	5/8	13.14	43.80	10.32	34.40
11/16	2.85	9.49	2.24	7.45	11/16	13.60	45.33	10.68	35.60
3/4	3.06	10.21	2.40	8.02	3/4	14.06	46.88	11.04	36.82
13/16	3.28	10.95	2.58	8.60	13/16	14.53	48.45	11.42	38.05
7/8	3.52	11.72	2.76	9.20	7/8	15.01	50.05	11.79	39.31
15/16	3.75	12.51	2.95	9.83	15/16	15.50	51.68	12.18	40.59

AREAS AND WEIGHTS OF SQUARE AND ROUND WROUGHT-IRON BARS.

(Continued.)

Thickness, Inches	□ Area.	□ W'ght per ft.	○ Area.	○ W'ght per ft.	Thickness, Inches	□ Area.	□ W'ght per ft.	○ Area.	○ W'ght per ft.
4	16.00	53.33	12.57	41.89	6	36.00	120.0	28.27	94.25
1/16	16.50	55.01	12.96	43.21	1/8	37.52	125.1	29.46	98.22
1/8	17.01	56.72	13.36	44.55	1/4	39.06	130.2	30.68	102.3
3/16	17.53	58.45	13.77	45.91	3/8	40.64	135.5	31.92	106.4
1/4	18.06	60.21	14.19	47.29	1/2	42.25	140.8	33.18	110.6
5/16	18.60	61.99	14.61	48.69	5/8	43.89	146.3	34.47	114.9
3/8	19.14	63.80	15.03	50.11	3/4	45.56	151.9	35.78	119.3
7/16	19.69	65.64	15.47	51.55	7/8	47.27	157.6	37.12	123.7
1/2	20.25	67.50	15.90	53.01	7	49.00	163.3	38.48	128.3
9/16	20.82	69.39	16.35	54.50	1/4	52.56	175.2	41.28	137.6
5/8	21.39	71.30	16.80	56.00	1/2	56.25	187.5	44.18	147.3
11/16	21.97	73.24	17.26	57.52	3/4	60.06	200.2	47.17	157.2
3/4	22.56	75.21	17.72	59.07	8	64.00	213.3	50.26	167.6
13/16	23.16	77.20	18.19	60.63	1/4	68.06	226.9	53.46	178.2
7/8	23.77	79.22	18.66	62.22	1/2	72.25	240.8	56.74	189.2
15/16	24.38	81.26	19.15	63.82	3/4	76.56	255.2	60.13	200.4
5	25.00	83.33	19.63	65.45	9	81.00	270.0	63.62	212.1
1/16	25.63	85.43	20.13	67.10	1/4	85.56	285.2	67.20	224.0
1/8	26.27	87.55	20.63	68.76	1/2	90.25	300.8	70.88	236.3
3/16	26.91	89.70	21.13	70.45	3/4	95.06	316.9	74.66	248.9
1/4	27.56	91.88	21.65	72.16	10	100.00	333.3	78.54	261.8
5/16	28.22	94.08	22.17	73.89	1/4	105.06	350.2	82.52	275.1
3/8	28.89	96.30	22.69	75.64	1/2	110.25	367.5	86.59	288.6
7/16	29.57	98.55	23.22	77.40	3/4	115.56	385.2	90.76	302.5
1/2	30.25	100.8	23.76	79.19	11	121.00	403.3	95.03	316.8
9/16	30.94	103.1	24.30	81.00	1/4	126.56	421.9	99.40	331.3
5/8	31.64	105.5	24.85	82.83	1/2	132.25	440.8	103.87	346.2
11/16	32.35	107.8	25.41	84.69	3/4	138.06	460.2	108.43	361.4
3/4	33.06	110.2	25.97	86.56	12	144.0	480.0	113.1	377.0
13/16	33.78	112.6	26.53	88.45					
7/8	34.52	115.1	27.11	90.36					
15/16	35.25	117.5	27.69	92.29					

AREAS OF FLAT ROLLED IRON.

Thickness in Inches.	1″	1¼″	1½″	1¾″	2″	2¼″	2½″	2¾″	3″
1/16	.063	.078	.094	.109	.125	.141	.156	.172	.188
1/8	.125	.156	.188	.219	.250	.281	.313	.344	.375
3/16	.188	.234	.281	.328	.375	.422	.469	.516	.563
1/4	.250	.313	.375	.438	.500	.563	.625	.688	.750
5/16	.313	.391	.469	.547	.625	.703	.781	.859	.938
3/8	.375	.469	.563	.656	.750	.844	.938	1.03	1.13
7/16	.438	.547	.656	.766	.875	.984	1.09	1.20	1.31
1/2	.500	.625	.750	.875	1.00	1.13	1.25	1.38	1.50
9/16	.563	.703	.844	.984	1.13	1.27	1.41	1.55	1.69
5/8	.625	.781	.938	1.09	1.25	1.41	1.56	1.72	1.88
11/16	.688	.859	1.03	1.20	1.38	1.55	1.72	1.89	2.06
3/4	.750	.938	1.13	1.31	1.50	1.69	1.88	2.06	2.25
13/16	.813	1.02	1.22	1.42	1.63	1.83	2.03	2.23	2.44
7/8	.875	1.09	1.31	1.53	1.75	1.97	2.19	2.41	2.63
15/16	.938	1.17	1.41	1.64	1.88	2.11	2.34	2.58	2.81
1	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
1 1/16	1.06	1.33	1.59	1.86	2.13	2.39	2.66	2.92	3.19
1 1/8	1.13	1.41	1.69	1.97	2.25	2.53	2.81	3.09	3.38
1 3/16	1.19	1.48	1.78	2.08	2.38	2.67	2.97	3.27	3.56
1 1/4	1.25	1.56	1.88	2.19	2.50	2.81	3.13	3.44	3.75
1 5/16	1.31	1.64	1.97	2.30	2.63	2.95	3.28	3.61	3.94
1 3/8	1.38	1.72	2.06	2.41	2.75	3.09	3.44	3.78	4.13
1 7/16	1.44	1.80	2.16	2.52	2.88	3.25	3.59	3.95	4.31
1 1/2	1.50	1.88	2.25	2.63	3.00	3.38	3.75	4.13	4.50
1 9/16	1.56	1.95	2.34	2.73	3.13	3.52	3.91	4.30	4.69
1 5/8	1.63	2.03	2.44	2.84	3.25	3.66	4.06	4.47	4.88
1 11/16	1.69	2.11	2.53	2.95	3.38	3.80	4.22	4.64	5.06
1 3/4	1.75	2.19	2.63	3.06	3.50	3.94	4.38	4.81	5.25
1 13/16	1.81	2.27	2.72	3.17	3.63	4.08	4.53	4.98	5.44
1 7/8	1.88	2.34	2.81	3.28	3.75	4.22	4.69	5.16	5.63
1 15/16	1.94	2.42	2.91	3.39	3.88	4.36	4.84	5.33	5.81
2	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00

AREAS OF FLAT ROLLED IRON.

(Continued.)

Thickness in Inches.	3½″	4″	4½″	5″	6″	7″	8″	9″	10″
1/16	.219	.250	.281	.313	.375	.438	.500	.563	.625
1/8	.438	.500	.563	.625	.750	.875	1.00	1.13	1.25
3/16	.656	.750	.844	.938	1.13	1.31	1.50	1.69	1.88
1/4	.875	1.00	1.13	1.25	1.50	1.75	2.00	2.25	2.50
5/16	1.09	1.25	1.41	1.56	1.88	2.19	2.50	2.81	3.13
3/8	1.31	1.50	1.69	1.88	2.25	2.63	3.00	3.38	3.75
7/16	1.53	1.75	1.97	2.19	2.63	3.06	3.50	3.94	4.38
1/2	1.75	2.00	2.25	2.50	3.00	3.50	4.00	4.50	5.00
9/16	1.97	2.25	2.53	2.81	3.38	3.94	4.50	5.06	5.63
5/8	2.19	2.50	2.81	3.13	3.75	4.38	5.00	5.63	6.25
11/16	2.41	2.75	3.09	3.44	4.13	4.81	5.50	6.19	6.88
3/4	2.63	3.00	3.38	3.75	4.50	5.25	6.00	6.75	7.50
13/16	2.84	3.25	3.66	4.06	4.88	5.69	6.50	7.31	8.13
7/8	3.06	3.50	3.94	4.38	5.25	6.13	7.00	7.88	8.75
15/16	3.28	3.75	4.22	4.69	5.63	6.56	7.50	8.44	9.38
1	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00	10.00
1 1/16	3.72	4.25	4.78	5.31	6.38	7.44	8.50	9.56	10.63
1 1/8	3.94	4.50	5.06	5.63	6.75	7.88	9.00	10.13	11.25
1 3/16	4.16	4.75	5.34	5.94	7.13	8.31	9.50	10.69	11.88
1 1/4	4.38	5.00	5.63	6.25	7.50	8.75	10.00	11.25	12.50
1 5/16	4.59	5.25	5.91	6.56	7.88	9.19	10.50	11.81	13.13
1 3/8	4.81	5.50	6.19	6.88	8.25	9.63	11.00	12.38	13.75
1 7/16	5.03	5.75	6.47	7.19	8.63	10.06	11.50	12.94	14.38
1 1/2	5.25	6.00	6.75	7.50	9.00	10.50	12.00	13.50	15.00
1 9/16	5.47	6.25	7.03	7.81	9.38	10.94	12.50	14.06	15.63
1 5/8	5.69	6.50	7.31	8.13	9.75	11.38	13.00	14.63	16.25
1 11/16	5.91	6.75	7.59	8.44	10.13	11.81	13.50	15.19	16.88
1 3/4	6.13	7.00	7.88	8.75	10.50	12.25	14.00	15.75	17.50
1 13/16	6.34	7.25	8.16	9.06	10.88	12.69	14.50	16.31	18.13
1 7/8	6.56	7.50	8.44	9.38	11.25	13.13	15.00	16.88	18.75
1 15/16	6.78	7.75	8.72	9.69	11.63	13.56	15.50	17.44	19.38
2	7.00	8.00	9.00	10.00	12.00	14.00	16.00	18.00	20.00

WEIGHTS OF FLAT ROLLED IRON, PER LINEAL FOOT.

Iron Weighing 480 Lbs. per Cubic Foot.

