ON THE STRENGTH

OF

CAST-IRON PILLARS,

WITH

TABLES

FOR THE USE OF ENGINEERS, ARCHITECTS, AND BUILDERS.

BY

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STRENGTH OF CAST-IRON PILLARS.

UNTIL the year 1840 the only rule in common use for computing the strength of cast-iron pillars was that given by Tredgold, in his essay on the strength of cast-iron and other metals.* This rule was not founded on experiments made on pillars, or on sound theoretical principles; fortunately, however, in its application to cases where great weights were to be supported, the errors were on the safe side. Profound theoretical investigations have been made by Euler and others on the resistance of pillars to *incipient flexure;* the results are valuable, but are not directly available for the wants of practice.

In the year 1840, Mr. Hodgkinson of Manchester, England, presented to the Royal Society his first paper on the strength of cast-iron pillars.† It contains an account of an elaborate series of experiments, on a large scale, made at the expense of William Fairbairn of Manchester, and affording ample data for determining the formulas for computing the breaking weights of solid and hollow cylindrical pillars of cast-iron, and of ordinary dimensions. The formula determined by Hodgkinson from these experiments for hollow cylindrical cast-iron pillars, the lengths being not less than thirty times the external diameters, and the ends being flat, that is to say, with the ends finished in planes perpendicular to the axis, the weight being uniformly distributed on these planes, is

$$W = 99{,}318 \frac{D^{3.55} - d^{3.55}}{l^{1.7}}, \qquad (1)$$

* Practical Essay on the Strength of Cast-iron and other Metals. By Thomas Tredgold, London, 1822, and three subsequent editions.

† Experimental Researches on the Strength of Pillars of Cast-iron and other Materials. By Eaton Hodgkinson. Philosophical Transactions of the Royal Society of London, for 1840. Part II.

in which

W = the breaking weight, in pounds.
D = the external diameter, in inches.
d = the internal diameter, in inches.
l = the length in feet.

When the pillars were shorter than thirty external diameters, it was found that they would break with less weight than is given by formula (1). In a long pillar the pressure tends to break it by crushing as well as by flexure, but it fails from flexure with a weight which is too small to sensibly affect it by crushing alone. In a short pillar, on the other hand, the weight required to break it by flexure is so great that the crushing effect becomes sensible, and it fails from the joint effects of the force. It was found by experiment that the effect of the crushing force became sensible when the pillars with flat ends were shorter than thirty times the external diameter, and the formula given by Hodgkinson for the breaking weight of such pillars is

$$W' = \frac{W c}{W + \frac{3}{4} c}; \qquad \text{(A)}$$

in which

W = the breaking weight by formula (1).
W' = the breaking weight for the combined effects of flexure and crushing.
c = the weight which would crush the pillar without flexure, which Hodgkinson finds for Low Moor iron, No. 3, is 109,801 pounds per square inch of section; consequently,

$$c = 109{,}801 \times \tfrac{1}{4} \pi (D^2 - d^2).$$

Substituting the value of c in (A), and reducing, we have

$$W' = \frac{86238 \, (D^2 - d^2) \, W}{W + 64678 \, (D^2 - d^2)}.* \qquad (2)$$

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* In computing the breaking weights of a series of pillars, in order to preserve continuity in the results obtained by formulas (1) and (2), it is necessary at the point where one formula is substituted for the other that we should have

$$W = W';$$

consequently, at this point

$$86238 \, (D^2 - d^2) = W + 64678 \, (D^2 - d^2).$$

Substituting the value of W in (1), and reducing, we have

$$l = 2.456 \left(\frac{D^{3.55} - d^{3.55}}{D^2 - d^2}\right)^{\frac{1}{1.7}}.$$

Numerous experiments were also made on pillars with the ends rounded, so that the weights bore on the axis. Most of these experiments were made on solid pillars; the hollow ones had hemispherical caps fitted on the ends. It was found that their breaking weight was about one third that of pillars of the same dimensions with flat ends. Some experiments were made on pillars with one end flat and the other end rounded; their breaking weight was about two thirds that of pillars of the same dimensions with both ends flat.

Hodgkinson determined separate formulas for the breaking weights of both solid and hollow cast-iron pillars, with flat ends and also with

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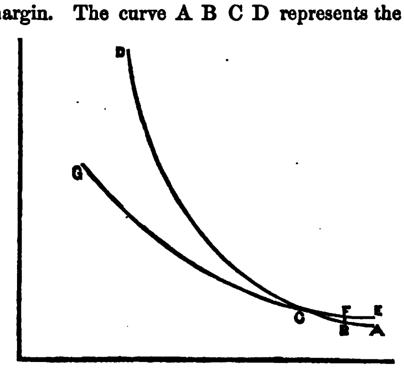
For simplicity, confining ourselves to solid pillars, in which $d = 0$, we have, by substituting this value in the last equation,

$$l = 2.456 \; D^{0.91}$$

l, in this formula, is the length, in feet, of a solid pillar of the diameter D, in inches, for which formulas (1) and (2) give the same breaking weight.

When $D = 0.1$	$\therefore l = 0.3022$ feet	$= 3.6264$ inches	$= 36.264$ diameters.
" $D = 0.821$	$\therefore l = 2.0525$ "	$= 24.6300$ "	$= 30.000$ "
" $D = 5.0$	$\therefore l = 10.6240$ "	$= 127.4880$ "	$= 25\ 498$ "
" $D = 10.0$	$\therefore l = 19.9630$ "	$= 239.5560$ "	$= 23.956$ "

The substitution of formula (2) for formula (1), for pillars of lengths less than 30 diameters, is for the purpose of diminishing the computed breaking weights to conform to the diminished strength of such pillars, on account of the crushing effects of the weights; but in all solid pillars of more than 0.821 inch in diameter there are certain lengths in which the substitution of formula (2) for (1) has the contrary effect; thus, in a pillar 5 inches in diameter, for all lengths between 25.498 diameters and 30 diameters, the breaking weights computed by formula (2) exceed those computed by formula (1), the maximum excess being about 6 per cent. This is illustrated by the diagram in the margin. The curve A B C D represents the breaking weights of solid pillars, 5 inches in diameter, by formula (1), and the curve E F C G the same by formula (2), the abscissas being the lengths in diameters, and the ordinates the breaking weights. The curves intersect at the point C, the abscissa of which is 25.498. According to Hodgkinson the breaking weights are represented by A B F C G, the abscissa of the points B and F being 30.



rounded ends; for practical purposes, however, formulas (1) and (2) are sufficient, recollecting that in a solid pillar $d = 0$, and that the breaking weight of a pillar with rounded ends is one third of that given by formulas (1) and (2). The breaking weight of pillars with rounded ends is so much less than that of pillars with flat ends, that Hodgkinson did not find the crushing effect sensible in pillars with rounded ends when longer than fifteen external diameters; consequently, one third the value of W′, as given by formula (2), will be less than the true breaking weight, when the formula is applied to pillars with rounded ends of lengths between fifteen and thirty diameters. For simplicity, however, I propose to adopt thirty diameters as the limit between formulas (1) and (2), whether the ends are flat or rounded. The errors resulting will be on the side of security, and in ordinary cases, not being large, may be neglected. In a solid pillar with rounded ends, 10 feet long and 8 inches in diameter, the computed breaking weight is about one fourth too small.

Two experiments were made by Hodgkinson on pillars with the pressure applied at intermediate points, between the centre and circumference. When the pressure was applied parallel to the axis, and half-way between the axis and one side, the breaking weight was about 54 per cent of the breaking weight of a pillar of the same dimensions with the ends rounded, so that the pressure was applied at the axis. In another experiment, the pressure was applied at one eighth of the diameter from one side; in this case, the breaking weight was about 61 per cent of that of a pillar of the same dimensions with rounded ends. In two experiments the pressure was applied in the direction of a diagonal; in both cases the breaking weight was nearly the same as for pillars of the same dimensions with rounded ends. A few experiments were also made on pillars with rounded ends, and other forms than cylindrical. Square pillars had an average breaking weight about 58 per cent greater than cylindrical pillars of diameters equal to the sides of the squares. The square pillars generally failed in the direction of the diagonals. A pillar of the section ✚, 90.75 inches long, 3 inches across, and the ribs 0.48 inch thick, had a breaking weight 63 per cent greater than the computed breaking weight of a solid cylindrical pillar of the same weight and length. A hollow cylindrical pillar of the same weight and length, and of an external diameter equal to the width of the ✚, has a computed breaking weight about double that found by experiment for the form ✚. A pillar of the section H, 3 inches in height and 2.5 inches in width, of the same length and nearly the same sectional area as the preceding, had a breaking weight about 2.6 times the computed breaking weight of a solid cylindrical pillar of the same weight and length. A hollow pillar, 3 inches in external diameter, and of the same weight and length, has a computed breaking weight about 19 per cent greater than was found by experiment for the pillar of H section.

Several pillars, larger in the middle than at the ends, were tested for the purpose of determining the most economical form; the experiments were not sufficiently numerous or varied to permit any definite conclusions to be drawn. It would appear, however, that in pillars with rounded ends there is a distinct advantage in making them somewhat larger in the middle than at the ends; that is to say, a pillar may be made of this form which would have a breaking weight greater than a cylindrical pillar of the same weight. In pillars with flat ends there is less advantage in departing from the cylindrical form. Hodgkinson observed that pillars with rounded ends generally broke at the middle only; pillars with flat ends generally broke in three places, at the middle and near each end.

In 1856, Hodgkinson presented a second paper, on the strength of cast-iron pillars, to the Royal Society.* Its special subject is the strength of pillars cast from iron from various parts of Great Britain. The experiments were made at University College, London, with a larger and more powerful apparatus than that which he previously used at Manchester. The pillars tested were longer and larger, and the results reported afford the means of testing, in a very satisfactory manner, the formulas previously determined. The earlier experiments were undertaken for the purpose of determining the laws according to which the breaking weights of pillars depended upon their dimensions. For this purpose, it was necessary to adhere to one description of iron. A Yorkshire iron, Low Moor, No. 3, was selected, which is described as a good iron, not very hard. The formulas were satisfactorily determined for this iron, but there was some risk in applying them to pillars cast from other descriptions of iron, without further experiments. In the second paper, experiments are described on pillars cast from thirteen kinds of iron, — two of them being mixtures.

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* Experimental Researches on the Strength of Pillars of Cast-iron, from various Parts of the Kingdom. By Eaton Hodgkinson. Philosophical Transactions of the Royal Society of London for 1857. Part III.

For the purpose of effecting a systematic comparison between the breaking weights by the experiments of 1856 and the breaking weights computed by the formulas of 1840, the three following tables have been computed, the data being extracted from Hodgkinson's paper of 1856.

TABLE I.

Designation of the Experiments in Hodgkinson's Tables.	Description of the iron from which the pillars were cast.	External diameter.	Internal diameter.	Length.	Breaking weight by formula (1).	Breaking weight by experiment.	Proportional difference.
		In.	In.	Ft.	Lbs.	Lbs.	
Tab. I. Exp. 1	Low Moor, No. 2	2.513	1.941	10.00	31,334	34,804	+0.1107
" " 2	" "	2.520	1.903	10.00	33,268	39,166	+0.1773
" " 3	" "	3.021	2.354	10.00	58,966	66,259	+0.1237
" " 4	" "	3.035	2.354	10.00	60,627	69,932	+0.1535
" " 5	" "	3.532	2.659	10.00	110,990	110,649	—0.0031
" " 6	" "	3.555	2.693	10.00	112,122	114,479	+0.0210
" " 7	" "	3.804	3.170	9.75	113,149	112,127	—0.0090
						Mean proportional difference	+0.0820

Table I. gives the dimensions and the breaking weights by formula (1) and by experiment of several long, hollow pillars with flat ends, made of Low Moor iron, No. 2. It will be seen that the breaking weights by experiment vary from about eighteen per cent greater to about one per cent less than the computed breaking weights, the mean being about eight per cent greater.

Table II. gives the dimensions and breaking weights of solid pillars with flat ends, cast from several kinds of iron made in Great Britain; also the breaking weights of the same pillars, computed by formula (1). It will be observed that the breaking weights by experiment vary from about thirty per cent greater to about fifteen per cent less than the breaking weights computed by the formula, the mean being about nine per cent greater.

TABLE II.