Thickness in Inches.	1″	1 1/4″	1 1/2″	1 3/4″	2″	2 1/4″	2 1/2″	2 3/4″	3″
1/16	.208	.260	.31	.36	.42	.47	.52	.57	0.62
1/8	.417	.521	.62	.73	.83	.94	1.04	1.15	1.25
3/16	.625	.781	.94	1.09	1.25	1.41	1.56	1.72	1.88
1/4	.833	1.04	1.25	1.46	1.67	1.88	2.08	2.29	2.50
5/16	1.04	1.30	1.56	1.82	2.08	2.34	2.60	2.86	3.13
3/8	1.25	1.56	1.88	2.19	2.50	2.81	3.13	3.44	3.75
7/16	1.46	1.82	2.19	2.55	2.92	3.28	3.65	4.01	4.38
1/2	1.67	2.08	2.50	2.92	3.33	3.75	4.17	4.58	5.00
9/16	1.88	2.34	2.81	3.28	3.75	4.22	4.69	5.16	5.63
5/8	2.08	2.60	3.13	3.65	4.17	4.69	5.21	5.73	6.25
11/16	2.29	2.86	3.44	4.01	4.58	5.16	5.73	6.30	6.88
3/4	2.50	3.13	3.75	4.38	5.00	5.63	6.25	6.88	7.50
13/16	2.71	3.39	4.06	4.74	5.42	6.09	6.77	7.45	8.13
7/8	2.92	3.65	4.38	5.10	5.83	6.56	7.29	8.02	8.75
15/16	3.13	3.91	4.69	5.47	6.25	7.03	7.81	8.59	9.38
1	3.33	4.17	5.00	5.83	6.67	7.50	8.33	9.17	10.00
1 1/16	3.54	4.43	5.31	6.20	7.08	7.97	8.85	9.74	10.63
1 1/8	3.75	4.69	5.63	6.56	7.50	8.44	9.38	10.31	11.25
1 3/16	3.96	4.95	5.94	6.93	7.92	8.91	9.90	10.89	11.88
1 1/4	4.17	5.21	6.25	7.29	8.33	9.38	10.42	11.46	12.50
1 5/16	4.37	5.47	6.56	7.66	8.75	9.84	10.94	12.03	13.13
1 3/8	4.58	5.73	6.88	8.02	9.17	10.31	11.46	12.60	13.75
1 7/16	4.79	5.99	7.19	8.39	9.58	10.78	11.98	13.18	14.38
1 1/2	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00
1 9/16	5.21	6.51	7.81	9.11	10.42	11.72	13.02	14.32	15.63
1 5/8	5.42	6.77	8.13	9.48	10.83	12.19	13.54	14.90	16.25
1 11/16	5.63	7.03	8.44	9.84	11.25	12.66	14.06	15.47	16.88
1 3/4	5.83	7.29	8.75	10.21	11.67	13.13	14.58	16.04	17.50
1 13/16	6.04	7.55	9.06	10.57	12.08	13.59	15.10	16.61	18.13
1 7/8	6.25	7.81	9.38	10.94	12.50	14.06	15.63	17.19	18.75
1 15/16	6.46	8.07	9.69	11.30	12.92	14.53	16.15	17.76	19.38
2	6.67	8.33	10.00	11.67	13.33	15.00	16.67	18.33	20.00

WEIGHTS OF FLAT ROLLED IRON, PER LINEAL FOOT.

Iron Weighing 480 Lbs. per Cubic Foot.

Thickness in Inches.	3½″	4″	4½″	5″	6″	7″	8″	9″	10″
1/16	0.73	0.83	0.94	1.04	1.25	1.46	1.67	1.88	2.08
1/8	1.46	1.67	1.88	2.08	2.50	2.92	3.33	3.75	4.17
3/16	2.19	2.50	2.81	3.13	3.75	4.38	5.00	5.63	6.25
1/4	2.92	3.33	3.75	4.17	5.00	5.83	6.67	7.50	8.33
5/16	3.65	4.17	4.69	5.21	6.25	7.29	8.33	9.38	10.42
3/8	4.38	5.00	5.63	6.25	7.50	8.75	10.00	11.25	12.50
7/16	5.10	5.83	6.56	7.29	8.75	10.21	11.67	13.13	14.58
1/2	5.83	6.67	7.50	8.33	10.00	11.67	13.33	15.00	16.67
9/16	6.56	7.50	8.44	9.38	11.25	13.13	15.00	16.88	18.75
5/8	7.29	8.33	9.38	10.42	12.50	14.58	16.67	18.75	20.83
11/16	8.02	9.17	10.31	11.46	13.75	16.04	18.33	20.63	22.92
3/4	8.75	10.00	11.25	12.50	15.00	17.50	20.00	22.50	25.00
13/16	9.48	10.83	12.19	13.54	16.25	18.96	21.67	24.38	27.08
7/8	10.21	11.67	13.13	14.58	17.50	20.42	23.33	26.25	29.17
15/16	10.94	12.50	14.06	15.63	18.75	21.88	25.00	28.13	31.25
1	11.67	13.33	15.00	16.67	20.00	23.33	26.67	30.00	33.33
1 1/16	12.40	14.17	15.94	17.71	21.25	24.79	28.33	31.88	35.42
1 1/8	13.13	15.00	16.88	18.75	22.50	26.25	30.00	33.75	37.50
1 3/16	13.85	15.83	17.81	19.79	23.75	27.71	31.67	35.63	39.58
1 1/4	14.58	16.67	18.75	20.83	25.00	29.17	33.33	37.50	41.67
1 5/16	15.31	17.50	19.69	21.88	26.25	30.62	35.00	39.38	43.75
1 3/8	16.04	18.33	20.63	22.92	27.50	32.08	36.67	41.25	45.83
1 7/16	16.77	19.17	21.56	23.96	28.75	33.54	38.33	43.13	47.92
1 1/2	17.50	20.00	22.50	25.00	30.00	35.00	40.00	45.00	50.00
1 9/16	18.23	20.83	23.44	26.04	31.25	36.46	41.67	46.88	52.08
1 5/8	18.96	21.67	24.38	27.08	32.50	37.92	43.33	48.75	54.17
1 11/16	19.69	22.50	25.31	28.13	33.75	39.38	45.00	50.63	56.25
1 3/4	20.42	23.33	26.25	29.17	35.00	40.83	46.67	52.50	58.33
1 13/16	21.15	24.17	27.19	30.21	36.25	42.29	48.33	54.38	60.42
1 7/8	21.88	25.00	28.13	31.25	37.50	43.75	50.00	56.25	62.50
1 15/16	22.60	25.83	29.06	32.29	38.75	45.21	51.67	58.13	64.58
2	23.33	26.67	30.00	33.33	40.00	46.67	53.33	60.00	66.67

WEIGHTS OF PLATE IRON, PER LINEAL FOOT.

Thickness in Inches.	12″	13″	14″	15″	16″	17″	18″	19″	20″	21″	22″	23″	24″	25″	26″	27″	28″
1/16	2.50	2.71	2.92	3.13	3.33	3.54	3.75	3.96	4.17	4.38	4.58	4.79	5.00	5.21	5.42	5.63	5.83
1/8	5.00	5.42	5.83	6.25	6.67	7.08	7.50	7.92	8.33	8.75	9.17	9.58	10.00	10.42	10.83	11.25	11.67
3/16	7.50	8.13	8.75	9.38	10.00	10.63	11.25	11.87	12.50	13.13	13.75	14.38	15.00	15.62	16.25	16.88	17.50
1/4	10.00	10.83	11.67	12.50	13.33	14.17	15.00	15.83	16.67	17.50	18.33	19.17	20.00	20.83	21.67	22.50	23.33
5/16	12.50	13.54	14.58	15.63	16.67	17.71	18.75	19.79	20.83	21.88	22.92	23.96	25.00	26.04	27.08	28.13	29.17
3/8	15.00	16.25	17.50	18.75	20.00	21.25	22.50	23.75	25.00	26.25	27.50	28.75	30.00	31.25	32.50	33.75	35.00
7/16	17.50	18.96	20.42	21.88	23.33	24.79	26.25	27.71	29.17	30.63	32.08	33.54	35.00	36.46	37.92	39.38	40.83
1/2	20.00	21.67	23.33	25.00	26.67	28.34	30.00	31.66	33.33	35.00	36.67	38.34	40.00	41.66	43.33	45.00	46.67
9/16	22.50	24.38	26.25	28.13	30.00	31.88	33.75	35.67	37.50	39.38	41.25	43.13	45.00	46.87	48.75	50.63	52.50
5/8	25.00	27.08	29.17	31.25	33.33	35.42	37.50	39.58	41.67	43.75	45.83	47.92	50.00	52.08	54.17	56.25	58.33
11/16	27.50	29.79	32.08	34.38	36.67	38.96	41.25	43.54	45.83	48.13	50.42	52.71	55.00	57.29	59.58	61.88	64.17
3/4	30.00	32.50	35.00	37.50	40.00	42.50	45.00	47.50	50.00	52.50	55.00	57.50	60.00	62.50	65.00	67.50	70.00
13/16	32.50	35.21	37.92	40.63	43.33	46.05	48.75	51.45	54.17	56.88	59.58	62.30	65.00	67.70	70.42	73.13	75.84
7/8	35.00	37.92	40.83	43.75	46.67	49.60	52.50	55.41	58.33	61.25	64.17	67.09	70.00	72.91	75.83	78.75	81.66
15/16	37.50	40.63	43.75	46.88	50.00	53.13	56.25	59.37	62.50	65.63	68.75	71.88	75.00	78.12	81.25	84.38	87.50
1	40.00	43.33	46.67	50.00	53.33	56.67	60.00	63.33	66.67	70.00	73.33	76.67	80.00	83.33	86.67	90.00	93.33

WEIGHTS OF PLATE IRON, PER LINEAL FOOT—*Continued.*

Thickness in Inches.	29″	30″	32″	34″	36″	38″	40″	42″	44″	46″	48″	50″	52″	54″	56″	58″	60″
1/16	6.04	6.25	6 67	7.08	7.50	7.92	8.33	8.75	9.17	9.58	10.00	10.42	10.83	11.25	11.67	12.08	12.50
1/8	12.08	12.50	13.33	14.17	15.00	15.83	16.67	17.50	18.33	19.17	20.00	20.83	21.67	22.50	23.33	24.17	25.00
3/16	18.13	18.75	20.00	21.25	22.50	23.75	25.00	26.25	27.50	28.75	30.00	31.25	32.50	33.75	35.00	36.25	37.50
1/4	24.17	25.00	26.67	28.33	30.00	31.67	33.33	35.00	36.67	38.33	40.00	41.66	43.33	45.00	46.66	48.33	50.00
5/16	30.21	31.25	33.33	35.42	37.50	39.59	41.67	43.75	45.84	47.92	50.00	52.08	54 17	56.25	58.33	60.42	62.50
3/8	36.25	37.50	40.00	42.50	45.00	47.50	50.00	52.50	55.02	57.50	60.00	62.50	65.00	67.50	70.00	72.50	75.00
7/16	42.29	43.75	46.67	49.58	52.50	55.42	58.33	61.25	64.17	67.08	70.00	72.91	75.83	78.75	81.66	84.58	87.50
1/2	48.34	50.00	53.33	56.66	60.00	63.34	66.66	70.00	73.34	76 66	80.00	83.33	86.66	90.00	93.33	96.66	100.0
9/16	54.38	56.25	60.00	63.75	67.50	71.25	75.00	78.75	82.50	86.25	90.00	93.74	97.50	101.25	105.0	108.7	112.5
5/8	60.42	62.50	66.67	70.83	75.00	79.17	83.33	87.50	91.67	95.83	100.0	104.2	108.3	112.50	116.7	120.8	125.0
11/16	66 46	68.75	73.33	77.91	82.50	87.09	91.66	96.25	100.8	105.4	110.0	114.6	119.2	123.75	128.3	132.9	137.5
3/4	72.50	75.00	80.00	85.00	90.00	95.00	100.00	105.0	110.0	115.0	120.0	125.0	130.0	135.00	140.0	145.0	150.0
13/16	78.55	81.25	86.67	92.08	97.50	102.9	108.3	113.7	119.2	124.6	130.0	135.4	140.8	146.25	151.7	157.1	162.5
7/8	84.59	87.50	93.33	99.16	105.00	110.8	116.7	122.5	128.3	134.2	140.0	145.8	151.7	157.50	163.3	169.2	175.0
15/16	90.63	93.75	100.0	106.2	112.50	118.8	125.0	131.2	137.5	143.7	150.0	156.2	162.5	168.75	175.0	181.2	187.5
1	96.67	100.0	106.7	113.3	120.00	126.7	133.3	140.0	146.7	153.3	160.0	166.7	173.3	180.00	186.7	193.3	200.0

WEIGHT PER SQUARE FOOT OF SHEETS OF WROUGHT IRON, STEEL, COPPER, AND BRASS.