Designation of the Experiments in Hodgkinson's Tables.	Description of the iron from which the pillars were cast.	Diameter.	Length.	Breaking weight by formula (1).	Breaking weight by experiment.	Proportional difference.
		In.	Ft.	Lbs.	Lbs.	
Tab. II. Ex. 11	Low Moor, No. 2	2.553	10.00	55,215	55,973	+0.0137
" " 12	" "	2.539	10.00	54,148	55,973	+0.0337
" " 13	Blaenavon, No. 3	2.556	10.00	55,446	56,914	+0.0265
" " 14	" "	2.546	10.00	54,680	57,855	+0.0581
Tab. III. Ex. 1	Old Park, No. 1	2.503	10.00	51,471	66,792	+0.2977
" " 2	" "	2.526	10.00	53,170	65,381	+0.2297
" " 3	Derwent, No. 1	2.529	10.00	53,394	57,855	+0.0835
" " 4	" "	2.517	10.00	52,500	66,733	+0.2711
" " 5	Portland, No. 1	2.493	10.00	50,745	59,736	+0.1772
" " 6	" "	2.527	10.00	53,245	62,559	+0.1749
" " 7	Calder, No. 1	2.490	10.00	50,528	60,677	+0.2009
" " 8	" "	2.519	10.00	52,649	60,677	+0.1525
" " 9	1st London Mixture, ½ old iron	2.533	10.00	53,695	54,562	+0.0161
" " 10	" "	2.548	10.00	54,832	59,266	+0.0809
" " 11	Level, No. 1	2.518	10.00	52,575	54,091	+0.0288
" " 12	" "	2.501	10.00	51,325	56,443	+0.0997
" " 13	Coltness, No. 1	2.516	10.00	52,426	56,443	+0.0766
" " 14	" "	2.496	10.00	50,962	48,917	—0.0401
" " 15	Carron, No. 1	2.506	10.00	51,691	52,210	+0.0100
" " 16	" "	2.510	10.00	51,984	53,151	+0.0224
" " 17	Blaenavon, No. 1	2.487	10.00	50,313	48,917	—0.0277
" " 18	" "	2.499	10.00	51,180	49,858	—0.0258
" " 19	Old Hill, No. 1	2.520	10.00	52,723	44,683	—0.1525
" " 20	" "	2.523	10.00	52,946	45,154	—0.1472
" " 21	2d London Mixture, ⅜ old iron	2.511	10.00	52,058	63,499	+0.2198
" " 22	" "	2.496	10.00	50,962	58,325	+0.1445
" " 23	" "	1.530	10.00	8,968	11,204	+0.2493
" " 24	" "	1.541	10.00	9,199	10,868	+0.1814
				Mean proportional difference		+0.0877

Table III. gives the results of experiments on solid pillars, cut out of the fragments of the pillars, 10 feet long, used in previous experiments, the results of which are given in Tables I. and II. In the last six experiments in Table III. the pillars were cut out of the fragments formed in the preceding experiments in the same table. The ends of all of them were turned flat and perpendicular to the axis. It will be seen that the breaking weights by experiment vary from about thirty-three per cent greater to about twenty-three per cent less than the breaking weights computed by formulas (1) and (2), the mean being about five per cent greater.

TABLE III.

Designation of the Experiments in Hodgkinson's Tables.	Description of the iron from which the pillars were cast.	Diameter.	Length.	Breaking weight by formula (1) or (2).	Breaking weight by experiment.	Proportional difference.
		In.	Ft.	Lbs.	Lbs.	
Tab. IV. Ex. 1	Old Park, No. 1	2.526	7.50	86,709	100,191	+0.1555
" " 2	" "	2.503	7.50	83,938	95,487	+0.1376
" " 3	Derwent, No. 1	2.517	7.50	85,617	105,365	+0.2307
" " 4	Portland, No. 1	2.527	7.50	86,830	102,543	+0.1810
" " 5	Calder, No. 1	2.490	7.50	82,401	93,135	+0.1303
" " 6	1st Lond. Mixture, $\frac{1}{2}$ old iron	2.548	7.50	89,419	93,605	+0.0468
" " 7	Level, No. 1	2.501	7.50	83,700	98,309	+0.1745
" " 8	Coltness, No. 1	2.516	7.50	85,496	87,019	+0.0178
" " 9	Carron, No. 1	2.506	7.50	84,296	72,437	—0.1407
" " 10	Blaenavon, No. 1	2.500	7.50	83,582	71,967	—0.1390
" " 11	Low Moor, No. 2	2.539	7.50	88,303	89,371	+0.0121
" " 12	Blaenavon, No. 3	2.556	7.50	90,420	85,608	—0.0532
Tab. V. Ex. 1	Derwent, No. 1	2.529	6.25	122,990	112,438	—0.0858
" " 2	1st Lond. Mixture, $\frac{1}{2}$ old iron	2.533	6.25	123,615	114,320	—0.0752
" " 3	Level, No. 1	2.518	6.25	121,284	131,275	+0.0824
" " 4	Old Hill, No. 1	2.523	6.25	122,058	93,622	—0.2330
" " 5	2d Lond. Mixture, $\frac{2}{3}$ old iron	2.511	6.25	120,206	127,432	+0.0601
" " 6	" "	2.496	6.25	113,305	116,672	+0.0297
" " 7	" "	1.530	6.25	19,938	26,527	+0.3305
" " 8	" "	1.530	6.25	19,938	24,763	+0.2420
" " 9	" "	1.541	6.25	20,452	25,939	+0.2683
" " 10	" "	1.528	3.00	63,218	57,384	—0.0923
" " 11	" "	1.544	3.00	65,266	70,555	+0.0810
" " 12	" "	1.527	3.00	63,091	57,856	—0.0830
" " 13	" "	1.531	2.50	77,812	85,138	+0.0941
" " 14	" "	1.530	2.50	77,662	72,907	—0.0612
" " 15	" "	1.515	2.50	75,433	70,555	—0.0647
					Mean proportional difference	+0.0462

In his second paper, Hodgkinson also describes a few experiments on square pillars and on pillars with the section of an equilateral triangle; these were compared with cylindrical pillars; two of each pattern were tested, all being cast from the same kind of iron, and were of the same length and nearly the same weights. The relative strengths, reduced to the same weights, were as follows:—

Cylindrical pillar, 100.
Square " 93.
Triangular " 110.

In many of the hollow pillars tested, Hodgkinson found that at the place of fracture the metal was much thicker on one side than on the other; it would be reasonable to expect that this would weaken them sensibly, but such was not generally the case. Thus, in the third experiment in Table I., the thickness on one side was 0.55 inch, and on the opposite side, 0.17 inch. In the fourth experiment in the same table, the relative thickness on opposite sides was as 2 to 1, nearly. In both of these experiments the breaking weights were above the mean. In the third experiment the direction of the flexure was such that the convex side coincided with the greatest thickness of metal; in the other experiment the convex side coincided with the least thickness. In most cases, however, the convex side coincided with the greatest thickness.

In experiment 1, Table IX., in Hodgkinson's paper of 1840, the pillar was 7 feet 4$\frac{3}{4}$ inches long, external diameter 1.78 inches, internal diameter 1.21 inches, the ends flat and well fitted. The ratio of the thickness on opposite sides of the ring of metal, at the place of fracture, was as 5 to 1. The convexity was on the thickest side. The breaking weight by experiment was 17,840 pounds, which is only about $\frac{1}{15}$ less than the breaking weight computed by formula (1).

The explanation of these remarkable results appears to me to be this: The weight being applied equally on all sides of the pillar, which is supposed to be straight when unloaded, the side having the least metal will be the most compressed; this will determine the direction of the flexure, so that its convexity will be on the thickest side. When the load is near the breaking weight, the convex side, near the middle, is subject to a tensile force, and the concave side to a crushing force. Hodgkinson found that it required seven or eight times the force per square inch to crush the kind of iron he used that it did to rupture it by a tensile force, and although the sum of the crushing forces, acting on one portion of the horizontal section at the place of fracture, largely exceeds the sum of the tensile forces acting on the other portion of the same section, the difference in the powers of the metal to resist the two forces is so great that, in a long pillar, a much less area of section is required to resist the sum of the crushing forces than to resist the sum of the tensile forces. If the iron from being harder on the thin side is less compressible on that side, or if the weight is not equally distributed on all sides, or if the pillar is not straight when unloaded, the direction of the flexure, when loaded, may be such that the convexity is on the thin side; in this case the deflection caused by the load will depend on the compression of the thick side; from the greater area subject to compression the amount of the compression, and consequently of the deflection, will be less than if the sides are of equal thickness. In either case, when the inequality in the thickness on opposite sides is not too much, the pillar may support a load as great, or even greater, than if the thickness was equal on all sides.

Hodgkinson determined a new formula for the breaking weight of hollow cylindrical pillars cast from Low Moor iron, No. 2, from the experiments given in his second paper, viz.: —

$$W = 94859 \frac{D^{3.5} - d^{3.5}}{l^{1.63}}. \qquad (3)$$

Formula (1) was determined from the experiments given in the first paper, which, from their wider range of dimensions, are much better fitted for such an induction than the experiments given in the second paper.

Table IV. contains a comparison between the breaking weights by experiment and by formulas (1) and (3). The pillars were all cast from Low Moor iron, No. 2, and are the same as those given in Table I. It will be seen that the computed breaking weights by formula (3) agree best with the breaking weights by experiment in the smaller pillars, and the computed breaking weights by formula (1) agree best with experiment in the larger pillars. On the whole there appears to be no doubt that formula (1) is the best determined and the safest to adopt in practice.

TABLE IV.

Designation of the Experiments in Hodgkinson's Tables.	External diameter.	Internal diameter.	Length.	Breaking weight by experiment.	Breaking weight by formula (1).	Breaking weight by formula (3).
	In.	In.	Ft.	Lbs.	Lbs.	Lbs.
Tab. I. Exp. 1	2.513	1.941	10.00	34,804	31,334	33,289
" " 2	2.520	1.903	10.00	39,166	33,268	35,350
" " 3	3.021	2.354	10.00	66,259	58,966	62,059
" " 4	3.035	2.354	10.00	69,932	60,627	63,798
" " 5	3.532	2.659	10.00	110,649	110,990	115,971
" " 6	3.555	2.693	10.00	114,479	112,122	117,103
" " 7	3.804	3.170	9.75	112,127	113,149	117,362

In applying the formulas to practice, it is of the greatest importance to determine the proper allowance to be made for possible defects, and to insure complete security against fracture, using no more material than is necessary. In doing this, many things should be considered.

The experiments from which the formulas are deduced were made on pillars of smaller dimensions than those commonly used, and they were very carefully cast from Low Moor iron, No. 3. The strength of iron in small castings is usually greater than in large castings.

Low Moor iron has a very high reputation; its transverse strength, however, by Hodgkinson's experiments, appears to be less than that of many other kinds of iron. The different qualities of iron are usually classed as Nos. 1, 2, and 3, differing from each other in the appearance and properties of the material. No. 1 includes the softest and richest irons, those having the largest crystals, and containing generally the most carbon; No. 3, the hardest and densest irons, those having the smallest crystals; No. 2 irons are intermediate between Nos. 1 and 3. No. 3 iron, although the least valuable, is usually the strongest. Castings made from a mixture containing a considerable portion of old metal have usually greater strength than castings from a simple iron (see Table II.) The cheapest irons thus appear to be the most suitable for making pillars.

The experimental pillars, from which the formulas are deduced, were cast in dry sand moulds, and most of them vertically, in order to obtain, as far as possible, uniformity in the texture of the iron. This is generally understood to be the best, as it is the most expensive mode of moulding; but casting vertically does not appear to produce the strongest castings. In the experiments made in 1856 at the Royal Gun Factories at Woolwich, England, on the strength of cast-iron,* fifty-three different kinds of iron were tested; bars were cast 22 inches long, and 2 inches square; in one half of them the moulds were laid horizontally, in the other half vertically; in nearly all cases the bars cast horizontally, when subjected to a transverse strain, had a greater breaking weight than those cast vertically; the average being about 19.5 per cent greater. Founders prefer to cast pillars in moulds laid horizontally, or nearly so, on account of economy; there is, however, much greater liability to imperfections in the castings than when cast vertically.

In the experimental pillars great care appears to have been taken to make them straight; a small variation from a straight line in the axis of a pillar will, in general, weaken it materially; this is a defect, however, which can be readily detected.