THICKNESS BY BIRMINGHAM GAUGE.

No. of Gauge.	Thickness in Inches.	Iron.	Steel.	Copper.	Brass.
0000	.454	18.22	18.46	20.57	19.43
000	.425	17.05	17.28	19.25	18.19
00	.38	15.25	15.45	17.21	16.26
0	.34	13.64	13.82	15.40	14.55
1	.3	12.04	12.20	13.59	12.84
2	.284	11.40	11.55	12.87	12.16
3	.259	10.39	10.53	11.73	11.09
4	.238	9.55	9.68	10.78	10.19
5	.22	8.83	8.95	9.97	9.42
6	.203	8.15	8.25	9.20	8.69
7	.18	7.22	7.32	8.15	7.70
8	.165	6.62	6.71	7.47	7.06
9	.148	5.94	6.02	6.70	6.33
10	.134	5.38	5.45	6.07	5.74
11	.12	4.82	4.88	5.44	5.14
12	.109	4.37	4.43	4.94	4.67
13	.095	3.81	3.86	4.30	4.07
14	.083	3.33	3.37	3.76	3.55
15	.072	2.89	2.93	3.26	3.08
16	.065	2.61	2.64	2.94	2.78
17	.058	2.33	2.36	2.63	2.48
18	.049	1.97	1.99	2.22	2.10
19	.042	1.69	1.71	1.90	1.80
20	.035	1.40	1.42	1.59	1.50
21	.032	1.28	1.30	1.45	1.37
22	.028	1.12	1.14	1.27	1.20
23	.025	1.00	1.02	1.13	1.07
24	.022	.883	.895	1.00	.942
25	.02	.803	.813	.906	.856
26	.018	.722	.732	.815	.770
27	.016	.642	.651	.725	.685
28	.014	.562	.569	.634	.599
29	.013	.522	.529	.589	.556
30	.012	.482	.488	.544	.514
31	.01	.401	.407	.453	.428
32	.009	.361	.366	.408	.385
33	.008	.321	.325	.362	.342
34	.007	.281	.285	.317	.300
35	.005	.201	.203	.227	.214
Specific Gravity..		7.704	7.806	8.698	8.218
Weight Cubic ft..		481.25	487.75	543.6	513.6
Weight Cubic in..		.2787	.2823	.3146	.2972

WEIGHT PER SQUARE FOOT OF SHEETS OF WROUGHT IRON, STEEL, COPPER, AND BRASS.

THICKNESS BY AMERICAN GAUGE.

No. of Gauge.	Thickness in Inches.	Iron.	Steel.	Copper.	Brass.
0000	.46	18.46	18.70	20.84	19.69
000	.4096	16.44	16.66	18.56	17.53
00	.3648	14.64	14.83	16.53	15.61
0	.3249	13.04	13.21	14.72	13.90
1	.2893	11.61	11.76	13.11	12.38
2	.2576	10.34	10.48	11.67	11.03
3	.2294	9.21	9.33	10.39	9.82
4	.2043	8.20	8.31	9.26	8.74
5	.1819	7.30	7.40	8.24	7.79
6	.1620	6.50	6.59	7.34	6.93
7	.1443	5.79	5.87	6.54	6.18
8	.1285	5.16	5.22	5.82	5.50
9	.1144	4.59	4.65	5.18	4.90
10	.1019	4.09	4.14	4.62	4.36
11	.0907	3.64	3.69	4.11	3.88
12	.0808	3.24	3.29	3.66	3.46
13	.0720	2.89	2.93	3.26	3.08
14	.0641	2.57	2.61	2.90	2.74
15	.0571	2.29	2.32	2.59	2.44
16	.0508	2.04	2.07	2.30	2.18
17	.0453	1.82	1.84	2.05	1.94
18	.0403	1.62	1.64	1.83	1.73
19	.0359	1.44	1.46	1.63	1.54
20	.0320	1.28	1.30	1.45	1.37
21	.0285	1.14	1.16	1.29	1.22
22	.0253	1.02	1.03	1.15	1.08
23	.0226	.906	.918	1.02	.966
24	.0201	.807	.817	.911	.860
25	.0179	.718	.728	.811	.766
26	.0159	.640	.648	.722	.682
27	.0142	.570	.577	.643	.608
28	.0126	.507	.514	.573	.541
29	.0113	.452	.458	.510	.482
30	.0100	.402	.408	.454	.429
31	.0089	.358	.363	.404	.382
32	.0080	.319	.323	.360	.340
33	.0071	.284	.288	.321	.303
34	.0063	.253	.256	.286	.270
35	.0056	.225	.228	.254	.240

As there are many gauges in use differing from each other, and even the thicknesses of a certain specified gauge, as the Birmingham, are not assumed the same by all manufacturers, orders for sheets and wire should always state the weight per □ foot or the thickness in thousandths of an inch.

DIFFERENT STANDARDS FOR WIRE GAUGE IN USE IN THE U. S.

DIMENSIONS IN DECIMAL PARTS OF AN INCH.

Number of Wire Gauge.	American, or Brown & Sharpe.	Birmingham, or Stubs'.	Washburn & Moen Mnfg. Co., Worcester, Mass.	Trenton Iron Co., Trenton, N. J.	G. W. Prentiss, Holyoke, Mass.	Old English, from Brass Mfrs. List.
000000			.46			
00000			.43	.45		
0000	.46	.454	.393	.4		
000	.40964	.425	.362	.36	.3586	
00	.3648	.38	.331	.33	.3282	
0	.32495	.34	.307	.305	.2994	
1	.2893	.3	.283	.285	.2777	
2	.25763	.284	.263	.265	.2591	
3	.22942	.259	.244	.245	.2401	
4	.20431	.238	.225	.225	.223	
5	.18194	.22	.207	.205	.2047	
6	.16202	.203	.192	.19	.1885	
7	.14428	.18	.177	.175	.1758	
8	.12849	.165	.162	.16	.1605	
9	.11443	.148	.148	.145	.1471	
10	.10189	.134	.135	.13	.1351	
11	.090742	.12	.12	.1175	.1205	
12	.080808	.109	.105	.105	.1065	
13	.071961	.095	.092	.0925	.0928	
14	.064084	.083	.08	.08	.0816	.083
15	.057068	.072	.072	.07	.0726	.072
16	.05082	.065	.063	.061	.0627	.065
17	.045257	.058	.054	.0525	.0546	.058
18	.040303	.049	.047	.045	.0478	.049
19	.03539	.042	.041	.039	.0411	.04
20	.031961	.035	.035	.034	.0351	.035
21	.028462	.032	.032	.03	.0321	.0315
22	.025347	.028	.028	.027	.029	.0295
23	.022571	.025	.025	.024	.0261	.027
24	.0201	.022	.023	.0215	.0231	.025
25	.0179	.02	.02	.019	.0212	.023
26	.01594	.018	.018	.018	.0194	.0205
27	.014195	.016	.017	.017	.0182	.01875
28	.012641	.014	.016	.016	.017	.0165
29	.011257	.013	.015	.015	.0163	.0155
30	.010025	.012	.014	.014	.0156	.01375
31	.008928	.01	.0135	.013	.0146	.01225
32	.00795	.009	.013	.012	.0136	.01125
33	.00708	.008	.011	.011	.013	.01025
34	.006304	.007	.01	.01	.0118	.0095
35	.005614	.005	.0095	.009	.0109	.009

GALVANIZED AND BLACK IRON.

Weight in Pounds per Square Foot of Galvanized Sheet Iron, both Flat and Corrugated.

The numbers and thicknesses are those of the iron before it is galvanized. When a flat sheet (the ordinary size of which is from 2 to 2½ feet in width, by 6 to 8 feet in length) is converted into a corrugated one, with corrugations 5 inches wide from center to center, and about an inch deep (the common sizes), its width is thereby reduced about $\frac{1}{10}$th part, or from 30 to 27 inches; and consequently the weight per square foot of area covered is increased about $\frac{1}{9}$th part. When the corrugated sheets are laid upon a roof, the overlapping of about 2½ inches along their sides, and of four inches along their ends, diminishes the covered area about $\frac{1}{7}$th part more; making their weight per square foot of roof about ⅙th part greater than before. Or the weight of corrugated iron per square foot, in place on a roof, is about ⅓ greater than that of the flat sheets of above sizes of which it is made.

Number by Birmingham Wire Gauge.	BLACK.		GALVANIZED.		
	Thickness in inches.	Flat. Lbs.	Flat. Lbs.	Corrugated. Lbs.	Cor. on Roof. Lbs.
30	.012	.485	.806	.896	1.08
29	.013	.526	.857	.952	1.14
28	.014	.565	.897	.997	1.20
27	.016	.646	.978	1.09	1.30
26	.018	.722	1.06	1.18	1.41
25	.020	.808	1.14	1.27	1.52
24	.022	.889	1.22	1.36	1.62
23	.025	1.01	1.34	1.49	1.79
22	.028	1.13	1.46	1.62	1.95
21	.032	1.29	1.63	1.81	2.17
20	.035	1.41	1.75	1.94	2.33
19	.042	1.69	2 03	2.26	2.71
18	.049	1.98	2.32	2.58	3.09
17	.058	2.34	2.68	2.98	3.57
16	.065	2.63	2.96	3.29	3.95
15	.072	2.91	3.25	3.61	4.33
14	.083	3.36	3.69	4.10	4.92
13	.095	3.84	4.18	4.64	5.57

NOTE.—The galvanizing of sheet iron adds about one-third of a pound to its weight per square foot.

WIRE—Iron, Steel, Copper, Brass.

Weight of 100 Feet in Pounds.

BIRMINGHAM WIRE GAUGE.

No. of Gauge.	PER LINEAL FOOT.			
	Iron.	Steel.	Copper.	Brass.
0000	54.62	55.13	62.39	58.93
000	47.86	48.32	54.67	51.64
00	38.27	38.63	43.71	41.28
0	30.63	30.92	34.99	33.05
1	23.85	24.07	27.24	25.73
2	21.37	21.57	24.41	23.06
3	17.78	17.94	20.3	19.18
4	15.01	15.15	17.15	16.19
5	12.82	12.95	14.65	13.84
6	10.92	11.02	12.47	11.78
7	8.586	8.667	9.807	9.263
8	7.214	7.283	8.241	7.783
9	5.805	5.859	6.63	6.262
10	4.758	4.803	5.435	5.133
11	3.816	3.852	4.359	4.117
12	3.148	3.178	3.596	3.397
13	2.392	2.414	2.732	2.58
14	1.826	1.843	2.085	1.969
15	1.374	1.387	1.569	1.482
16	1.119	1.13	1.279	1.208
17	.8915	.9	1.018	.9618
18	.6363	.6423	.7268	.6864
19	.4675	.472	.534	.5043
20	.3246	.3277	.3709	.3502
21	.2714	.274	.31	.2929
22	.2079	.2098	.2373	.2241
23	.1656	.1672	.1892	.1788
24	.1283	.1295	.1465	.1384
25	.106	.107	.1211	.1144
26	.0859	.0867	.0981	.0926
27	.0678	.0685	.0775	.0732
28	.0519	.0524	.0593	.056
29	.0448	.0452	.0511	.0483
30	.0382	.0385	.0436	.0412
31	.0265	.0267	.0303	.0286
32	.0215	.0217	.0245	.0231
33	.017	.0171	.0194	.0183
34	.013	.0131	.0148	.014
35	.0066	.0067	.0076	.0071
36	.0042	.0043	.0048	.0046

WROUGHT-IRON WELDED TUBES, FOR STEAM, GAS, OR WATER.

1¼ inch and below, Butt Welded; proved to 300 lbs. per square inch, Hydraulic Pressure.
1½ inch and above, Lap Welded; proved to 500 lbs. per square inch, Hydraulic Pressure.

TABLE OF STANDARD SIZES.—MORRIS, TASKER & CO.

Inside Diameter.	Actual Inside Diameter.	Actual Outside Diameter.	Thickness.	Internal Circumference.	External Circumference.	Length of Pipe per □ foot inside Surface.	Length of Pipe per □ ft. outside Surface.	Internal Area.	External Area.	Length of Pipe containing 1 cubic ft.	Weight per foot of Length.	No. of Threads per inch of Screw
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Feet.	Feet.	Inches.	Inches.	Feet.	Lbs.	
⅛	.270	.405	.068	.848	1.272	14.15	9.44	.0572	.129	2500.	.243	27
¼	.364	.54	.088	1.144	1.699	10.50	7.075	.1041	.229	1385.	.422	18
⅜	.494	.675	.091	1.552	2.121	7.67	5.657	.1916	.358	751.5	.561	18
½	.623	.84	.109	1.957	2.652	6.13	4.502	.3048	.554	472.4	.845	14
¾	.824	1.05	.113	2.589	3.299	4.635	3.637	.5333	.866	270.	1.126	14
1	1.048	1.315	.134	3.292	4.134	3.679	2.903	.8627	1.357	156.9	1.670	11½
1¼	1.380	1.66	.140	4.335	5.215	2.768	2.301	1.496	3.164	96.25	2.258	11½
1½	1.611	1.9	.145	5.061	5.969	2.371	2.01	2.038	2.835	70.65	2.694	11½
2	2.067	2.375	.154	6.494	7.461	1.848	1.611	3.355	4.430	42.36	3.667	11½
2½	2.468	2.875	.204	7.754	9.032	1.547	1.328	4.783	6.491	30.11	5.773	8
3	3.067	3.5	.217	9.636	11.996	1.245	1.091	7.388	9.621	19.49	7.547	8
3½	3.548	4.	.226	11.146	12.566	1.077	.955	9.887	12.566	14.56	9.055	8
4	4.026	4.5	.237	12.648	14.137	.949	.849	12.730	15.904	11.31	10.728	8
4½	4.508	5.	.247	14.153	15.708	.848	.765	15.939	19.635	9.03	12.492	8
5	5.045	5.563	.259	15.849	17.475	.757	.629	19.990	24.299	7.20	14.564	8
6	6.065	6.625	.280	19.054	20.813	.63	.577	28.889	34.471	4.98	18.767	8
7	7.023	7.625	.301	22.063	23.954	.544	.505	38.737	45.663	3.72	23.410	8
8	7.982	8.625	.322	25.076	27.096	.478	.444	50.039	58.426	2.88	28.348	8
9	9.001	9.688	.344	28.277	30.433	.425	.394	63.633	73.715	2.26	34.077	8
10	10.019	10.75	.366	31.475	33.772	.381	.355	78.838	90.762	1.80	40.641	8

BOLTS WITH SQUARE HEADS AND NUTS.

Weight of 100 Bolts.

Length. Inches.	$\frac{1}{4}''$	$\frac{3}{8}''$	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	1″	$1\frac{1}{8}''$	$1\frac{1}{4}''$
$1\frac{1}{2}$	5.0	14.6	28	53	88	145	172	221	371
2	5.7	16.1	31	57	94	153	183	235	388
$2\frac{1}{2}$	6.4	17.6	34	61	100	162	194	249	405
3	7.1	19.2	36	65	106	170	205	263	422
$3\frac{1}{2}$	7.8	21.7	39	70	112	178	216	276	439
4	8.5	22.2	42	74	118	187	227	290	456
$4\frac{1}{2}$	9.2	23.7	44	78	125	195	238	304	473
5	9.8	25.3	47	83	131	203	249	318	490
$5\frac{1}{2}$	10.5	26.8	50	87	137	212	260	332	507
6	11.2	28.3	53	91	143	220	271	345	524
$6\frac{1}{2}$	11.9	29.9	55	95	149	228	282	360	542
7	12.5	31.4	58	100	155	237	293	372	558
$7\frac{1}{2}$	13.2	33.0	61	104	161	245	304	397	576
8	13.9	34.5	64	108	167	253	315	401	593
9	15.3	37.5	69	116	179	270	337	428	628
10	16.6	41.6	74	125	192	287	359	456	660
11	18.0	43.7	80	134	204	303	381	483	694
12	19.4	46.8	85.4	142	216	320	402	511	729
Add for each foot increase in length.									
	16.4	36.8	65.4	102	146	200	262	331	409

STANDARD SIZES OF WASHERS.

Number in 100 Lbs.

Diameter.	Size of Hole.	Thickness Wire Gauge.	Size of Bolt.	Number in 100 lbs.
Inch.	Inch.	No.	Inch.	
$\frac{5}{8}$	$\frac{5}{16}$	16	$\frac{1}{4}$	29,300
$\frac{3}{4}$	$\frac{3}{8}$	16	$\frac{5}{16}$	18,000
1	$\frac{7}{16}$	14	$\frac{3}{8}$	7,600
$1\frac{1}{2}$	$\frac{9}{16}$	11	$\frac{1}{2}$	3,300
$1\frac{1}{2}$	$\frac{5}{8}$	11	$\frac{9}{16}$	2,180
$1\frac{1}{2}$	$\frac{11}{16}$	11	$\frac{5}{8}$	2,350
$1\frac{3}{4}$	$\frac{13}{16}$	11	$\frac{3}{4}$	1,680
2	$\frac{31}{32}$	10	$\frac{7}{8}$	1,140
$2\frac{1}{2}$	$1\frac{1}{8}$	8	1	580
$2\frac{3}{4}$	$1\frac{1}{4}$	8	$1\frac{1}{8}$	470
3	$1\frac{3}{8}$	7	$1\frac{1}{4}$	360
3	$1\frac{1}{2}$	6	$1\frac{3}{8}$	360

FRANKLIN INSTITUTE

STANDARD SIZES

SQUARE AND HEXAGON NUTS.

Number of Each Size in 100 Lbs.

THESE NUTS ARE CHAMFERED AND TRIMMED.

Width.	Thickness	Hole.	Size of Bolt.	Number of Square.	Number of Hexagon.
1/2	1/4	13/64	1/4	8140	9300
19/32	5/16	1/4	5/16	3000	6200
11/16	3/8	5/16	3/8	2320	3120
25/32	7/16	11/32	7/16	1940	2200
7/8	1/2	13/32	1/2	1180	1350
31/32	9/16	29/64	9/16	920	1000
1 1/16	5/8	33/64	5/8	738	830
1 1/4	3/4	5/8	3/4	420	488
1 7/16	7/8	23/32	7/8	280	309
1 5/8	1	27/32	1	180	216
1 13/16	1 1/8	15/16	1 1/8	130	148
2	1 1/4	1 1/16	1 1/4	96	111
2 3/16	1 3/8	1 5/32	1 3/8	70	85
2 3/8	1 1/2	1 9/32	1 1/2	60	70

HEXAGON NUTS.

REGULAR SIZES.

Width.	Thickness.	Hole.	Size of Bolt.	Number in 100 lbs.
1/2	1/4	7/32	1/4	8600
5/8	5/16	17/64	5/16	4260
3/4	3/8	21/64	3/8	2500
3/4	7/16	3/8	7/16	2180
1	9/16	7/16	1/2	900
1	9/16	15/32	9/16	880
1 1/8	3/4	17/32	5/8	535
1 3/8	7/8	21/32	3/4	295
1 1/2	1	3/4	7/8	224
1 3/4	1 1/8	27/32	1	150
2	1 3/8	15/16	1 1/8	100
2	1 3/8	1 1/16	1 1/4	96
2 1/4	1 1/2	1 3/16	1 3/8	72
2 3/4	1 5/8	1 5/16	1 1/2	43

SQUARE NUTS.

REGULAR SIZES.

Width.	Thickness.	Hole.	Size of Bolt.	Number in 100 lbs.
1/2	1/4	7/32	1/4	6680
5/8	5/16	17/64	5/16	3540
3/4	3/8	21/64	3/8	2050
7/8	3/8	3/8	7/16	1380
1	1/2	7/16	1/2	840
1 1/8	1/2	1/2	9/16	650
1 1/4	5/8	17/32	5/8	410
1 3/8	3/4	21/32	3/4	270
1 1/2	7/8	3/4	7/8	215
1 3/4	1	27/32	1	140
2	1 1/8	15/16	1 1/8	95
2 1/4	1 1/4	1 1/16	1 1/4	72
2 1/2	1 1/2	1 3/16	1 3/8	45
3	1 1/2	1 5/16	1 1/2	32

NAILS AND SPIKES.

Size, Length, and Number to the Pound.

CUMBERLAND NAIL AND IRON CO.

ORDINARY.

Size.	Length.	No. to Lb.
2d	7/8"	716
3 fine	1 1/16	588
3	1 1/16	448
4	1 3/8	336
5	1 3/4	216
6	2	166
7	2 1/4	118
8	2 1/2	94
10	2 3/4	72
12	3 1/8	50
20	3 3/4	32
30	4 1/4	20
40	4 3/4	17
50	5	14
60	5 1/2	10

LIGHT.

Size.	Length.	No. to Lb.
4d	1 3/8"	373
5	1 3/4	272
6	2	196

BRADS.

Size.	Length.	No. to Lb.
6d	2"	163
8	2 1/2	96
10	2 3/4	74
12	3 1/8	50

CLINCH.

Length.	No. to Lb.
2"	152
2 1/4	133
2 1/2	92
2 3/4	72
3	60
3 1/4	43

FENCE.

Length.	No. to Lb.
2"	96
2 1/4	66
2 1/2	56
2 3/4	50
3	40

SPIKES.

Length.	No. to Lb.
3 1/2"	19
4	15
4 1/2	13
5	10
5 1/2	9
6	7

BOAT.

Length.	No. to Lb.
1 1/2"	206

FINISHING.

Size.	Length.	No. to Lb.
4d	1 3/8"	384
5	1 3/4	256
6	2	204
8	2 1/2	102
10	3	80
12	3 5/8	65
20	3 7/8	46

CORE.

Size.	Length.	No. to Lb.
6d	2"	143
8	2 1/2	68
10	2 1/3	60
12	3 1/8	42
20	3 3/4	25
30	4 1/4	18
40	4 3/4	14
W H	2 1/2	69
W H L	2 1/4	72

SLATE.

Size.	Length.	No. to Lb.
3d	1 5/16"	288
4	1 7/16	244
5	1 3/4	187
6	2	146

TACKS.