In the experiments on pillars with flat ends, much care was taken to have the weight uniformly distributed over the whole area of the metal at the ends; this is not an easy matter to accomplish in so unyielding a material as cast-iron; it can be most readily done by interposing a

* Cast-iron experiments ordered, by the House of Commons, to be printed, July 30, 1858.

plate of more ductile metal, such as copper, between the two surfaces of cast-iron. Although this was not done in testing the experimental pillars, there can be no doubt but that they were much better fitted in this respect than can be expected in ordinary practice.

The experimental pillars were tested in a rigid iron frame, which must have secured them from sensible vibration, except for the moments when the weights were applied. In many structures in which cast-iron pillars are used, such as factories, they are pretty constantly subject to vibration; what effect this has in weakening the pillar, it is not easy to estimate; the additional strain tending to produce fracture by lateral flexure must be in some proportion to the amplitude of the vibrations; in pillars of ordinary length and size, such as are commonly used in factories, the amplitudes of the vibrations are very small; although they may be very sensible to the touch, they are usually too small to be detected by the eye; this being the case, it would appear that, ordinarily, the additional strain due to the vibration is very small. It has been a common opinion that long-continued vibration, although very small in amplitude, causes a change in the structure of iron, rendering it more liable to break; of late, however, this notion appears to have been abandoned by those best informed.

In testing the experimental pillars, sufficient weight was applied to break the pillar in a short time, and it is certain that a somewhat less weight would have produced fracture in each case, if applied during a sufficiently long period of time. Fairbairn made some experiments on this point.* He loaded a pillar with 97 per cent of the weight which had previously broken another pillar of the same dimensions; it bore this weight between five and six months, and then broke. In another pillar, loaded with 75 per cent of the weight which had broken another of the same dimensions, at the end of three years its lateral deflection was still increasing slightly; this does not indicate, however, that it would ultimately fail, as we find the deflection of bars of cast-iron subject to a lateral strain increasing for a much longer time, although loaded with from 70 to 96 per cent of the weight which broke another bar of the same dimensions and material. Fairbairn,† referring to his

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* Tredgold on Cast-iron. Part II., 4th London edition.

† On the Application of Cast and Wrought Iron to Building Purposes. By William Fairbairn. London, 1854.

experiments on the progressive deflection of bars of cast-iron, subjected to a transverse strain for a period of about five years, remarks as follows: —

"Viewing the whole of these experiments in relation to the solution of a problem affecting the laws which regulate the resistance of bodies to continuous strain, it is important to observe how admirably the cohesive powers of matter adapt themselves to circumstances, and with what tenacity they resist forces tending to dissever and rupture their parts.

"It is still a question for consideration how far this power extends, and whether or not bodies, when loaded within even $\frac{1}{1000}$ part of their breaking weight, would sustain the load forever, provided that no disturbing cause were present to produce fracture.

"I am strongly inclined to think that such would be the case, notwithstanding the fact that the whole of the loaded bars exhibit a progressive increase of deflection, which fact I am disposed to attribute to the vibrations continually going on in the building where the bars were fixed, and to those atmospheric changes, such as temperature, oxidation, &c., to which every description of material is subject."

I think we may safely infer that a pillar, not subject to disturbances, may be loaded with a very large proportion of its breaking weight, say $\frac{9}{10}$, or more, for a time indefinitely long without breaking; but that a pillar, loaded with a weight a very little less than just sufficient to break it in a short time, will be liable to break within an indefinitely long time; and that this time will be much shortened if the pillar is subject to vibration.

Pillars in some situations, such as warehouses, are subject to concussions from bodies falling on a floor above; the effect of this on the pillar would be much weakened by the mass of the floor, and it can scarcely happen when the pillar is otherwise loaded to the full extent it is designed to support.

We have seen that the formulas for the breaking weight are deduced from experiments made on small pillars, very carefully cast from iron of superior quality; when the same formulas are applied to pillars made of iron of inferior quality for the purpose, and are less carefully cast, it is reasonable to expect that the computed breaking weight will be too great. From what has been stated above, however, it may be inferred that, if the pillars are cast straight and sound, they will, in general, be as strong when made of the cheaper material and by the cheaper mode of casting, as the experimental pillars of Hodgkinson.

We have seen, also, that when the formulas were applied to experimental pillars of somewhat larger dimensions than those from which the formulas were deduced, cast from different kinds of iron, that the actual breaking weights generally exceeded the breaking weights computed by the formulas.

In practice pillars are subject to the effects of vibration and time, which tend to cause them to fail when loaded with less than the computed breaking weights.

What allowance should be made to cover all unfavorable influences, and to afford sufficient surplus strength to insure complete security against failure, is a matter of opinion, and one in which the most experienced and skilful may differ widely.

In 1847, a commission was appointed by the British government to inquire into the application of iron to railway structures. This commission obtained the opinions of the most eminent English engineers and constructors, and in the appendix to their report* they give the following analysis of the evidence relating to cast-iron beams or girders: —

"There appears to be a considerable difference of opinion as to the proportion between the greatest load which a girder should be allowed to bear and the breaking weight. There are two conditions under which the weight may be applied, viz.: 1st, when stationary, as in the case of water-tanks, floors, &c.; 2d, when the weight moves so as to cause concussions and vibrations, as in railway bridges. In girders required for the first case, Mr. Fox and Mr. T. Cubitt consider that the breaking weight should be three times the greatest load; Mr. P. W. Barlow, four times; and Mr. Glynn would not make it less than five times the load.

"In girders for railway bridges, Mr. Brunel states that he allows the load to be $\frac{1}{3}$, or $\frac{2}{5}$, of the breaking weight; but he considers that the rule he adopts for calculating the dimensions of his girders gives more than the usual strength. Mr. Grissell and Mr. Charles May consider $\frac{1}{3}$ to be sufficient; Mr. Rastrick, Mr. P. W. Barlow, Mr. R. Stephen-

* Report of the Commissioners appointed to inquire into the Application of Iron to Railway Structures. London, 1849.

son, and Mr. Joseph Cubitt adopt $\frac{1}{6}$; Mr. Hawkshaw prefers $\frac{1}{7}$, except in cases where great care is exercised in the selection of materials and workmanship, when a smaller proportion would suffice; and Mr. Glynn considers that, in structures exposed to concussion and vibration, the ultimate strength of a girder should be 10 times the greatest load."

Defects in material and workmanship are as likely to occur in girders as in pillars, and, with the exception of defective alignment, the defects in girders must be at least as injurious, and require as large an allowance of surplus strength to provide for them as is required to afford the same degree of security in pillars. In determining the proper allowance to be made for security, regard should be had to the consequences of failure. In most of the large modern buildings erected for commercial and industrial purposes, cast-iron pillars are extensively used for supporting the floors, and in many cases the walls of the upper stories are supported in the same manner. The failure of the pillars, in such cases, involves such disastrous consequences, that no economical considerations would warrant the use of pillars of insufficient or doubtful strength.

It is possible that a single pillar, although ample to support the superincumbent weight, may be broken by a lateral blow; in such an event, the neighboring pillars will usually have a large additional weight thrown upon them, and if they have not considerable surplus strength, the whole structure may be involved in ruin.

These considerations apply to girders as well as pillars, and no doubt they were taken into account by the experienced men whose opinions have been quoted.

It is very obvious that a large allowance of surplus strength must be provided to insure the complete security of a building depending for support on cast-iron pillars; the various considerations which have been offered do not, however, afford any definite data for determining the amount of this allowance. The only safe course is to rely upon the practice and opinions of experienced engineers and constructors. Taking all things into account, it appears to me that, in pillars made with ordinary care to support walls and floors, to insure complete security without using more material than is necessary, the greatest load should be about one fifth of the computed breaking weight; and I have adopted this as the rule in computing the following tables.

Whatever allowance of surplus strength may be made for defects, there must be some assurance that the pillars will be cast with, at least, ordinary care. The best guaranty is to employ a founder of known skill and integrity. Some defects can be readily detected by inspection. Pillars having considerable imperfections in the casting should, of course, be rejected. In moulding hollow pillars of ordinary dimensions, the core should be made in one piece; if of more than one piece lengthwise, there is danger of injurious irregularities in the thickness at the junctions of the several parts. In moulding long hollow pillars, it is usual to insert small pieces of iron, called chaplets, to prevent the rising of the core, which, in pillars cast horizontally, is the principal cause of irregularity in the thickness; the chaplets remain, and form part of the pillar; they are frequently the cause of imperfections in the casting, but without using them it appears to be impracticable to make the iron of uniform thickness; a considerable inequality, however, in this respect does not weaken the pillar materially; but it should not be inferred, because Hodgkinson found that pillars in which the thickness on opposite sides varied as much as 3 to 1, were not sensibly weaker than those in which the thickness was uniform, that this irregularity may be disregarded; in Hodgkinson's experiments great care was taken to make sound castings, and also to make the pillars straight, often by turning them in a lathe when not cast straight. Some inequality in thickness must, however, be admitted, if the pillars are cast without chaplets; the extent of the inequality can be ascertained by means of long callipers; in my opinion it should not exceed the proportion of 2 to 1.

Cast-iron pillars are liable to be made crooked from two causes, well known to founders. If the iron is much thicker on one side of a hollow pillar than on the other, the thick side cooling last strains the thin side, and frequently produces a curvature. If the pillar is taken out of the mould while very hot, and laid on supports not furnishing a uniform bearing throughout its length, it is very liable to become bent. It is too much to expect that long pillars will be cast quite straight. I examined ten hollow pillars supporting five floors and the roof of a cotton-mill; I have no doubt they were cast with, at least, ordinary care; I found none of them quite straight. The pillars were about 11.5 feet long, 6 inches in diameter, and about 0.75 inch thick; the average deviation from a straight line in ten feet, which is all that could be conveniently measured, was about 0.03 foot; in other words, considering the axis to be the arc of a circle, the chord of which was 10 feet, the average versed sine was about 0.03 foot. In one pillar the deviation was about 0.08 foot. These pillars were well-fitted with flat ends, and loaded with less than one tenth of their computed breaking weight. A small part of the observed curvatures must have been due to the load. It may be necessary to admit a curvature when unloaded of $\frac{1}{300}$ of the length as a maximum, which in ten feet would give a versed sine of 0.033 foot.

It is usual to make round pillars a little smaller at the upper end than at the middle, frequently both ends are smaller; this is advantageous in strength with the same weight of iron, and also in appearance; the difference should not much exceed one tenth of the diameter. If smaller at both ends than at the middle, the surface of the pillar should be regularly curved from one end to the other; when so made a small deviation in the axis from a straight line is less observable.

In estimating the amount of the greatest load to which a pillar may be subjected, doubtful points should be taken on the safe side. In warehouses and stores, it would not be safe to take the ordinary load on the floors; they are liable to be packed full of heavy goods. When a warehouse or store is erected for a particular use, it will seldom be safe to estimate the weight due to that particular use; it should be made for the greatest weight due to any use to which such a building may be applied in the ordinary course of business. In modern cotton-mills with wooden floors I have found that the average weight, including the floor itself, the machinery, shafting, stock in process of manufacture, &c., is about 50 pounds per square foot of floor, and a flat roof when loaded with snow is liable to be as heavy. It is not safe, however, to take the average weight, as some pillars will have to support more and some less than the average; I think an addition of one fifth should be made to the average weight for the possible excess. In warehouses and stores, the weights to be provided for are usually much greater than in factories.

In pillars to support railway bridges, or other structures subject to violent concussions or vibrations, a less proportion than one fifth of the breaking weight should be allowed. In experiments on the deflections of railway bridges with a stationary load and with the same load moving at a high velocity, a greater deflection has been observed in the latter case, indicating a corresponding increase of the strain. The increased strain will, however, be principally felt in the girders, and will be only partially communicated to the pillars or other supports of the bridge.

Formulas (1) and (2) give the breaking weights of cast-iron pillars with the ends carefully fitted, so that the weight will be uniformly distributed on all sides; in ordinary constructions the ends are frequently unfinished, the inequalities in the bearing surfaces causing the weight to rest on a few points of the ends; the breaking weight of the pillar, in such case, cannot safely be taken as greater than that of a pillar with rounded ends, which, as we have seen, is about one third that of a pillar with flat ends. In cotton-mills, and many other structures largely supported by cast-iron pillars, the ends of the pillars are frequently turned, corresponding in this respect to the experimental pillars with flat ends; it would generally not be safe, however, to assume that they are as perfectly fitted as they were in the experiments; when put in place it must frequently happen that they will be canted a little, causing the bearing to fall on one edge; it will, accordingly, not be safe to assume that formulas (1) and (2) apply to this case without modification. If the ends are as perfectly fitted as they were in the experimental pillars, the breaking weight would be three times as great as in pillars with rounded ends; if one end is well fitted and the other end rounded, the breaking weight is twice that of pillars with both ends rounded; it would seem, therefore, that we may safely assume that, when pillars with flat ends are fitted and put up with ordinary care, they will support one and a half times as much as pillars with rounded ends, or, what is equivalent, one half the weight of pillars fitted and put up as perfectly as in the experiments.