Size.	Length.	No. to Lb.	Size.	Length.	No. to Lb.	Size.	Length.	No. to Lb.
1 oz.	1/8	16000	4 oz.	7/16	4000	14 oz.	13/16	1143
1 1/2	3/16	10666	6	9/16	2666	16	7/8	1000
2	1/4	8000	8	5/8	2000	18	15/16	888
2 1/2	5/16	6400	10	11/16	1600	20	1	800
3	3/8	5333	12	3/4	1333	22	1 1/16	727

LAP-WELDED AMERICAN CHARCOAL IRON BOILER TUBES.

TABLES OF STANDARD SIZES.

MORRIS, TASKER & CO.

External Diameter.	Internal Diameter.	Thickness.	External Circumference.	Internal Circumference.	Length of Pipe per □ foot inside surface.	Length of Pipe per □ foot outside surface.	Internal Area.	External Area.	Weight per foot.
Inch.	Inch.	Inch.	Inch.	Inch.	Feet.	Feet.	Inch.	Inch.	Lbs.
1	0.856	0.072	3.142	2.689	4.460	3.819	0.575	0.785	0.708
1¼	1.106	0.072	3.927	3.474	3.455	3.056	0.960	1.227	0.9
1½	1.334	0.083	4.712	4.191	2.863	2.547	1.396	1.767	1.250
1¾	1.560	0.095	5.498	4.901	2.448	2.183	1.911	2.405	1.665
2	1.804	0.098	6.283	5.667	2.118	1.909	2.556	3.142	1.981
2¼	2.054	0.098	7.069	6.484	1.850	1.698	3.314	3.976	2.238
2½	2.283	0.109	7.854	7.172	1.673	1.528	4.094	4.909	2.755
2¾	2.533	0.109	8.639	7.957	1.508	1.390	5.039	5.940	3.045
3	2.783	0.109	9.425	8.743	1.373	1.273	6.083	7.069	3.333
3¼	3.012	0.119	10.210	9.462	1.268	1.175	7.125	8.296	3.958
3½	3.262	0.119	10.995	10.248	1.171	1.091	8.357	9.621	4.272
3¾	3.512	0.119	11.781	11.033	1.088	1.018	9.687	11.045	4.590
4	3.741	0.130	12.566	11.753	1.023	0.955	10.992	12.566	5.320
4½	4.241	0.130	14.137	13.323	0.901	0.849	14.126	15.904	6.010
5	4.72	0.140	15.708	14.818	0.809	0.764	17.497	19.635	7.226
6	5.699	0.151	18.849	17.904	0.670	0.637	25.509	28.274	9.346
7	6.657	0.172	21.991	20.914	0.574	0.545	34.805	38.484	12.435
8	7.636	0.182	25.132	23.989	0.500	0.478	45.795	50.265	15.109
9	8.615	0.193	28.274	27.055	0.444	0.424	58.291	63.617	18.002
10	9.573	0.214	31.416	30.074	0.399	0.382	71.975	78.540	22.19

WROUGHT-IRON WELDED TUBES.

EXTRA STRONG.

Nominal Diameter.	Actual Outside Diameter.	Thickness. Extra Strong.	Thickness. Double Extra Strong.	Actual Inside Diameter. Extra Strong	Actual Inside Diam. Double Extra Strong
⅛	.405	.100		.205	
¼	.54	.123		.294	
⅜	.675	.127		.421	
½	.84	.149	.298	.542	.244
¾	1.05	.157	.314	.736	.422
1	1.315	.182	.364	.951	.587
1¼	1.66	.194	.388	1.272	.884
1½	1.9	.203	.406	1.494	1.088
2	2.375	.221	.442	1.933	1.491
2½	2.875	.280	.560	2.315	1.755
3	3.5	.304	.608	2.892	2.284
3½	4.	.321	.642	3.358	2.716
4	4.5	.341	.682	3.818	3.136

WINDOW GLASS.

Number of Lights per Box of 50 Feet.

Inches.	No.	Inches.	No.	Inches.	No.	Inches.	No.
6× 8	150	12×18	33	16×44	10	26×32	9
7 9	115	12 20	30	18 20	20	26 34	8
8 10	90	12 22	27	18 22	18	26 36	8
8 11	82	12 24	25	18 24	17	26 40	7
8 12	75	12 26	23	18 26	15	26 42	7
8 13	70	12 28	21	18 28	14	26 44	6
8 14	64	12 30	20	18 30	13	26 48	6
8 15	60	12 32	18	18 32	13	26 50	6
8 16	55	12 34	17	18 34	12	26 54	5
9 11	72	13 14	40	18 36	11	26 58	5
9 12	67	13 16	35	18 38	11	28 30	9
9 13	62	13 18	31	18 40	10	28 32	8
9 14	57	13 20	28	18 44	9	28 34	8
9 15	53	13 22	25	20 22	16	28 36	7
9 16	50	13 24	23	20 24	15	28 38	7
9 17	47	13 26	21	20 26	14	28 40	6
9 18	44	13 28	19	20 28	13	28 44	6
9 20	40	13 30	18	20 30	12	28 46	6
10 12	60	14 16	32	20 32	11	28 50	5
10 13	55	14 18	29	20 34	11	28 52	5
10 14	52	14 20	26	20 36	10	28 56	4
10 15	48	14 22	23	20 38	9	30 36	7
10 16	45	14 24	22	20 40	9	30 40	6
10 17	42	14 26	20	20 44	8	30 42	6
10 18	40	14 28	18	20 46	8	30 44	5
10 20	36	14 30	17	20 48	8	30 46	5
10 22	33	14 32	16	20 50	7	30 48	5
10 24	30	14 34	15	20 60	6	30 50	5
10 26	28	14 36	14	22 24	14	30 54	4
10 28	26	14 40	13	22 26	13	30 56	4
10 30	24	14 44	11	22 28	12	30 60	4
10 32	22	15 18	27	22 30	11	32 42	5
10 34	21	15 20	24	22 32	10	32 44	5
11 13	50	15 22	22	22 34	10	32 46	5
11 14	47	15 24	20	22 36	9	32 48	5
11 15	44	15 26	18	22 38	9	32 50	4
11 16	41	15 28	17	22 40	8	32 54	4
11 17	39	15 30	16	22 44	8	32 56	4
11 18	36	15 32	15	22 46	7	32 60	4
11 20	33	16 18	25	22 50	7	34 40	5
11 22	30	16 20	23	24 28	11	34 44	5
11 24	27	16 22	20	24 30	10	34 46	5
11 26	25	16 24	19	24 32	9	34 50	4
11 28	23	16 26	17	24 36	8	34 52	4
11 30	21	16 28	16	24 40	8	34 56	4
11 32	20	16 30	15	24 44	7	36 44	5
11 34	19	16 32	14	24 46	7	36 50	4
12 14	43	16 34	13	24 48	6	36 56	4
12 15	40	16 36	12	24 50	6	36 60	3
12 16	38	16 38	12	24 54	5	36 64	3
12 17	35	16 40	11	24 56	5	40 60	3

ROOFING SLATE.

General Rule for the Computation of Slate.

From the length of the Slate take three inches, or as many as the third covers the first; divide the remainder by 2, and multiply the quotient by the width of the slate, and the product will be the number of square inches in a single slate. Divide the number of square inches thus procured by 144, the number of square inches in square foot, and the quotient will be the number of feet and inches required. A square of slate is what will cover 100 feet square, when laid upon the roof.

Weight per Cubic Foot, - 174 Pounds.

Weight per Square Foot.

Thickness......	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1 inch.
Weight	1.81	2.71	3.62	5.43	7.25	9.06	10.87	14.5 lbs.

Table of Sizes and Number of Slate in One Square.

Size in Inches.	No. of Slate in Square.	Size in Inches.	No. of Slate in Square.	Size in Inches.	No. of Slate in Square.
6×12	530	8×16	277	12×20	141
7 12	457	9 16	246	14 20	121
8 12	400	10 16	221	11 22	137
9 12	355	12 16	184	12 22	126
10 12	320	9 18	213	14 22	108
12 12	266	10 18	192	12 24	114
7 14	374	11 18	174	14 24	98
8 14	327	12 18	160	16 24	86
9 14	291	14 18	137	14 26	89
10 14	261	10 20	169	16 26	78
12 14	218	11 20	154		

CAPACITY OF CISTERNS,

In Gallons, for Each Foot in Depth.

Diameter in Feet.	Gallons.	Diameter in Feet.	Gallons.
2.	23.5	9.	475.87
2.5	36.7	9.5	553.67
3.	52.9	10.	587.5
3.5	71.96	11.	710.9
4.	94.02	12.	846.4
4.5	119.	13.	992.9
5.	146.8	14.	1,151.5
5.5	177.7	15.	1,321.9
6.	211.6	20.	2,350.0
6.5	248.22	25.	3,570.7
7.	287.84	30.	5,287.7
7.5	330.48	35.	7,189.
8.	376.	40.	9,367.2
8.5	424.44	45.	11,893.2

The American standard gallon contains 231 cubic inches, or 8⅓ pounds of pure water. A cubic foot contains 62.3 pounds of water, or 7.48 gallons. Pressure per square inch is equal to the depth or head in feet multiplied by .433. Each 27.72 inches of depth gives a pressure of one pound to the square inch.

SKYLIGHT AND FLOOR GLASS.

Weight per Cubic Foot, - 156 Pounds.

Weight per Square Foot.

Thickness.....	⅛	3/16	¼	⅜	½	⅝	¾	1 inch.
Weight.........	1.62	2.43	3.25	4.88	6.50	8.13	9.75	13 lbs.

FLAGGING.

Weight per Cubic Foot, - 168 Pounds.

Weight per Square Foot.

Thickness.......	1	2	3	4	5	6	7	8 inch.
Weight.........	14	28	42	56	70	84	98	112 lbs.

NOTES ON BRICKWORK.

In ordinary brickwork, one cubic foot of wall will require 21 bricks of 8 in. × 2½ in. × 3½ in.

For 1000 ordinary bricks is required 1 barrel of good lime, 2 cartloads of ordinary sharp sand.

One brick as above weighs 4 lbs., dry; if perfectly soaked in water, 5 lbs. It will absorb 1 lb. or 1 pint of water.

Edgewise arches will require about 7 bricks per square foot of floor, and endwise arches will require about 14 bricks of the size given above.

For 1 cubic yard of concrete is required 1 barrel of cement, 2 barrels of good sharp sand, 1 cubic yard of broken stone.

SPECIFIC GRAVITY AND WEIGHTS OF VARIOUS SUBSTANCES.

NAMES OF SUBSTANCES.	Average Weights.		Specific Gravity.
	Per Cubic Foot.	Per □ Foot, 1 in. thick.	
Anthracite, solid, of Pa	93		1.50
〃 broken, loose	54		
〃 〃 shaken	58		
〃 heaped bushel, loose	(80 per	bushel,	heaped).
Ash, white, dry	38	$3\frac{1}{6}$	0.61
Asphaltum	87	7.25	1.40
Brass, cast	504	42.	8.09
〃 rolled	524	43.7	8.4
Brick, best pressed	150		2.4
〃 common hard	125		2.0
〃 soft	100		1.6
Brickwork, pressed brick	140		2.25
〃 ordinary	112		1.8
Cement, Rosendale (loose)	56		
〃 Louisville 〃	50		
〃 Portland 〃	90		
Cherry, dry	42	3.50	0.67
Chestnut, dry	41	3.41	0.66
Coal, bituminous, solid	84		1.35
〃 〃 broken, loose	49		
〃 〃 〃 〃	(74 per	bushel,	heaped).
Coke, loose	27		
〃 heaped bushel, 38 lbs			
Copper, cast	542	45.2	8.7
〃 rolled	548	45.7	8.8
Earth, common dry, loose	76		
〃 〃 rammed	95		
〃 soft mud	108		
Ebony, dry	76	6.33	1.22
Elm, dry	35	2.9	0.56
Glass	157	13	2.53
Gneiss	168		2.7
Gold, cast, 24 carat	1204		19.3
〃 hammered, 24 carat	1217		19.6
Granite	170		2.73
Hemlock, dry	25	$2\frac{1}{12}$	0.40
Hickory, dry	53	4.62	0.85
Ice	58.7		0.95
Iron, cast	450	37.5	7.24
〃 wrought (hammered)	485	40.6	7.8
〃 〃 (rolled)	480	40.0	7.7
Lead	711	59.25	11.4

SPECIFIC GRAVITY AND WEIGHTS OF VARIOUS SUBSTANCES.—*Cont'd.*

NAMES OF SUBSTANCES.	Average Weights. Per Cubic Foot.	Per □ Foot, 1 in. thick.	Specific Gravity.
Lime, loose quicklime	53		
" per bushel, 66 lbs.			
Limestone and marble	168		2.7
Maple	49	$4\frac{1}{12}$	0.79
Masonry, granite or limestone	165		
" rubble	154		
" dry	138		
" sandstone	144		
Mercury, at 32° F.	849		13.6
Mortar, hardened	103	8.6	1.66
Mud, dry	80–110		
Oak, live, dry	59	$4\frac{11}{12}$	0.95
" white	52	$4\frac{1}{3}$	0.83
Petroleum	55		0.88
Pine, white, dry	25	$2\frac{1}{12}$	0.40
" yellow, Northern	34	$2\frac{5}{6}$	0.55
" " Southern	45	$3\frac{3}{4}$	0.72
Quartz	165		2.65
Salt, Syracuse, coarse	45		
" fine Liverpool	49		
Sand, pure, dry, loose	90–106		
" shaken	99–117		
" perfectly wet	120–140		
Sandstone	151		2.43
Shales, red or black	162		2.6
Silver	655		10.5
Slate	175	14.6	2.8
Snow, fresh	5– 12		
" slush	15– 20		
Spruce, dry	25	$2\frac{1}{12}$	0.40
Steel	490	$40\frac{5}{6}$	7.9
Sulphur	125		2.0
Sycamore, dry	37		0.60
Tar	62		1.0
Tin	459		7.4
Turf or Peat, dry	20– 30		
Walnut, dry	38	$3\frac{1}{6}$	0.61
Water, pure, at 60° F	$62\frac{1}{3}$		1.00
" sea	64		1.028
Zinc or Spelter, cast	446	37.1	7.15
" " rolled	448	37.3	7.19
Green timbers $\frac{1}{5}$ to $\frac{1}{2}$ more than dry			

LINEAR EXPANSION OF METALS.

	Between 0° and 100° C.	For 1° C.	For 1° Fahr.
Zinc	0.00294	....	....
Lead	0.00284	....	....
Tin	0.00222	....	....
Copper, yellow	0.00188	....	....
" red	0.00171	....	....
* Forged iron	0.00122	.0000122	.00000677
† Steel	0.00114	.0000114	.00000633
* Cast iron	0.00111	.0000111	.00000616

For a change of 100° Fahr. a bar of iron 1475′ long will extend 1 foot. Similarly, a bar 100 feet long will extend .0678 foot, or .8136 inch.

According to the experiments of Du Long & Petit, we have the mean expansion of iron, copper, and platinum, between 0° and 100° C., and 0° and 300° C., as below:

	From 0° to 100° C.	0° to 300° C.
Iron	0.00180	0.00146
Copper	0.00171	0.00188
Platinum	0.00884	0.00918

The law for the expansion of iron, steel, and cast iron, at very high temperatures, according to Rinman, is as follows:

	From 25° to 55° C. red heat = 500° C.	For 1° C.	1° Fahr.
Iron	.00714	.0000143=	.0000080
Steel	.01071	.0000214=	.0000119
Cast iron	.01250	.0000250=	.0000139
	From 25° to 1300° nascent white = 1275° C.		
Iron	.01250	.00000981=	.00000545
Steel	.01787	.00001400=	.00000777
Cast iron	.02144	.00001680=	.00000933
	From 500° to 1500° dull red to white heat = 1000° C. difference.		
Iron	.00535	.00000535=	.0000030
Steel	.00714	.00000714=	.0000040
Cast iron	.00893	.00000893=	.0000050

Ratio of Expansion in Hundred parts, assuming Forge Iron to expand between 0° and 100° C. = .00122.

	From 0° to 100°	25° to 525°	25° to 1300°	500° to 1500°
Iron	100 per ct.	117 per ct.	80 per ct.	44 per ct.
Steel	93 "	175 "	114 "	58 "
Cast iron	91 "	205 "	137 "	73 "

* Laplace and Lavoisier. † Ramsden.

The contraction of a wrought-iron rod in cooling is about equivalent to $\frac{1}{10000}$ of its length from a decrease of 15° Fahr., and the strain thus induced is about *one ton* for every square inch of sectional area in the bar.

For a rod of the lengths given below, the contraction will be as follows:

Length of rod in feet..	10	20	30	40	50	75	100	150
Contrac'n in inches for **15°**	.012	.024	.036	.048	.060	.090	.120	.180
" " **150°**	.120	.240	.360	.480	.600	.900	1.200	1.800
" " **100°**	.080	.160	.240	.320	.400	.600	.800	1.200

Contraction and expansion being equal, the pressure per square inch induced by heating or cooling is as follows:

For temperatures varying by 15° Fahr.:

Variation....	15	30	45	60	75	105	120	150 degrees.
Pressure....	1	2	3	4	5	7	8	10 tons.

Stoney gives 8° C. = 14.4 Fahr. as equivalent to a pressure of one ton per square inch for wrought iron, and 15° C. = 27 Fahr. for cast iron.

Diminution of Tenacity of Wrought Iron at High Temperatures.

EXPERIMENTS FRANKLIN INSTITUTE, 1839. WALTER JOHNSON AND BENJ. REEVES, COM.

C.	Fahr.	Diminution p. ct. of max. tenacity.	C.	Fahr.	Diminution p. ct. of max. tenacity.
271°	520°	0.0738	500°	932°	0.3324
299		0.0869	508		0.3593
313		0.0899	554		0.4478
316		0.0964	599		0.5514
332	630	0.1047	624	1154	0.6000
350		0.1155	626		0.6011
378		0.1436	642		0.6352
389	732	0.1491	669		0.6622
390		0.1535	674	1245	0.6715
408		0.1589	708	1306	0.7001
410		0.1627			
440		0.2010			

DIFFERENT COLORS OF IRON CAUSED BY HEAT.

POUILLET.

C.	FAHR.	COLOR.
210°	410°	Pale Yellow.
221	430	Dull Yellow.
256	493	Crimson.
261 370	502 680	Violet, Purple, and Dull Blue; between 261° C. to 370° C. it passes to Bright Blue, to Sea Green, and then disappears.
500	932	Commences to be covered with a light coating of oxide; loses a good deal of its hardness; becomes a good deal more impressible to the hammer and can be twisted with ease.
525	977	Becomes Nascent Red.
700	1292	Somber Red.
800	1472	Nascent Cherry.
900	1657	Cherry.
1000	1832	Bright Cherry.
1100	2012	Dull Orange.
1200	2192	Bright Orange.
1300	2372	White.
1400	2552	Brilliant White—welding heat.
1500 1600	2732 2912	Dazzling White.

MELTING POINT OF METALS.

NAME.	FAHR.	FAHR.	AUTHORITY.
Platina	4593°		
Antimony	955	842	J. Lowthian Bell.
Bismuth	487	507	"
Tin (average)	475		
Lead "	622	620	"
Zinc	772	782	"
Cast iron	2786	1922..2012 White, 2012..2192 Gray,	Pouillet.
Wrought iron	2552	2733 Welding heat.	"
Copper (average)	2174		

ULTIMATE RESISTANCE OF MATERIALS.

IN POUNDS PER SQUARE INCH.

	Tension Average.	Compression Average.	Shearing Average.
Brass, cast	18,000	10,300	
〃 wire	49,000		
Bronze, gun metal	39,000	175,000	
Copper, cast	19,000	117,000	
〃 sheet	30,000	103,000	
〃 bolts	36,000		
〃 wire	60,000		
Iron, cast	13,400–29,000	80,000–145,000	27,000
Iron wrought:			45,000
Rods of 1 to 2″ diam.	50,000–55,000		
Specimens of rerolled	50,000–55,000		
Rerolled, large bars	46,000–47,000	36000–40000	
Plates, L and shapes	47,000–50,000		
〃 over 30″ wide	45,000–48,000		
Iron wire	70,000–100,000		
〃 〃 ropes	90,000		
Lead, sheet	3,300	7,700	
Steel, 0.25% c. for eye bars	70,000		
〃 0.42% c. compression members	80,000		
〃 tool steel	110,000		
〃 wire	200,000		
Tin, cast	4,600	15,500	
Zinc, 〃	7,500		
〃 sheet rolled	16,000		
Ash, seasoned	16,500	6,000	
Beech, 〃	15,000	7,000	
Box, 〃	20,000	10,000	
Cedar, 〃	10,300	6,500	
Chestnut, 〃	13,000		
Elm, 〃	6,000	10,000	
Fir or spruce, seasoned	10,000–13,600	6,800	5–800
Hickory, 〃	12,800–18,000		
Locust, 〃	18,000		
Maple, 〃	10,000		
Oak, white, 〃	18,000	7,200–9,100	2,000
〃 European 〃	10,000–19,800	10,000	2,300
Pine, white, red and pitch.	10,000	5,000–5,600	5–800
〃 long leaf yellow	12,600–19,200	8,000	6–1,000
Poplar, seasoned	7,000	5,100	
Silk fiber	52,000		
Walnut, seasoned	16,000	7,200	

ULTIMATE RESISTANCE OF MATERIALS.

IN POUNDS, PER SQUARE INCH.

	Tension Average.	Compression Average.
Brick, weak	150	550–800
〃 good	300	1,100
〃 fire		1,700
Brickwork, good ordinary		300
〃 in cement		450
〃 〃 extra		1,000
Granite and Syenite		4,500–18,000
Basalt		10,500
Limestone and marble	700–1,600	3,750–15,000
Oölites	100– 200	1,500–3,750
Sandstone		3,750–8,000
〃 of New Jersey		3,000
Slate	2,500–4,000	6,000–12,000
Chalk		300–450
Plaster of Paris	70	600
Concrete		450–750
Portland cement, pure	100– 450	1,200–2,400
Roman 〃 〃	200	750
Glass	3,000–9,000	20,000–35,000
Ice		180–270
Mortar, hydraulic	150	
〃 common	20	
Rope, best manilla	12,000	
〃 〃 hemp	15,000	

NATURAL SINES, ETC.