The following tables have been computed by formulas (1) and (2), taking one third of the breaking weight as given by them for the breaking weight of a pillar with rounded ends, and one fifth of this last breaking weight as the safe weight for a pillar with rounded ends, or, what we assume to be equivalent, with the ends not turned. The safe weights for the other cases can be easily deduced from the same tables, as will be seen in the explanation of their use.

Tredgold's table was generally relied upon by constructors, until the publication of Hodgkinson's experiments. The same table reappears in the fourth edition of Tredgold's work, edited by Hodgkinson, with the note that "This table has no solid basis." As no other table is given, however, it is probable that its use has been continued by many persons not accustomed to such computations. Table V. contains a comparison of the safe weights, in tons of 2,000 pounds, which several solid pillars will support according to Tredgold's table, and according to Hodgkinson's formulas (1) and (2), taking one fifth of the breaking weight of a pillar with rounded ends as the safe weight. It will be seen that in the smaller pillars Tredgold gives a larger weight than according to Hodgkinson, while in the larger pillars Tredgold's weight is less than Hodgkinson's. It is remarkable, however, considering the origin of Tredgold's table, that they should differ so little.

TABLE V.

Diameter of the pillar.	Safe weight a pillar 8 feet long will support,		Safe weight a pillar 10 feet long will support,		Safe weight a pillar 12 feet long will support,	
	According to Tredgold.	According to Hodgkinson.	According to Tredgold.	According to Hodgkinson.	According to Tredgold.	According to Hodgkinson.
In.						
2.0	2.74	1.13	2.24	0.77	1.79	0.57
2.5	5.10	2.50	4.31	1.71	3.64	1.25
3.0	8.12	4.77	7.17	3.26	6.22	2.39
3.5	11.98	8.38	10.70	5.64	9.63	4.14
4.0	16.13	12.76	14.90	9.06	13.55	6.65
4.5	22.32	18.36	19.82	13.95	18.31	10.10
5.0	26.82	25.28	25.31	19.46	23.91	15.38
6.0	32.09	43.31	30.80	34.15	29.40	27.46
7.0	55.38	67.26	53.70	54.20	51.74	44.30
8.0	72.18	97.36	70.50	79.99	68.54	66.36
9.0	93.63	133.73	91.84	111.78	89.77	94.02
10.0	116.31	176.41	114.52	149.73	112.39	127.53

In the Journal of the Franklin Institute of Pennsylvania, commencing in the number for November, 1861, there have appeared a large number of interesting and useful tables relating to the strength of pillars of various materials, computed by the formulas of Hodgkinson, Tredgold, and others, by W. Bryson, Civ. Eng. These tables mostly give the breaking weights of solid pillars. Similar tables of more limited extent may be found in other works, but none of them appear to meet the wants of the practical man.

Use of the Following Tables.

The weights are given in lawful tons of the State of Massachusetts, viz. of 2,000 pounds avoirdupois, and are the weights which can be borne with safety by cylindrical cast-iron pillars made with ordinary care and with rounded ends, or what are assumed for this purpose to be equivalent, with ends not finished in planes at right angles to the axis, and the weight not uniformly distributed over the whole area of the ends.

Rule for Cylindrical Cast-iron Pillars.

For practical purposes we may divide the use of cylindrical cast-iron pillars into three cases: —

1. Pillars with rounded ends, or put up as they come from the founder, or with only the prominent irregularities at the ends chipped off, or however the ends may be, if the weight is very unequally distributed over their surfaces, or if unequal settlements may be apprehended. When the designer of the pillars has no control over the execution of the work or any guaranty that his directions will be minutely followed, his only safe course will be to consider them in this case. The weights given in the tables are the safe weights the pillars will support in this case.

2. Pillars with the ends turned in a lathe, to planes at right angles to the axes, and put up with ordinary care, so that the weight will be distributed over the whole area of the ends; the pillars being made and put up under the eye of the person responsible for their sufficiency, or with such other guaranty for faithful workmanship as may be satisfactory to him. In this case, it is assumed that the safe weight is one and a half times that for a pillar with rounded ends, and may be found from the tables by adding one half to the tabular weight.

3. Pillars with the ends finished, and put up with the degree of perfection attained in Hodgkinson's experiments on pillars with flat ends. The safe weight in this case is three times that given in the tables.

Note. The tables give the dimensions of several pillars of nearly equal strengths, from which, of course, may be selected the pillar deemed most suitable for the intended purpose. If the pillar is made a little smaller at one or both ends than in the middle, its strength will be nearly the same as that of a cylindrical pillar of the same length and of a diameter equal to its middle diameter.

Example. Required the dimensions of a pillar 12 feet long, the greatest load to be supported by it being 25 tons.

If in the first case, we find at the page of the table headed, "Cylindrical pillars of cast-iron 12 feet long," taking the tabular weights, nearest to, but not less than, 25 tons, that if solid, the pillar must be 6 inches in diameter; if $\frac{3}{4}$ inch thick, $7\frac{1}{2}$ inches in diameter; if 1 inch thick, $6\frac{3}{4}$ inches in diameter, &c.

If in the second case, take $\frac{2}{3}$ of 25 tons, which is 16.67 tons; proceeding in the same manner as in the first case, we find that, if solid, the pillar must be $5\frac{1}{4}$ inches in diameter; if $\frac{3}{4}$ inch thick, $6\frac{1}{4}$ inches in diameter; if 1 inch thick, $5\frac{3}{4}$ inches in diameter, &c.

If in the third case, take $\frac{1}{3}$ of 25 tons, which is 8.33 tons; proceeding in the same manner, we find that, if solid, the pillar must be $4\frac{1}{2}$ inches in diameter; if $\frac{3}{4}$ inch thick, $4\frac{3}{4}$ inches in diameter; if 1 inch thick, $4\frac{1}{2}$ inches in diameter, &c.

In the absence of tables specially computed for the purpose, the use of the following tables may be extended to rectangular pillars of cast-iron, and to pillars both cylindrical and rectangular of some other materials.

Rule for Solid Square Cast-iron Pillars.

Calling the strength of a cylindrical pillar 100, the strength of a prismatic pillar of square section, whose side is equal to the diameter of the cylindrical pillar, according to different authorities, is as follows: —

According to Tredgold, when the distance of the direction of the force from the axis of the pillar is $\frac{1}{8}$ of the diameter . . 146

Also, according to Tredgold, when the neutral axis is at or near the axis of the pillar 170

According to three experiments on square cast-iron pillars with rounded ends, given in Table III. of Hodgkinson's paper in Phil. Trans. for 1840 158

According to experiments on two square cast-iron pillars and two cylindrical cast-iron pillars, all with flat ends, given in the appendix to Hodgkinson's paper in Phil. Trans. for 1858 . 143

Assuming the proportion to be as 100 to 150, the safe weight which can be supported by a solid square cast-iron pillar is given by the following rule: —

Determine the weight for a cylindrical cast-iron pillar, of a diameter equal to the side of the square pillar, by the preceding rule for the particular case; add one half to this weight, the sum will be the weight for the square pillar.

Rule for Solid Prismatic Cast-iron Pillars, whose Section is a Rectangular Parallelogram.

Find, by the rule for square cast-iron pillars, the weight for a square pillar whose side is equal to the small side of the parallelogram; multiply this weight by the long side of the parallelogram, and divide the product by the small side; the quotient is the safe weight required.

Rule for Hollow Rectangular Pillars.

Find by the preceding rules the weights for solid pillars of the outside and inside dimensions of the hollow pillar; subtract one from the other; the difference will be the safe weight for the hollow pillar.

Rule for Solid Cylindrical Wrought-iron Pillars.

According to Hodgkinson, calling the strength of a cast-iron pillar 1000, the strength of a wrought-iron pillar of the same dimensions is 1745. Then to find the safe weight for a solid cylindrical wrought-iron pillar, find, by the preceding rules for cylindrical cast-iron pillars, the weight for a cast-iron pillar of the same dimensions; multiply this weight by 1.745; the product will be the safe weight for the wrought-iron pillar.

Note. This rule must be confined to pillars very long in proportion to their diameters; say, in pillars with flat ends, to lengths of not less than 60 diameters. Hodgkinson's experiments indicate that wrought-iron pillars with flat ends, of lengths equal to 30 diameters, are only about one tenth stronger than cast-iron pillars of the same dimensions. In a single experiment on a wrought-iron pillar with flat ends, of a length equal to about 15 diameters, the strength was nearly 40 per cent less than that of a like pillar of cast-iron. This great difference in the relative strengths of cast and wrought-iron pillars of different lengths in proportion to the diameters, arises from the greater strength of wrought-iron to resist a tensile force, and its less strength to resist a crushing force, the strength of short pillars depending mainly on the power of the material to resist the latter force.*

Rule for Solid Square Wrought-iron Pillars.

Find by the preceding rule the weight for a solid cylindrical pillar of wrought iron, whose diameter is equal to the side of the square pillar; add one half to this weight, the sum will be the safe weight for the square pillar. The length of the pillars to which this rule applies is subject to the same limitations as in the preceding rule.

---

* Strength of cast-iron (Low Moor, No. 3) to resist a crushing force 109,801 pounds per square inch; to resist a tensile force 14,535 pounds per square inch (Hodgkinson). Then crushing strength to tensile strength as 7.55 to 1.

Strength of wrought-iron to resist a crushing force 36,000 to 40,000 pounds per square inch; to resist a tensile force 60,000 to 70,000 pounds per square inch (Rankine). Then crushing strength to tensile strength about as 1 to 1.7.

Rule for Solid Cylindrical Cast-steel Pillars.

According to Hodgkinson, calling the strength of a cast-iron pillar 1000, the strength of a cast-steel pillar, not hardened, of the same dimensions, is 2518. Then to find the safe weight for a solid cylindrical cast-steel pillar, find, by the preceding rules for cylindrical cast-iron pillars, the weight for a cast-iron pillar of the same dimensions, multiply this weight by 2.518, the product will be the safe weight for the cast-steel pillar.

*Rule for Solid Cylindrical Pillars of Dantzic Oak and Red Deal.**

According to Hodgkinson, calling the strength of a cast-iron pillar 1000, the strength of a pillar of the same dimensions of Dantzic Oak is 108.8 and of Red Deal 78.5. Then, to find the safe weight for solid cylindrical pillars of these materials, find, by the preceding rules for cylindrical pillars of cast-iron, the weight for a cast-iron pillar of the same dimensions; if for Dantzic Oak, divide this weight by nine, if for Red Deal, by thirteen, the quotient will be the safe weight for the wooden pillar.

Rule for Solid Square Pillars of Dantzic Oak and Red Deal.

Find the weight for a cylindrical pillar of a diameter equal to the side of the square pillar by the next preceding rule; add one half to this weight, the sum will be the safe weight for the square pillar.

---

* Barlow's formula for the breaking weight of a beam supported at each end and loaded in the middle is, $S = \frac{W l}{4 a d^2}$; in which S is a constant to be determined by experiment, W the breaking weight, l the length between the points of support, a the breadth and d the depth of the beam, the dimensions being all in inches.

For Dantzic oak (so called in England from the place of shipment), from experiments by Barlow and Moore . . . . S = 1518
For American White Oak (*Quercus alba*), from experiments by Nelson . . . . S = 1699
For Red Deal (*Pinus sylvestris*, Scotch Fir, Riga Fir), from experiments by Barlow . . . . S = 1165
For American White Pine (*Pinus strobus*), from experiments by Nelson . . . . S = 1456

The values of S do not necessarily give the relative strengths of different woods when used for pillars; they, however, afford some indication, and we may conclude, from the values quoted, that we may safely adopt the rule for pillars of Dantzic Oak for pillars of American White Oak, and the rule for pillars of Red Deal for pillars of American White Pine.

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in								
Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	1.13	0.92	1.03					
2¼	1.72	1.31	1.50	1.62				
2½	2.50	1.79	2.09	2.28	2.40			
2¾	3.50	2.37	2.80	3.09	3.29	3.41		
3	4.77	3.05	3.64	4.07	4.36	4.56	4.67	
3¼	6.61	3.62	4.43	5.07	5.57	5.94	6.21	6.39
3½	8.38	4.30	5.30	6.12	6.77	7.28	7.66	7.94
3¾	10.42	5.03	6.24	7.25	8.08	8.74	9.26	9.66
4	12.76	5.79	7.24	8.46	9.48	10.32	11.00	11.53
4¼	15.40	6.60	8.28	9.73	10.97	12.00	12.86	13.55
4½	18.36	7.44	9.38	11.07	12.53	13.78	14.83	15.71
4¾	21.65	8.31	10.51	12.46	14.17	15.65	16.91	17.98
5	25.28	9.20	11.69	13.91	15.87	17.59	19.09	20.37
5¼	29.25	10.13	12.90	15.40	17.63	19.61	21.35	22.86
5½	33.57	11.07	14.15	16.94	19.45	21.69	23.69	25.45
5¾	38.26	12.04	15.42	18.51	21.31	23.84	26.10	28.12
6	43.31	13.02	16.72	20.12	23.22	26.03	28.58	30.86
6¼	48.73	14.02	18.04	21.75	25.16	28.28	31.11	33.67
6½	54.53	15.04	19.39	23.42	27.14	30.56	33.70	36.55
6¾	60.70	16.07	20.75	25.11	29.15	32.89	36.33	39.48
7	67.26	17.11	22.13	26.82	31.19	35.25	39.01	42.46
7¼	74.20	18.16	23.52	28.55	33.26	37.64	41.72	45.49
7½	81.53	19.22	24.93	30.30	35.35	40.06	44.47	48.56
7¾	89.25	20.29	26.35	32.07	37.45	42.51	47.24	51.66
8	97.36	21.36	27.78	33.85	39.58	44.98	50.05	54.80
8¼	105.87	22.45	29.22	35.64	41.72	47.46	52.88	57.96
8½	114.76	23.53	30.66	37.44	43.88	49.97	55.73	61.16
8¾	124.05	24.63	32.12	39.26	46.05	52.49	58.60	64.37
9	133.73	25.73	33.58	41.08	48.23	55.03	61.49	67.61
9¼	143.81	26.83	35.05	42.91	50.42	57.58	64.39	70.86
9½	154.28	27.95	36.52	44.75	52.62	60.14	67.31	74.13
9¾	165.15	29.05	38.00	46.59	54.83	62.71	70.24	77.42
10	176.41	30.16	39.48	48.44	57.04	65.28	73.18	80.72

Cast-iron 8 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	8.13						
3¾	9.95	10.15					
4	11.94	12.25	12.46				
4¼	14.10	14.53	14.84	15.08			
4½	16.42	16.99	17.43	17.76	18.01		
4¾	18.87	19.60	20.19	20.65	21.00	21.26	
5	21.46	22.37	23.12	23.73	24.21	24.58	24.86
5¼	24.17	25.28	26.21	26.98	27.61	28.11	28.50
5½	26.98	28.31	29.44	30.40	31.19	31.85	32.37
5¾	29.89	31.45	32.80	33.96	34.94	35.76	36.44
6	32.90	34.70	36.28	37.65	38.84	39.85	40.69
6¼	35.98	38.04	39.86	41.47	42.87	44.08	45.12
6½	39.13	41.46	43.55	45.40	47.03	48.46	49.70
6¾	42.36	44.96	47.32	49.43	51.30	52.97	54.43
7	45.64	48.53	51.17	53.54	55.68	57.59	59.28
7¼	48.97	52.16	55.09	57.75	60.15	62.32	64.26
7½	52.35	55.85	59.07	62.02	64.70	67.14	69.34
7¾	55.77	59.59	63.11	66.36	69.33	72.05	74.52
8	59.24	63.37	67.21	70.76	74.03	77.04	79.78
8¼	62.73	67.19	71.35	75.21	78.79	82.09	85.13
8½	66.26	71.05	75.54	79.72	83.61	87.21	90.54
8¾	69.82	74.95	79.76	84.27	88.47	92.39	96.02
9	73.40	78.87	84.01	88.85	93.38	97.62	101.56
9¼	77.00	82.81	88.30	93.47	98.33	102.89	107.16
9½	80.63	86.78	92.61	98.12	103.32	108.21	112.79
9¾	84.27	90.77	96.95	102.81	108.34	113.56	118.47
10	87.92	94.78	101.31	107.51	113.39	118.94	124.19

Cylindrical Pillars of

Safe weight, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.92	0.75	0.85					
2¼	1.41	1.07	1.23	1.33				
2½	2.04	1.47	1.71	1.87	1.96			
2¾	2.87	1.94	2.29	2.53	2.69	2.79		
3	3.90	2.50	2.98	3.33	3.57	3.73	3.82	
3¼	5.19	3.14	3.78	4.26	4.61	4.85	5.01	5.11
3½	6.75	3.88	4.70	5.34	5.82	6.17	6.41	6.57
3¾	8.95	4.39	5.44	6.31	7.01	7.57	8.01	8.34
4	11.00	5.08	6.34	7.39	8.27	8.98	9.56	10.01
4¼	13.32	5.82	7.29	8.55	9.61	10.50	11.23	11.81
4½	15.94	6.59	8.29	9.77	11.03	12.11	13.01	13.75
4¾	18.86	7.39	9.34	11.05	12.53	13.81	14.91	15.82
5	22.10	8.22	10.43	12.38	14.10	15.60	16.90	18.00
5¼	25.66	9.08	11.55	13.77	15.73	17.47	18.98	20.29
5½	29.55	9.97	12.72	15.20	17.42	19.40	21.15	22.68
5¾	33.78	10.88	13.91	16.67	19.16	21.40	23.39	25.16
6	38.36	11.81	15.14	18.19	20.95	23.46	25.71	27.72
6¼	43.30	12.76	16.39	19.73	22.79	25.57	28.09	30.36
6½	48.59	13.73	17.67	21.32	24.67	27.74	30.54	33.07
6¾	54.25	14.71	18.97	22.93	26.58	29.95	33.03	35.85
7	60.28	15.71	20.29	24.56	28.53	32.20	35.58	38.68
7¼	66.68	16.72	21.63	26.23	30.51	34.49	38.17	41.57
7½	73.46	17.74	22.99	27.91	32.51	36.81	40.80	44.50
7¾	80.62	18.78	24.36	29.62	34.55	39.16	43.47	47.48
8	88.16	19.83	25.75	31.34	36.60	41.55	46.18	50.50
8¼	96.09	20.88	27.15	33.08	38.68	43.95	48.91	53.56
8½	104.40	21.94	28.55	34.83	40.77	46.38	51.67	56.65
8¾	113.11	23.01	29.97	36.60	42.88	48.84	54.46	59.77
9	122.20	24.08	31.40	38.38	45.01	51.31	57.28	62.92
9¼	131.68	25.17	32.84	40.17	47.15	53.80	60.11	66.09
9½	141.56	26.25	34.29	41.97	49.31	56.30	62.96	69.29
9¾	151.83	27.33	35.74	43.78	51.48	58.82	65.83	72.50
10	162.50	28.44	37.20	45.60	53.65	61.36	68.72	75.74

Cast-iron 9 feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	6.67						
3¾	8.57	8.74					
4	10.34	10.59	10.77				
4¼	12.27	12.62	12.88	13.07			
4½	14.35	14.83	15.19	15.47	15.66		
4¾	16.58	17.19	17.68	18.06	18.35	18.56	
5	18.94	19.71	20.34	20.85	21.25	21.55	21.77
5¼	21.42	22.37	23.16	23.81	24.33	24.75	25.07
5½	24.01	25.15	26.12	26.93	27.61	28.15	28.58
5¾	26.71	28.06	29.22	30.21	31.05	31.74	32.30
6	29.51	31.08	32.45	33.63	34.65	35.50	36.22
6¼	32.39	34.20	35.79	37.18	38.39	39.43	40.31
6½	35.36	37.41	39.24	40.86	42.27	43.50	44.57
6¾	38.40	40.71	42.79	44.64	46.28	47.72	48.98
7	41.52	44.09	46.43	48.52	50.40	52.06	53.53
7¼	44.69	47.54	50.15	52.50	54.62	56.53	58.22
7½	47.92	51.06	53.94	56.57	58.95	61.10	63.03
7¾	51.20	54.64	57.80	60.71	63.36	65.76	67.94
8	54.53	58.27	61.73	64.92	67.85	70.52	72.96
8¼	57.90	61.95	65.71	69.20	72.41	75.37	78.07
8½	61.31	65.68	69.75	73.53	77.04	80.28	83.27
8¾	64.76	69.45	73.83	77.93	81.74	85.27	88.54
9	68.24	73.25	77.96	82.37	86.48	90.32	93.88
9¼	71.75	77.09	82.12	86.85	91.28	95.43	99.29
9½	75.28	80.96	86.32	91.38	96.13	100.59	104.76
9¾	78.84	84.86	90.56	95.94	101.02	105.79	110.28
10	82.42	88.78	94.82	100.54	105.94	111.04	115.85

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.77	0.63	0.71					
2¼	1.17	0.90	1.03	1.11				
2½	1.71	1.23	1.43	1.56	1.64			
2¾	2.40	1.62	1.91	2.12	2.25	2.33		
3	3.26	2.09	2.49	2.78	2.98	3.12	3.20	
3¼	4.34	2.63	3.16	3.56	3.85	4.06	4.19	4.27
3½	5.64	3.24	3.93	4.47	4.87	5.16	5.36	5.50
3¾	7.21	3.94	4.81	5.50	6.03	6.43	6.72	6.93
4	9.06	4.73	5.80	6.67	7.35	7.89	8.29	8.58
4¼	11.63	5.16	6.45	7.55	8.48	9.25	9.87	10.37
4½	13.95	5.86	7.36	8.66	9.77	10.71	11.49	12.12
4¾	16.56	6.60	8.33	9.83	11.14	12.26	13.21	14.00
5	19.46	7.37	9.33	11.06	12.58	13.90	15.03	15.99
5¼	22.65	8.17	10.38	12.35	14.09	15.62	16.95	18.09
5½	26.16	9.00	11.46	13.68	15.66	17.41	18.95	20.29
5¾	29.99	9.85	12.58	15.06	17.28	19.27	21.03	22.59
6	34.15	10.73	13.74	16.47	18.96	21.19	23.20	24.98
6¼	38.64	11.63	14.92	17.93	20.68	23.18	25.43	27.44
6½	43.48	12.54	16.13	19.43	22.45	25.21	27.72	29.99
6¾	48.66	13.48	17.36	20.96	24.27	27.30	30.08	32.60
7	54.20	14.43	18.62	22.52	26.12	29.44	32.49	35.28
7¼	60.10	15.40	19.90	24.10	28.00	31.62	34.95	38.02
7½	66.36	16.39	21.21	25.72	29.92	33.84	37.46	40.82
7¾	72.99	17.38	22.52	27.35	31.87	36.09	40.02	43.66
8	79.99	18.39	23.86	29.01	33.85	38.38	42.61	46.56
8¼	87.37	19.41	25.21	30.69	35.85	40.70	45.24	49.49
8½	95.12	20.44	26.58	32.39	37.87	43.05	47.91	52.47
8¾	103.26	21.48	27.96	34.10	39.92	45.42	50.60	55.48
9	111.78	22.53	29.35	35.83	41.99	47.82	53.33	58.53
9¼	120.68	23.58	30.75	37.58	44.07	50.24	56.08	61.60
9½	129.98	24.64	32.16	39.33	46.17	52.67	58.85	64.71
9¾	139.66	25.71	33.58	41.10	48.29	55.13	61.65	67.84
10	149.73	26.79	35.01	42.88	50.41	57.61	64.47	71.00