Deg.	Sine.	Cover.	Cosecnt.	Tangt.	Cotang.	Secant.	Versin.	Cosine.	Deg.
0	.00	1.00000	Infinite.	.0	Infinite.	1.00000	.0	1.00000	90
1	.01745	.98254	57.2986	.01745	57.2899	1.00015	.0001	.99984	89
2	.03489	.96510	28.6537	.03492	28.6362	1.00060	.0006	.99939	88
3	.05233	.94766	19.1073	.05240	19.0811	1.00137	.0013	.99862	87
4	.06975	.93024	14.3355	.06992	14.3006	1.00244	.0024	.99756	86
5	.08715	.91284	11.4737	.08748	11.4300	1.00381	.0038	.99619	85
6	.10452	.89547	9.5667	.10510	9.5143	1.00550	.0054	.99452	84
7	.12186	.87813	8.2055	.12278	8.1443	1.00750	.0074	.99254	83
8	.13917	.86082	7.1852	.14054	7.1153	1.00982	.0097	.99026	82
9	.15643	.84356	6.3924	.15838	6.3137	1.01246	.0123	.98768	81
10	.17364	.82635	5.7587	.17632	5.6712	1.01542	.0151	.98480	80
11	.19080	.80919	5.2408	.19438	5.1445	1.01871	.0183	.98162	79
12	.20791	.79208	4.8097	.21255	4.7046	1.02234	.0218	.97814	78
13	.22495	.77504	4.4454	.23086	4.3314	1.02630	.0256	.97437	77
14	.24192	.75807	4.1335	.24932	4.0107	1.03061	.0297	.97029	76
15	.25881	.74118	3.8637	.26794	3.7320	1.03527	.0340	.96592	75
16	.27563	.72436	3.6279	.28674	3.4874	1.04029	.0387	.96126	74
17	.29237	.70762	3.4203	.30573	8.2708	1.04569	.0436	.95630	73
18	.30901	.69098	3.2360	.32491	3.0776	1.05146	.0489	.95105	72
19	.32556	.67443	3.0715	.34432	2.9042	1.05762	.0544	.94551	71
20	.34202	.65797	2.9238	.36397	2.7474	1.06417	.0603	.93969	70
21	.35836	.64163	2.7904	.38386	2.6050	1.07114	.0664	.93358	69
22	.37460	.62539	2.6694	.40402	2.4750	1.07853	.0728	.92718	68
23	.39073	.60926	2.5593	.42447	2.3558	1.08636	.0794	.92050	67
24	.40673	.59326	2.4585	.44522	2.2460	1.09463	.0864	.91354	66
25	.42261	.57738	2.3662	.46630	2.1445	1.10337	.0936	.90630	65
26	.43837	.56162	2.2811	.48773	2.0503	1.11260	.1012	.89879	64
27	.45399	.54600	2.2026	.50952	1.9626	1.12232	.1089	.89100	63
28	.46947	.53052	2.1300	.53170	1.8807	1.13257	.1170	.88294	62
29	.48480	.51519	2.0626	.55430	1.8040	1.14335	.1253	.87461	61
30	.50000	.50000	2.0000	.57735	1.7320	1.15470	.1339	.86602	60
31	.51503	.48496	1.9416	.60086	1.6642	1.16663	.1428	.85716	59
32	.52991	.47008	1.8870	.62486	1.6003	1.17917	.1519	.84804	58
33	.54463	.45536	1.8360	.64940	1.5398	1.19236	.1613	.83867	57
34	.55919	.44080	1.7882	.67450	1.4825	1.20621	.1709	.82903	56
35	.57357	.42642	1.7434	.70020	1.4281	1.22077	.1808	.81915	55
36	.58778	.41221	1.7013	.72654	1.3763	1.23606	.1909	.80901	54
37	.60181	.39818	1.6616	.75355	1.3270	1.25213	.2013	.79863	53
38	.61566	.38433	1.6242	.78128	1.2799	1.26901	.2119	.78801	52
39	.62932	.37067	1.5890	.80978	1.2348	1.28675	.2228	.77714	51
40	.64278	.35721	1.5557	.83909	1.1917	1.30540	.2339	.76604	50
41	.65605	.34394	1.5242	.86928	1.1503	1.32501	.2452	.75470	49
42	.66913	.33086	1.4944	.90040	1.1106	1.34563	.2568	.74314	48
43	.68199	.31800	1.4662	.93251	1.0723	1.36732	.2686	.73135	47
44	.69465	.30534	1.4395	.96568	1.0355	1.39016	.2806	.71933	46
45	.70710	.29289	1.4142	1.00000	1.0000	1.41421	.2928	.70710	45
	Cosine.	Versin.	Secant.	Cotang.	Tangt.	Cosecant.	Cover.	Sine.	

CIRCUMFERENCES OF CIRCLES,

Advancing by Eighths.

CIRCUMFERENCES.

Diam.	.0	.⅛	.¼	.⅜	.½	.⅝	.¾	.⅞
0	.0	.3927	.7854	1.178	1.571	1.963	2.356	2.749
1	3.142	3.534	3.927	4.320	4.712	5.105	5.498	5.890
2	6.283	6.676	7.069	7.461	7.854	8.246	8.639	9.032
3	9.425	9.817	10.21	10.60	10.99	11.39	11.78	12.17
4	12.56	12.96	13.35	13.74	14.13	14.53	14.92	15.31
5	15.71	16.10	16.49	16.88	17.28	17.67	18.06	18.45
6	18.85	19.24	19.63	20.02	20.42	20.81	21.20	21.60
7	21.99	22.38	22.77	23.17	23.56	23.95	24.34	24.74
8	25.13	25.52	25.92	26.31	26.70	27.09	27.49	27.88
9	28.27	28.66	29.06	29.45	29.84	30.23	30.63	31.02
10	31.41	31.81	32.20	32.59	32.98	33.38	33.77	34.16
11	34.55	34.95	35.34	35 73	36.13	36.52	36.91	37.30
12	37.70	38.09	38.48	38.87	39.27	39.66	40.05	40.45
13	40.84	41.23	41.62	42.02	42.41	42.80	43.19	43.59
14	43.98	44.37	44.76	45.16	45.55	45.94	46.34	46.73
15	47.12	47.51	47.91	48.30	48.69	49.08	49.48	49.87
16	50.26	50.66	51.05	51.44	51.83	52.23	52.62	53.01
17	53.40	53.80	54.19	54.58	54.97	55.37	55.76	56.15
18	56.55	56.94	57.33	57.72	58.12	58.51	58.90	59.29
19	59.69	60.08	60.47	60.87	61.26	61.65	62.04	62.43
20	62.83	63.22	63.61	64.01	64.40	64.79	65.19	65.58
21	65.97	66.36	66.76	67.15	67.54	67.93	68.33	68.72
22	69.11	69.50	69.90	70.29	70.68	71.08	71.47	71.86
23	72.25	72.65	73.04	73.43	73 82	74 22	74.61	75.00
24	75 40	75.79	76.18	76.57	76.97	77.36	77.75	78.14
25	78.54	78.93	79.32	79.71	80.11	80.50	80.89	81.29
26	81.68	82.07	82.46	82.86	83.25	83.64	84.03	84.43
27	84.82	85.21	85.60	86.00	86.39	86.78	87.18	87.57
28	87.96	88.35	88.75	89.14	89.53	89.93	90.32	90.71
29	91.10	91.50	91.89	92.28	92.67	93.07	93.46	93.85
30	94.24	94.64	95.03	95.42	95.82	96.21	96.60	96.99
31	97.39	97.78	98.17	98.57	98.96	99.35	99.75	100.14
32	100.53	100.92	101.32	101.71	102.10	102.49	102.89	103.28
33	103.67	104.07	104.46	104.85	105.24	105.64	106.03	106.42
34	106.81	107.21	107.60	107.99	108.39	108.78	109.17	109.56
35	109.96	110.35	110.74	111.13	111.53	111.92	112.31	112.71
36	113.10	113.49	113.88	114.28	114.67	115.06	115.45	115.85
37	116.24	116.63	117.02	117.42	117.81	118.20	118.60	118.99
38	119.38	119.77	120.17	120.56	120.95	121.34	121.74	122.13
39	122.52	122.92	123.31	123.70	124.09	124.49	124.88	125.27
40	125.66	126.06	126.45	126.84	127.24	127.63	128.02	128.41
41	128.81	129.20	129.59	129.98	130.38	130.77	131.16	131.55
42	131.95	132.34	132.73	133.13	133.52	133.91	134.30	134.70
43	135.09	135.48	135.87	136.27	136.66	137.05	137.45	137.84
44	138.23	138.62	139.02	139.41	139.80	140.19	140.59	140.98
45	141.37	141.76	142.16	142.55	142.94	143.34	143.73	144.12

AREAS OF CIRCLES,

Advancing by Eighths.

AREAS.

Diam.	.0	.⅛	.¼	.⅜	.½	.⅝	.¾	.⅞
0	.0	.0122	.0491	.1104	.1963	.3068	.4418	.6013
1	.7854	.9940	1.227	1.485	1.767	2.074	2.405	2.761
2	3.1416	3.546	3.976	4.430	4.908	5.411	5.939	6.492
3	7.068	7.670	8.296	8.946	9.621	10.32	11.04	11.79
4	12.56	13.36	14.18	15.03	15.90	16.80	17.72	18.66
5	19.63	20.63	21.65	22.69	23.76	24.85	25.96	27.10
6	28.27	29.46	30.68	31.92	33.18	34.47	35.78	37.12
7	38 48	39.87	41.28	42.72	44.18	45.66	47.17	48.70
8	50.26	51.85	53.45	55.09	56.74	58.42	60.13	61.86
9	63.61	65.39	67.20	69.03	70.88	72.76	74.66	76.59
10	78.54	80.51	82.51	84.54	86.59	88.66	90.76	92.88
11	95.03	97.20	99.40	101.6	103.9	106.1	108.4	110.7
12	113.1	115.5	117.9	120.3	122.7	125.2	127.7	130.2
13	132.7	135.3	137.9	140.5	143.1	145.8	148.5	151.2
14	153.9	156.7	159.5	162.3	165.1	168.0	170.9	173.8
15	176.7	179.7	182.7	185.7	188.7	191.7	194.8	197.9
16	201.1	204.2	207.4	210.6	213.8	217.1	220.3	223.6
17	227.0	230.3	233.7	237.1	240.5	244.0	247.4	250.9
18	254.5	258.0	261.6	265.2	268.8	272.4	276.1	279.8
19	283.5	287.3	291.0	294.8	298.6	302.5	306.3	310.2
20	314.2	318.1	322.1	326.0	330.1	334.1	338.2	342.2
21	346.4	350.5	354.7	358.8	363.0	367.3	371.5	375.8
22	380.1	384.5	388.8	393.2	397.6	402.0	406.5	411.0
23	415.5	420.0	424.6	429.1	433.7	438.4	443.0	447.7
24	452.4	457.1	461.9	466.6	471.4	476.3	481.1	486.0
25	490.9	495.8	500.7	505.7	510.7	515.7	520.8	525.8
26	530.9	536.0	541.2	546.3	551.6	556.8	562.0	567.3
27	572.6	577.9	583.2	588.6	594.0	599.4	604.8	610.3
28	615.7	621.3	626.8	632.4	637.9	643.5	649.2	654.8
29	660.5	666.2	672.0	677.7	683.5	689.3	695.1	701.0
30	706.9	712.8	718.7	724.6	730.6	736.6	742.6	748.7
31	754.8	760.9	767.0	773.1	779.3	785.5	791.7	798.0
32	804.3	810.5	816.9	823.2	829.6	836.0	842.4	848.8
33	855.3	861.8	868.3	874.9	881.4	888.0	894.6	901.3
34	907.9	914.6	921.3	928.1	934.8	941.6	948.4	955.2
35	962.1	969.0	975.9	982.8	989.8	996.8	1003.8	1010.8
36	1017.9	1025.0	1032.1	1039.2	1046.3	1053.5	1060.7	1068.0
37	1075.2	1082.5	1089.8	1097.1	1104.5	1111.8	1119.2	1126.7
38	1134.1	1141.6	1149.1	1156.6	1164.2	1171.7	1179.3	1186.9
39	1194.6	1202.3	1210.0	1217.7	1225.4	1233.2	1241.0	1248.8
40	1256.6	1264.5	1272.4	1280.3	1288.2	1296.2	1304.2	1312.2
41	1320.3	1328.3	1336.4	1344.5	1352.7	1360.8	1369.0	1377.2
42	1385.4	1393.7	1402.0	1410.3	1418.6	1427.0	1435.4	1443.8
43	1452.2	1460.7	1469.1	1477.6	1486.2	1494.7	1503.3	1511.9
44	1520.5	1529.2	1537.9	1546.6	1555.3	1564.0	1572.8	1581.6
45	1590.4	1599.3	1608.2	1617.0	1626.0	1634.9	1643.9	1652.9

SURVEYING MEASURE (LINEAL).