Cast-iron **10** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	5.57						
3¾	7.06	7.14					
4	8.78	8.92	9.00				
4¼	10.76	11.06	11.27	11.43			
4½	12.64	13.04	13.35	13.57	13.73		
4¾	14.65	15.18	15.59	15.91	16.15	16.32	
5	16.80	17.46	18.00	18.43	18.76	19.01	19.20
5¼	19.07	19.89	20.57	21.12	21.57	21.91	22.18
5½	21.46	22.45	23.28	23.98	24.55	25.01	25.37
5¾	23.95	25.13	26.14	26.99	27.71	28.30	28.77
6	26.55	27.93	29.12	30.15	31.03	31.76	32.37
6¼	29.24	30.83	32.23	33.45	34.49	35.39	36.14
6½	32.02	33.84	35.45	36.87	38.10	39.17	40.09
6¾	34.89	36.94	38.78	40.41	41.85	43.10	44.20
7	37.82	40.12	42.20	44.06	45.71	47.17	48.45
7¼	40.83	43.39	45.71	47.81	49.69	51.37	52.85
7½	43.90	46.73	49.31	51.65	53.77	55.68	57.38
7¾	47.03	50.14	52.98	55.59	57.95	60.10	62.03
8	50.22	53.60	56.73	59.60	62.23	64.62	66.79
8¼	53.45	57.13	60.54	63.69	66.58	62.23	71.65
8½	56.73	60.71	64.41	67.84	71.01	73.93	76.61
8¾	60.06	64.34	68.34	72.06	75.52	78.71	81.66
9	63.42	68.02	72.32	76.34	80.09	83.57	86.79
9¼	66.82	71.73	76.35	80.67	84.72	88.49	91.99
9½	70.25	75.49	80.42	85.05	89.40	93.47	97.27
9¾	73.71	79.28	84.53	89.48	94.14	98.51	102.60
10	77.20	83.10	88.67	93.95	98.92	103.60	108.00

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.66	0.53	0.60					
2¼	1.00	0.76	0.88	0.94				
2½	1.45	1.04	1.22	1.33	1.40			
2¾	2.04	1.38	1.63	1.80	1.91	1.98		
3	2.77	1.78	2.12	2.36	2.54	2.65	2.72	
3¼	3.69	2.23	2.69	3.03	3.28	3.45	3.56	3.63
3½	4.80	2.76	3.34	3.80	4.14	4.39	4.56	4.67
3¾	6.13	3.35	4.09	4.68	5.13	5.47	5.72	5.89
4	7.71	4.02	4.93	5.67	6.25	6.71	7.05	7.30
4¼	9.56	4.76	5.87	6.78	7.52	8.10	8.56	8.90
4½	12.31	5.24	6.58	7.73	8.70	9.52	10.20	10.76
4¾	14.64	5.92	7.46	8.80	9.96	10.94	11.77	12.46
5	17.24	6.64	8.39	9.93	11.28	12.44	13.44	14.28
5¼	20.13	7.38	9.36	11.12	12.67	14.03	15.20	16.21
5½	23.30	8.15	10.37	12.35	14.12	15.68	17.05	18.24
5¾	26.77	8.95	11.41	13.64	15.63	17.41	18.98	20.36
6	30.55	9.77	12.49	14.96	17.20	19.20	20.99	22.58
6¼	34.64	10.62	13.61	16.34	18.82	21.06	23.08	24.88
6½	39.06	11.49	14.75	17.74	20.48	22.97	25.23	27.26
6¾	43.82	12.37	15.92	19.19	22.19	24.94	27.45	29.72
7	48.91	13.28	17.11	20.67	23.95	26.96	29.72	32.24
7¼	54.34	14.20	18.33	22.18	25.74	29.03	32.06	34.83
7½	60.12	15.14	19.58	23.71	27.57	31.14	34.44	37.49
7¾	66.26	16.10	20.84	25.28	29.43	33.29	36.88	40.19
8	72.76	17.07	22.12	26.87	31.32	35.48	39.35	42.95
8¼	79.62	18.05	23.42	28.49	33.24	37.70	41.88	45.77
8½	86.84	19.04	24.74	30.12	35.19	39.96	44.43	48.62
8¾	94.44	20.05	26.07	31.78	37.17	42.25	47.03	51.52
9	102.41	21.06	27.42	33.45	39.16	44.56	49.66	54.45
9¼	110.76	22.09	28.78	35.14	41.18	46.90	52.32	57.42
9½	119.49	23.12	30.15	36.85	43.22	49.27	55.00	60.43
9¾	128.60	24.17	31.54	38.57	45.28	51.66	57.72	63.47
10	138.09	25.21	32.93	40.31	47.35	54.06	60.46	66.53

Cast-iron **11** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	4.74						
3¾	6.00	6.07					
4	7.47	7.58	7.65				
4¼	9.15	9.32	9.43	9.50			
4½	11.20	11.54	11.80	12.00	12.13		
4¾	13.03	13.48	13.83	14.10	14.30	14.45	
5	14.98	15.56	16.02	16.39	16.67	16.88	17.03
5¼	17.06	17.78	18.36	18.84	19.22	19.51	19.73
5½	19.26	20.13	20.85	21.46	21.95	22.34	22.64
5¾	21.56	22.60	23.48	24.22	24.84	25.35	25.75
6	23.97	25.19	26.24	27.14	27.90	28.53	29.05
6¼	26.48	27.89	29.12	30.19	31.11	31.88	32.53
6½	29.08	30.70	32.12	33.37	34.46	35.39	36.19
6¾	31.76	33.60	35.23	36.68	37.95	39.05	40.01
7	34.53	36.59	38.44	40.10	41.56	42.85	43.98
7¼	37.37	39.67	41.75	43.62	45.30	46.78	48.09
7½	40.28	42.83	45.15	47.25	49.15	50.84	52.35
7¾	43.25	46.06	48.63	50.97	53.10	55.01	56.73
8	46.29	49.37	52.19	54.78	57.15	59.29	61.23
8¼	49.38	52.73	55.83	58.68	61.29	63.67	65.84
8½	52.52	56.16	59.53	62.64	65.52	68.15	70.56
8¾	55.72	59.64	63.29	66.68	69.82	72.71	75.37
9	58.96	63.17	67.12	70.79	74.20	77.36	80.28
9¼	62.23	66.75	71.00	74.95	78.65	82.08	85.27
9½	65.55	70.38	74.92	79.18	83.16	86.88	90.34
9¾	68.91	74.05	78.89	83.45	87.73	91.74	95.48
10	72.30	77.75	82.91	87.78	92.36	96.66	100.69

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.57	0.46	0.52					
2¼	0.86	0.66	0.75	0.81				
2½	1.25	0.90	1.05	1.15	1.20			
2¾	1.76	1.19	1.40	1.55	1.65	1.71		
3	2.39	1.53	1.83	2.04	2.19	2.29	2.34	
3¼	3.18	1.93	2.32	2.61	2.83	2.98	3.07	3.13
3½	4.14	2.38	2.88	3.27	3.57	3.78	3.93	4.03
3¾	5.29	2.89	3.53	4.03	4.42	4.72	4.93	5.08
4	6.65	3.47	4.25	4.89	5.39	5.78	6.08	6.29
4¼	8.24	4.10	5.06	5.85	6.48	6.99	7.38	7.67
4½	10.10	4.81	5.96	6.92	7.70	8.34	8.84	9.23
4¾	12.23	5.59	6.95	8.10	9.05	9.84	10.48	10.98
5	15.38	6.00	7.57	8.96	10.16	11.19	12.08	12.82
5¼	17.99	6.69	8.47	10.05	11.44	12.65	13.70	14.59
5½	20.86	7.40	9.41	11.20	12.78	14.18	15.40	16.46
5¾	24.02	8.15	10.38	12.39	14.19	15.79	17.19	18.42
6	27.46	8.92	11.39	13.63	15.65	17.46	19.06	20.48
6¼	31.21	9.72	12.44	14.92	17.17	19.19	21.01	22.63
6½	35.25	10.54	13.51	16.24	18.73	20.99	23.02	24.85
6¾	39.61	11.37	14.62	17.61	20.34	22.84	25.11	27.16
7	44.30	12.24	15.75	19.00	22.00	24.74	27.25	29.53
7¼	49.30	13.11	16.91	20.44	23.70	26.70	29.46	31.98
7½	54.65	14.01	18.10	21.90	25.43	28.70	31.72	34.49
7¾	60.33	14.92	19.30	23.39	27.21	30.75	34.03	37.06
8	66.36	15.85	20.53	24.91	29.01	32.84	36.39	39.69
8¼	72.74	16.80	21.78	26.46	30.85	34.96	38.80	42.37
8½	79.47	17.75	23.04	28.03	32.72	37.13	41.25	45.09
8¾	86.56	18.72	24.33	29.62	34.62	39.32	43.74	47.87
9	94.02	19.70	25.63	31.24	36.54	41.55	46.26	50.69
9¼	101.84	20.70	26.94	32.87	38.49	43.81	48.83	53.55
9½	110.03	21.70	28.27	34.53	40.46	46.09	51.42	56.45
9¾	118.59	22.71	29.61	36.19	42.46	48.40	54.05	59.38
10	127.53	23.73	30.97	37.88	44.47	50.74	56.70	62.35

Cast-iron **12** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	4.09						
3¾	5.18	5.24					
4	6.44	6.54	6.60				
4¼	7.89	8.04	8.14	8.19			
4½	9.53	9.74	9.89	9.99	10.05		
4¾	11.37	11.66	11.88	12.03	12.13	12.18	
5	13.44	13.94	14.34	14.66	14.90	15.08	15.21
5¼	15.34	15.97	16.48	16.90	17.22	17.47	17.66
5½	17.36	18.13	18.77	19.29	19.72	20.05	20.32
5¾	19.49	20.41	21.19	21.84	22.38	22.81	23.16
6	21.73	22.81	23.73	24.53	25.19	25.74	26.20
6¼	24.06	25.31	26.41	27.35	28.16	28.84	29.41
6½	26.48	27.93	29.20	30.31	31.27	32.09	32.79
6¾	29.00	30.64	32.11	33.39	34.52	35.50	36.33
7	31.60	33.45	35.11	36.59	37.90	39.04	40.04
7¼	34.27	36.35	38.22	39.90	41.40	42.72	43.88
7½	37.02	39.33	41.43	43.32	45.02	46.53	47.88
7¾	39.84	42.39	44.72	46.83	48.74	50.46	52.00
8	42.73	45.53	48.10	50.44	52.57	54.50	56.24
8¼	45.67	48.73	51.55	54.14	56.50	58.65	60.61
8½	48.68	52.00	55.08	57.91	60.52	62.91	65.08
8¾	51.73	55.33	58.67	61.77	64.62	67.25	69.66
9	54.84	58.72	62.33	65.69	68.81	71.69	74.34
9¼	57.99	62.16	66.05	69.69	73.07	76.21	79.11
9½	61.19	65.65	69.83	73.74	77.40	80.80	83.96
9¾	64.43	69.19	73.66	77.86	81.80	85.47	88.90
10	67.71	72.77	77.54	82.03	86.26	90.21	93.91

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.49	0.40	0.45					
2¼	0.75	0.57	0.66	0.71				
2½	1.09	0.79	0.92	1.00	1.05			
2¾	1.53	1.04	1.23	1.36	1.44	1.49		
3	2.09	1.34	1.59	1.78	1.91	2.00	2.05	
3¼	2.78	1.68	2.02	2.28	2.47	2.60	2.68	2.73
3½	3.61	2.08	2.52	2.86	3.12	3.30	3.43	3.52
3¾	4.61	2.52	3.08	3.52	3.86	4.12	4.30	4.43
4	5.80	3.02	3.71	4.27	4.71	5.05	5.31	5.49
4¼	7.19	3.58	4.42	5.10	5.66	6.10	6.44	6.70
4½	8.81	4.20	5.20	6.04	6.72	7.28	7.72	8.06
4¾	10.68	4.88	6.06	7.07	7.90	8.59	9.14	9.58
5	12.81	5.62	7.01	8.20	9.20	10.03	10.72	11.28
5¼	16.17	6.08	7.70	9.12	10.37	11.46	12.40	13.19
5½	18.78	6.75	8.57	10.19	11.62	12.88	13.97	14.92
5¾	21.66	7.45	9.48	11.30	12.93	14.37	15.63	16.74
6	24.81	8.17	10.42	12.46	14.29	15.92	17.37	18.65
6¼	28.23	8.91	11.40	13.66	15.70	17.54	19.18	20.64
6½	31.95	9.69	12.41	14.91	17.17	19.22	21.07	22.72
6¾	35.96	10.48	13.46	16.19	18.69	20,96	23.02	24.88
7	40.27	11.29	14.53	17.51	20.25	22.76	25.04	27.12
7¼	44.90	12.13	15.63	18.87	21.86	24.60	27.12	29.42
7½	49.84	12.98	16.75	20.26	23.50	26.50	29.26	31.79
7¾	55.11	13.85	17.90	21.68	25.19	28.45	31.45	34.23
8	60.70	14.74	19.07	23.13	26.91	30.43	33.70	36.72
8¼	66.64	15.64	20.27	24.61	28.67	32.46	35.99	39.27
8½	72.91	16.56	21.48	26.11	30.46	34.53	38.33	41.87
8¾	79.53	17.49	22.71	27.64	32.28	36.63	40.71	44.53
9	86.50	18.44	23.97	29.19	34.13	38.77	43.14	47.23
9¼	93.82	19.40	25.23	30.77	36.00	40.94	45.60	49.98
9½	101.51	20.37	26.52	32.36	37.90	43.14	48.10	52.77
9¾	109.55	21.35	27.82	33.98	39.83	45.38	50.63	55.60
10	117.96	22.34	29.13	35.61	41.77	47.63	53.20	58.46

Cast-iron **13** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	3.57						
3¾	4.52	4.57					
4	5.62	5.71	5.76				
4¼	6.89	7.02	7.10	7.15			
4½	8.32	8.50	8.63	8.72	8.77		
4¾	9.92	10.18	10.37	10.50	10.58	10.63	
5	11.72	12.06	12.31	12.50	12.63	12.72	12.77
5¼	13.86	14.41	14.87	15.23	15.52	15.73	15.89
5½	15.72	16.40	16.97	17.43	17.80	18.09	18.32
5¾	17.69	18.51	19.20	19.77	20.25	20.63	20.93
6	19.76	20.73	21.55	22.26	22.84	23.33	23.72
6¼	21.93	23.06	24.03	24.87	25.59	26.19	26.69
6½	24.20	25.49	26.63	27.62	28.48	29.21	29.82
6¾	26.55	28.03	29.34	30.50	31.50	32.37	33.11
7	28.99	30.66	32.16	33.49	34.66	35.68	36.56
7¼	31.50	33.39	35.08	36.59	37.94	39.12	40.16
7½	34.10	36.20	38.10	39.81	41.34	42.70	43.90
7¾	36.77	39.09	41.21	43.12	44.85	46.39	47.77
8	39.50	42.06	44.40	46.53	48.46	50.21	51.77
8¼	42.30	45.10	47.68	50.03	52.18	54.13	55.89
8½	45.17	48.22	51.03	53.62	56.00	58.16	60.13
8¾	48.09	51.39	54.46	57.29	59.90	62.29	64.48
9	51.06	54.63	57.96	61.04	63.89	66.52	68.93
9¼	54.08	57.93	61.52	64.86	67.96	70.83	73.48
9½	57.16	61.28	65.14	68.75	72.11	75.23	78.12
9¾	60.28	64.68	68.82	72.70	76.33	79.70	82.85
10	63.44	68.14	72.56	76.71	80.61	84.26	87.66

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.44	0.35	0.40					
2¼	0.66	0.51	0.58	0.63				
2½	0.96	0.69	0.81	0.88	0.93			
2¾	1.35	0.91	1.08	1.19	1.27	1.31		
3	1.84	1.18	1.40	1.57	1.68	1.76	1.80	
3¼	2.45	1.48	1.78	2.01	2.17	2.29	2.36	2.41
3½	3.18	1.83	2.20	2.52	2.75	2.91	3.03	3.10
3¾	4.07	2.22	2.71	3.10	3.40	3.63	3.79	3.91
4	5.11	2.67	3.27	3.76	4.15	4.45	4.68	4.84
4¼	6.34	3.16	3.90	4.50	4.99	5.38	5.68	5.81
4½	7.77	3.70	4.58	5.32	5.93	6.42	6.80	7.11
4¾	9.41	4.30	5.35	6.23	6.97	7.57	8.06	8.45
5	11.29	4.95	6.18	7.23	8.11	8.85	9.45	9.94
5¼	13.43	5.66	7.09	8.31	9.36	10.24	10.98	11.59
5½	15.84	6.43	8.07	9.50	10.73	11.77	12.66	13.39
5¾	19.63	6.82	8.68	10.34	11.82	13.12	14.27	15.26
6	22.51	7.50	9.56	11.42	13.09	14.57	15.88	17.04
6¼	25.65	8.20	10.48	12.55	14.41	16.08	17.58	18.90
6½	29.07	8.93	11.43	13.71	15.79	17.66	19.34	20.84
6¾	32.77	9.68	12.41	14.92	17.21	19.29	21.17	22.86
7	36.75	10.45	13.43	16.17	18.68	20.98	23.07	24.96
7¼	41.02	11.24	14.47	17.45	20.20	22.72	25.03	27.13
7½	45.60	12.05	15.53	18.77	21.76	24.52	27.05	29.37
7¾	50.49	12.88	16.63	20.12	23.36	26.36	29.13	31.67
8	55.69	13.72	17.75	21.50	25.00	28.25	31.26	34.04
8¼	61.22	14.59	18.88	22.91	26.67	30.18	33.44	36.46
8½	67.07	15.47	20.05	24.35	28.38	32.15	35.67	38.94
8¾	73.25	16.36	21.23	25.81	30.12	34.17	37.95	41.48
9	79.77	17.27	22.43	27.30	31.90	36.22	40.27	44.06
9¼	86.63	18.19	23.65	28.82	33.70	38.30	42.63	46.69
9½	93.84	19.13	24.89	30.35	35.53	40.42	45.03	49.37
9¾	101.40	20.07	26.14	31.91	37.38	42.57	47.46	52.09
10	109.31	21.03	27.41	33.49	39.26	44.74	49.94	54.85

Cast-iron **14** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	3.15						
3¾	3.98	4.03					
4	4.96	5.03	5.08				
4¼	6.07	6.19	6.26	6.31			
4½	7.33	7.50	7.61	7.69	7.73		
4¾	8.75	8.98	9.14	9.26	9.33	9.39	
5	10.33	10.63	10.86	11.02	11.14	11.21	11.26
5¼	12.08	12.46	12.77	12.99	13.16	13.27	13.35
5½	14.00	14.49	14.88	15.18	15.40	15.57	15.68
5¾	16.12	16.85	17.46	17.98	18.40	18.73	19.00
6	18.04	18.91	19.65	20.28	20.80	21.23	21.57
6¼	20.06	21.07	21.95	22.70	23.34	23.87	24.31
6½	22.17	23.35	24.37	25.26	26.02	26.67	27.22
6¾	24.37	25.72	26.90	27.94	28.84	29.62	30.28
7	26.66	28.19	29.54	30.74	31.79	32.70	33.50
7¼	29.03	30.74	32.28	33.67	34.86	35.93	36.86
7½	31.48	33.39	35.12	36.67	38.05	39.28	40.36
7¾	34.00	36.12	38.05	39.79	41.36	42.76	44.00
8	36.59	38.93	41.07	43.01	44.77	46.35	47.76
8¼	39.25	41.82	44.18	46.33	48.29	50.06	51.66
8½	41.98	44.78	47.36	49.73	51.90	53.87	55.66
8¾	44.76	47.81	50.62	53.22	55.61	57.79	59.79
9	47.60	50.90	53.96	56.79	59.41	61.81	64.02
9¼	50.50	54.05	57.36	60.44	63.29	65.92	68.35
9½	53.44	57.26	60.83	64.16	67.25	70.12	72.77
9¾	56.44	60.53	64.36	67.95	71.29	74.40	77.29
10	59.48	63.85	67.95	71.80	75.40	78.77	81.90

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.39	0.32	0.36					
2¼	0.59	0.45	0.52	0.56				
2½	0.86	0.62	0.72	0.78	0.82			
2¾	1.20	0.81	0.96	1.06	1.13	1.17		
3	1.64	1.05	1.25	1.40	1.50	1.56	1.60	
3¼	2.18	1.32	1.59	1.79	1.93	2.04	2.10	2.14
3½	2.83	1.63	1.97	2.24	2.44	2.59	2.69	2.76
3¾	3.62	1.98	2.41	2.76	3.03	3.23	3.38	3.48
4	4.55	2.37	2.91	3.35	3.69	3.96	4.16	4.31
4¼	5.64	2.81	3.46	4.00	4.44	4.78	5.05	5.25
4½	6.91	3.29	4.08	4.73	5.27	5.71	6.05	6.32
4¾	8.37	3.82	4.75	5.54	6.20	6.73	7.17	7.51
5	10.04	4.40	5.50	6.43	7.21	7.87	8.41	8.84
5¼	11.94	5.03	6.30	7.39	8.33	9.11	9.77	10.30
5½	14.09	5.72	7.18	8.45	9.54	10.47	11.26	11.91
5¾	16.50	6.45	8.12	9.59	10.86	11.95	12.88	13.66
6	19.19	7.24	9.14	10.81	12.28	13.55	14.64	15.57
6¼	23.41	7.57	9.66	11.55	13.26	14.79	16.15	17.35
6½	26.56	8.25	10.55	12.65	14.55	16.27	17.80	19.17
6¾	29.97	8.95	11.48	13.79	15.89	17.80	19.52	21.07
7	33.65	9.68	12.43	14.96	17.28	19.39	21.31	23.04
7¼	37.62	10.43	13.42	16.18	18.71	21.03	23.15	25.08
7½	41.86	11.20	14.43	17.42	20.19	22.73	25.06	27.19
7¾	46.41	11.99	15.47	18.71	21.71	24.48	27.03	29.37
8	51.25	12.80	16.53	20.02	23.26	26.27	29.05	31.61
8¼	56.40	13.62	17.62	21.36	24.86	28.11	31.12	33.91
8½	61.86	14.46	18.73	22.74	26.49	29.99	33.25	36.27
8¾	67.63	15.32	19.86	24.14	28.15	31.91	35.42	38.69
9	73.74	16.19	21.02	25.57	29.85	33.87	37.63	41.15
9¼	80.17	17.08	22.19	27.02	31.58	35.87	39.89	43.67
9½	86.93	17.98	23.38	28.50	33.33	37.90	42.20	46.24
9¾	94.04	18.89	24.59	30.00	35.12	39.96	44.54	48.85
10	101.48	19.82	25.81	31.52	36.93	42.06	46.91	51.50

Cast-iron **15** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	2.80						
3¾	3.54	3.58					
4	4.41	4.48	4.52				
4¼	5.40	5.50	5.57	5.61			
4½	6.52	6.67	6.77	6.84	6.88		
4¾	7.78	7.98	8.13	8.23	8.30	8.34	
5	9.19	9.45	9.66	9.80	9.90	9.97	10.01
5¼	10.74	11.09	11.35	11.55	11.70	11.80	11.87
5½	12.45	12.88	13.23	13.50	13.70	13.85	13.95
5¾	14.32	14.86	15.29	15.64	15.91	16.11	16.25
6	16.35	17.01	17.55	17.98	18.33	18.60	18.80
6¼	18.41	19.33	20.12	20.80	21.37	21.84	22.24
6½	20.38	21.45	22.37	23.18	23.86	24.45	24.93
6¾	22.44	23.66	24.74	25.68	26.49	27.19	27.78
7	24.59	25.98	27.21	28.30	29.25	30.07	30.78
7¼	26.82	28.38	29.78	31.03	32.12	33.09	33.92
7½	29.12	30.87	32.45	33.86	35.12	36.23	37.21
7¾	31.51	33.45	35.21	36.80	38.23	39.50	40.62
8	33.96	36.11	38.07	39.84	41.45	42.89	44.17
8¼	36.48	38.85	41.01	42.98	44.77	46.39	47.84
8½	39.07	41.66	44.03	46.21	48.19	50.00	51.63
8¾	41.72	44.54	47.13	49.52	51.71	53.72	55.54
9	44.43	47.48	50.31	52.92	55.33	57.53	59.55
9¼	47.20	50.49	53.56	56.40	59.02	61.45	63.67
9½	50.02	53.57	56.87	59.95	62.81	65.45	67.89
9¾	52.90	56.70	60.25	63.58	66.67	69.54	72.20
10	55.82	59.88	63.70	67.27	70.61	73.72	76.61