Inches.		Links.		Feet.		Yards.		Chains.		Mile.		Fr. Meters.
1.	=	.126	=	.0833	=	.0278	=	.00126	=	.0000158	=	.0254
7.92		1.		.66		.22		.01		.000125		.2012
12.		1.515		1.		.333		.01515		.000189		.3048
36.		4.545		3.		1.		.04545		.000568		.9144
792.		100.		66.		22.		1.		.0125		20.116
63360.		8000.		5280.		1760.		80.		1.		1609.315

One knot or geographical mile = 6086.07 feet = 1855.11 metres = 1.1526 statute mile.

One admiralty knot = 1.1515 statute miles = 6080 feet.

LONG MEASURE.

Inches.		Feet.		Yards.		Fath.		Poles.		Furl.		Mile.		Fr. Meters.
1.	=	.083	=	.02778	=	.0139	=	.005	=	.000126	=	.0000158	=	.0254
12.		1.		.333		.1667		.0606		.00151		.0001894		.3048
36.		3.		1.		.5		.182		.00454		.000568		.9144
72.		6.		2.		1.		.364		.0091		.001136		1.8287
198.		16½.		5½.		2¾.		1.		.025		.003125		5.0291
7920.		660.		220.		110.		40.		1.		.125		201.16
63360.		5280.		1760.		880.		320.		8.		1.		1609.315

A palm = 3 inches.

A span = 9 inches.

A hand = 4 inches.

A cable's length = 120 fathoms.

FRENCH LONG MEASURE.

	Inches.	Feet.	Yards.	Miles
Millimetre . .	.039368	.00328		
Centimetre . .	.39368	.03280		
Decimetre . . .	3.9368	.32807	.109357	
Metre	39.368	3.2807	1.09357	
Decametre . .	393.68	32.807	10.9357	
Hectometre .		328.07	109.357	.0621346
Kilometre . . .		3280.7	1093.57	.6213466
Myriametre .		32807.	10935.7	6.213466

SQUARE MEASURE.

Inches.	Feet.	Yards.	Perches.	Roods.	Acre.	Sq. Metres.
1. =	.00694 =	.000772 =	.0000255 =	.00000064 =	.000000159 =	.000645
144.	1.	.111	.00367	.0000918	.000023	.0929
1296.	9.	1.	.0331	.000826	.0002066	.8361
39204.	272¼.	30¼.	1.	.025	.00625	25.292
1568160.	10890.	1210.	40.	1.	.25	1011.7
6272640.	43560.	4840.	160.	4.	1.	4046.7

100 square feet = 1 square.
10 square chains = 1 acre.
1 chain wide = 8 acres per mile.
1 hectare = 2.471143 acres.

1 square mile { = 27878400 square feet. = 3097600 square yards. = 640 acres.

Acres × .0015625 = square miles.
Square yard × .000000323 = square miles.
Acres × 4840 = square yards.
Square yards × .0002066 = acres.
A section of land is 1 mile square, and contains 640 acres.
A square acre is 208.71 ft. at each side; or 220 × 198 ft.
A square ½-acre is 147.58 ft. at each side; or 110 × 198 ft.
A square ¼-acre is 104.355 ft. at each side; or 55 × 198 ft.
A circular acre is 235.504 feet in diameter.
A circular ½-acre is 166.527 feet in diameter.
A circular ¼-acre is 117.752 feet in diameter.

FRENCH SQUARE MEASURE.

Square.	Square Inches.	Square Feet.	Square Yards.	Acres.
Millimetre...	.00154	.0000107	000001	
Centimetre...	.15498	.0010763	.000119	
Decimetre ...	15.498	.1076305	.011958	
Metre or Cen	1549.8	10.76305	1.19589	.000247
Decametre...	154988.	1076.305	119.589	.024709
Hectare......		107630.58	11958.95	2.47086
Kilometre....	.38607 □ mls.	10763058.	1195895.	247.086
Myriametre..	38.607 "			24708 6

CUBIC MEASURE.

Inches.		Feet.		Yard.		Cubic Metres.
1.	=	.0005788	=	.000002144	=	.000016386
1728.		1.		.03704		.028315
46656.		27.		1.		.764513

A cord of wood = 128 cubic feet, being four feet high, four feet wide, and eight feet long.

Forty-two cubic feet = a ton of shipping.

A perch of masonry contains 24¾ cubic feet.

A Cubic Foot is Equal to

1728 cubic inches.
.037037 cubic yard.
.803564 U. S. struck bushel of 2150.42 cubic inches.
3.21426 U. S. pecks.
7.48052 U. S. liquid galls. of 231 cubic inches.
6.42851 U. S. dry galls.
29.92208 U. S. liquid quarts.
25.71405 U. S. dry quarts.
59.84416 U. S. liquid pints.
51.42809 U. S. dry pints.
239.37662 U. S. gills.
.26667 flour barrel of 3 struck bushels.
.23748 U. S. liquid barrel of 31½ galls.

FRENCH CUBIC OR SOLID MEASURE.

	Gill.	Pint.	Quart.	Gallon.	Peck.	Bush.	Cubic Inches.	Cubic Feet.
Centilitre, Dry	....	.0181	.....	.....	....	....	.61016	....
Liquid	.0845	.0211	....	.....	....	....		
Decilitre... Dry	....	.1816	.0908	.....	.0113	....	6.1016	....
Liquid	.8452	.2113	.1056	.0264	....	....		
Litre ...... Dry	....	1.816	.908	.....	.1135	....	61.016	.0353
Liquid	8.452	2.113	1.056	.2641	....	....		
Decalitre.. Dry	....	....	9.08	.....	1.135	.2837	610.16	.3531
Liquid	84.52	21.13	10.56	2.641	....	....		
Hectolitre. Dry	....	....	90.8	.....	11.35	2.837	6101.6	3.531
Liquid	....	211.3	105.6	26.41	....	....		
Kilolitre or Cubic Metre, Dry	....	....	.....	.....	113.5	28.37	61016.	35.31
Liquid	....	....	1056.5	264.1	....	....		
Myrialitre. Dry	....	....	.....	.....	1135.	283.7	......	353.1
Liquid	....	....	10565.	2641.4	....	....		

AVOIRDUPOIS WEIGHT.

The standard avoirdupois pound is the weight of 27.7015 cubic inches of distilled water, weighed in the air, at 39.83 degrees Fahr., barometer at thirty inches.

27.343 grains = 1 drachm.

Drachms.	Ounces.	Lbs.	Qrs.	Cwts.	Ton.	French Grammes.
1. =	.0625 =	.0039 =	.000139 =	.000035 =	.00000174 =	1.771846
16.	1.	.0625	00223	000558	.000028	28.34954
256.	16.	1.	.0357	.00893	.000447	453.59
7168.	448.	28.	1.	.25	.0125	12700.
28672.	1792.	112.	4.	1.	.05	50802.
573440.	35840	2240.	80.	20.	1.	1016048.

A stone = 14 pounds.

A quintal = 100 pounds.

7000 grains = one avoirdupois pound = 1.21528 troy pounds.

5760 grains = one troy pound = .82285 avoirdupois pounds.

FRENCH WEIGHTS.

EQUIVALENT TO AVOIRDUPOIS.

	Grains.	Ounces.	Lbs.	Tons. 2240 lbs.
Milligramme .	.015433			
Centigramme .	.154331	.000352	.000022	
Decigramme .	1.54331	.003527	.000220	
Gramme	15.4331	.035275	.002204	
Decagramme .	154.331	.352758	.022047	
Hectogramme	1543.31	3.52758	.220473	.000098
Kilogramme .	15433.1	35.2758	2.20473	.000984
Myriagramme		352.758	22.0473	.009842
Quintal		3527.58	220.473	.098425
Millier or Tonne . .		35275.8	2204.73	.984258

DIMENSIONS OF PASSAIC R. M. STANDARD TURN-TABLES.

Plates 19 and 20.

	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
Diameter of pit	35.0	40.0	45.0	50.0	55.0	60.0
Length of girder, out to out	34.4	39.4	44.4	49.6	54.6	59.6
Diameter of circular tracks, center to center of rail	31.0	36.0	41.0	46.0	51.0	56.0
Depth from top of rail on table to top of center stone	5.0	5.0	5.0	5.6	5.6	5.6
Depth from top of rail on table to top of rail of circular track	3.4	3.4	3.4	3.10	3.10	3.10
Ditto for special turn-table, shallow pit	2.0	2.0	2.0	2.6	2.6	2.6

POINTS OF MERIT IN PASSAIC R. M. CO'S STANDARD TURN-TABLES.

The table is entirely center-bearing, and rests on steel discs, A, six inches in diameter, which offer very little resistance to turning around, and at the same time give ample bearing surface to maintain the parts in good working order. As the friction acts on a lever 2 inches long, and the power on one whose length is equal to the radius of the turn-table, it is apparent that very little power will be required to turn it. The table is hung to the center-pin by two bolts, B B, made of re-rolled iron; this arrangement prevents any uneven distribution of the load, produced by tightening of the bolts, such as is liable to be produced when more than two are used. The shape of the girder is such as to approach, in the nearest practicable manner, the theoretical form, which requires a constant flange section, when due regard is taken to the influence of the varying sign of the strains at any point of either flange, according to the position of the engine. The flanges are made of 4x6 in. angle iron, extending all the way through at the top without a splice, and spliced in the center at the bottom. The flange of this iron, being 6 inches wide, gives ample room for good fastenings for the lateral bracing, which runs all the way through the top and bottom, and makes the table very stiff sideways, the chords being $12\frac{3}{8}$ in. wide. By making the top and bottom bracing of angle iron, no twist can be brought on the table by unskillful adjustment.

Where shipment can be made by rail, the tables are loaded complete, ready to be set in pit. Full dimensions for building of pit, etc., accompany each contract. We take pleasure in referring to any of the roads to whom we have sent our tables, and will give further information promptly on application.

PASSAIC ROLLING MILL CO.