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they càn support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.35	0.28	0.32					
2¼	0.53	0.40	0.46	0.50				
2½	0.77	0.55	0.64	0.70	0.74			
2¾	1.08	0.73	0.86	0.95	1.01	1.05		
3	1.47	0.94	1.12	1.25	1.34	1.40	1.44	
3¼	1.95	1.18	1.42	1.60	1.73	1.82	1.88	1.92
3½	2.54	1.46	1.77	2.01	2.19	2.32	2.41	2.47
3¾	3.24	1.77	2.16	2.47	2.71	2.89	3.02	3.12
4	4.08	2.13	2.61	3.00	3.31	3.55	3.73	3.86
4¼	5.05	2.52	3.10	3.59	3.98	4.29	4.53	4.71
4½	6.19	2.95	3.65	5.24	4.72	5.11	5.42	5.66
4¾	7.50	3.43	4.26	4.96	5.55	6.03	6.42	6.73
5	9.00	3.95	4.92	5.76	6.46	7.05	7.53	7.92
5¼	10.70	4.51	5.65	6.63	7.46	8.16	8.75	9.23
5½	12.62	5.12	6.43	7.57	8.55	9.38	10.09	10.67
5¾	14.78	5.78	7.28	8.59	9.73	10.71	11.54	12.24
6	17.19	6.49	8.19	9.69	11.00	12.14	13.12	13.95
6¼	19.87	7.25	9.17	10.87	12.37	13.68	14.82	15.80
6½	24.35	7.64	9.77	11.70	13.45	15.02	16.43	17.68
6¾	27.51	8.30	10.64	12.77	14.71	16.47	18.05	19.46
7	30.92	8.99	11.54	13.88	16.02	17.96	19.72	21.31
7¼	34.60	9.70	12.47	15.03	17.37	19.51	21.47	23.24
7½	38.55	10.43	13.43	16.21	18.77	21.12	23.27	25.23
7¾	42.78	11.18	14.42	17.42	20.21	22.77	25.13	27.29
8	47.29	11.95	15.43	18.67	21.68	24.47	27.04	29.41
8¼	52.10	12.74	16.47	19.95	23.20	26.22	29.01	31.60
8½	57.20	13.54	17.53	21.26	24.75	28.01	31.03	33.84
8¾	62.61	14.36	18.61	22.60	26.34	29.84	33.10	36.14
9	68.32	15.20	19.71	23.97	27.97	31.71	35.22	38.49
9¼	74.36	16.05	20.84	25.36	29.62	33.63	37.38	40.90
9½	80.71	16.91	21.98	26.78	31.31	35.57	39.59	43.35
9¾	87.39	17.79	23.14	28.22	33.02	37.56	41.83	45.86
10	94.40	18.68	24.33	29.68	34.76	39.57	44.12	48.40

Cast-iron **16** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	2.51						
3¾	3.18	3.21					
4	3.95	4.01	4.05				
4¼	4.84	4.93	4.99	5.02			
4½	5.84	5.97	6.07	6.13	6.16		
4¾	6.97	7.15	7.29	7.38	7.44	7.47	
5	8.23	8.47	8.65	8.78	8.87	8.93	8.97
5¼	9.62	9.93	10.17	10.35	10.49	10.58	10.64
5½	11.16	11.55	11.86	12.10	12.28	12.41	12.50
5¾	12.83	13.31	13.70	14.01	14.25	14.43	14.57
6	14.66	15.24	15.72	16.11	16.42	16.66	16.84
6¼	16.63	17.34	17.92	18.41	18.80	19.11	19.34
6½	18.79	19.76	20.61	21.33	21.95	22.48	22.91
6¾	20.72	21.84	22.82	23.67	24.41	25.04	25.57
7	22.74	24.01	25.13	26.12	26.98	27.73	28.37
7¼	24.83	26.27	27.55	28.68	29.68	30.55	31.31
7½	27.01	28.61	30.06	31.35	32.49	33.51	34.39
7¾	29.26	31.05	32.66	34.12	35.42	36.58	37.60
8	31.58	33.56	35.36	36.99	38.46	39.77	40.94
8¼	33.97	36.15	38.14	39.96	41.60	43.08	44.41
8½	36.43	38.82	41.01	43.01	44.84	46.50	47.99
8¾	38.95	41.56	43.96	46.16	48.18	50.02	51.69
9	41.54	44.36	46.98	49.39	51.61	53.64	55.50
9¼	44.18	47.24	50.08	52.71	55.13	57.37	59.41
9½	46.88	50.17	53.24	56.10	58.74	61.18	63.43
9¾	49.63	53.17	56.48	59.56	62.43	65.09	67.54
10	52.44	56.23	59.78	63.10	66.20	69.08	71.75

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.31	0.25	0.29					
2¼	0.48	0.36	0.42	0.45				
2½	0.69	0.50	0.58	0.63	0.67			
2¾	0.97	0.66	0.78	0.86	0.91	0.94		
3	1.32	0.85	1.01	1.13	1.21	1.26	1.30	
3¼	1.76	1.07	1.28	1.44	1.56	1.65	1.70	1.73
3½	2.29	1.32	1.60	1.81	1.97	2.09	2.18	2.23
3¾	2.92	1.60	1.95	2.23	2.45	2.61	2.73	2.81
4	3.68	1.92	2.35	2.70	2.98	3.20	3.36	3.48
4¼	4.56	2.27	2.80	3.24	3.59	3.87	4.08	4.25
4½	5.58	2.66	3.30	3.83	4.26	4.61	4.89	5.11
4¾	6.77	3.09	3.84	4.48	5.01	5.44	5.79	6.07
5	8.12	3.56	4.44	5.19	5.83	6.36	6.79	7.15
5¼	9.65	4.07	5.09	5.98	6.73	7.36	7.89	8.33
5½	11.39	4.62	5.80	6.83	7.71	8.46	9.10	9.63
5¾	13.33	5.21	6.57	7.75	8.77	9.66	10.41	11.04
6	15.51	5.85	7.39	8.74	9.92	10.95	11.83	12.58
6¼	17.93	6.54	8.27	9.81	11.16	12.34	13.37	14.25
6½	20.61	7.27	9.22	10.95	12.49	13.84	15.02	16.05
6¾	23.56	8.05	10.23	12.17	13.91	15.44	16.79	17.97
7	28.51	8.37	10.74	12.90	14.88	16.68	18.31	19.77
7¼	31.93	9.04	11.62	13.99	16.16	18.14	19.95	21.58
7½	35.61	9.73	12.53	15.11	17.48	19.66	21.65	23.46
7¾	39.55	10.45	13.46	16.26	18.84	21.22	23.41	25.41
8	43.76	11.18	14.42	17.45	20.25	22.84	25.23	27.42
8¼	48.25	11.93	15.41	18.66	21.69	24.50	27.10	29.49
8½	53.03	12.69	16.42	19.91	23.17	26.20	29.02	31.62
8¾	58.09	13.48	17.46	21.19	24.69	27.95	30.99	33.81
9	63.45	14.28	18.51	22.50	26.24	29.74	33.01	36.06
9¼	69.12	15.10	19.59	23.83	27.82	31.57	35.07	38.35
9½	75.09	15.93	20.69	25.19	29.44	33.43	37.19	40.70
9¾	81.38	16.77	21.81	26.58	31.08	35.33	39.34	43.10
10	87.98	17.63	22.94	27.98	32.76	37.27	41.53	45.55

Cast-iron 17 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	2.26						
3¾	2.86	2.90					
4	3.56	3.62	3.65				
4¼	4.36	4.45	4.50	4.53			
4½	5.27	5.39	5.47	5.53	5.56		
4¾	6.29	6.45	6.57	6.65	6.71	6.74	
5	7.43	7.64	7.80	7.92	8.01	8.06	8.09
5¼	8.68	8.96	9.18	9.34	9.46	9.54	9.59
5½	10.06	10.42	10.69	10.91	11.07	11.19	11.27
5¾	11.57	12.01	12.36	12.64	12.86	13.02	13.14
6	13.22	13.75	14.18	14.54	14.82	15.03	15.19
6¼	15.00	15.64	16.17	16.60	16.95	17.23	17.45
6½	16.93	17.68	18.32	18.85	19.28	19.63	19.91
6¾	19.00	19.88	20.64	21.27	21.80	22.24	22.59
7	21.08	22.24	23.27	24.18	24.97	25.65	26.23
7¼	23.05	24.37	25.54	26.58	27.50	28.29	28.98
7½	25.10	26.58	27.91	29.09	30.14	31.06	31.87
7¾	27.23	28.88	30.37	31.70	32.90	33.96	34.89
8	29.42	31.25	32.91	34.41	35.76	36.97	38.04
8¼	31.69	33.71	35.55	37.22	38.73	40.09	41.31
8½	34.03	36.24	38.27	40.12	41.80	43.33	44.70
8¾	36.43	38.84	41.07	43.11	44.97	46.66	48.20
9	38.89	41.52	43.94	46.18	48.23	50.10	51.81
9¼	41.41	44.26	46.89	49.33	51.58	53.64	55.53
9½	43.99	47.06	49.92	52.57	55.02	57.28	59.36
9¾	46.63	49.93	53.01	55.88	58.54	61.00	63.28
10	49.32	52.85	56.17	59.26	62.14	64.82	67.30

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	3/8 Inch.	1/2 Inch.	5/8 Inch.	3/4 Inch.	7/8 Inch.	1 Inch.	1 1/8 Inch.
Inches.								
2	0.28	0.23	0.26					
2 1/4	0.43	0.33	0.38	0.41				
2 1/2	0.63	0.45	0.53	0.58	0.60			
2 3/4	0.88	0.60	0.70	0.78	0.83	0.86		
3	1.20	0.77	0.92	1.02	1.10	1.15	1.18	
3 1/4	1.60	0.97	1.16	1.31	1.42	1.49	1.54	1.57
3 1/2	2.08	1.19	1.45	1.64	1.79	1.90	1.97	2.02
3 3/4	2.65	1.45	1.77	2.02	2.22	2.37	2.48	2.55
4	3.34	1.74	2.13	2.45	2.71	2.90	3.05	3.16
4 1/4	4.14	2.06	2.54	2.94	3.26	3.51	3.70	3.85
4 1/2	5.07	2.41	2.99	3.47	3.87	4.19	4.44	4.64
4 3/4	6.14	2.80	3.49	4.06	4.54	4.94	5.26	5.51
5	7.37	3.23	4.03	4.71	5.29	5.77	6.17	6.48
5 1/4	8.76	3.69	4.62	5.42	6.11	6.68	7.16	7.56
5 1/2	10.33	4.19	5.26	6.20	7.00	7.68	8.26	8.74
5 3/4	12.10	4.73	5.96	7.03	7.96	8.76	9.45	10.02
6	14.07	5.31	6.71	7.93	9.00	9.94	10.74	11.42
6 1/4	16.27	5.93	7.51	8.90	10.13	11.20	12.13	12.93
6 1/2	18.70	6.60	8.36	9.94	11.33	12.56	13.63	14.56
6 3/4	21.38	7.31	9.28	11.05	12.62	14.01	15.24	16.31
7	24.32	8.06	10.25	12.23	13.99	15.56	16.96	18.18
7 1/4	29.55	8.44	10.84	13.05	15.07	16.91	18.58	20.09
7 1/2	32.98	9.10	11.70	14.11	16.32	18.34	20.19	21.86
7 3/4	36.66	9.78	12.59	15.20	17.61	19.82	21.85	23.71
8	40.60	10.47	13.51	16.33	18.94	21.35	23.57	25.61
8 1/4	44.81	11.19	14.45	17.49	20.31	22.93	25.35	27.58
8 1/2	49.28	11.92	15.41	18.68	21.72	24.55	27.18	29.60
8 3/4	54.03	12.67	16.40	19.90	23.17	26.22	29.06	31.69
9	59.07	13.44	17.41	21.15	24.65	27.93	30.98	33.83
9 1/4	64.40	14.22	18.44	22.42	26.16	29.67	32.96	36.02
9 1/2	70.02	15.01	19.50	23.73	27.71	31.46	34.97	38.27
9 3/4	75.94	15.83	20.57	25.06	29.29	33.28	37.04	40.56
10	82.17	16.65	21.66	26.41	30.90	35.14	39.14	42.90

Cast-iron **18** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	2.05						
3¾	2.60	2.63					
4	3.23	3.28	3.31				
4¼	3.96	4.03	4.08	4.11			
4½	4.78	4.89	4.97	5.01	5.04		
4¾	5.71	5.86	5.96	6.04	6.09	6.12	
5	6.74	6.93	7.08	7.19	7.26	7.31	7.34
5¼	7.88	8.13	8.33	8.48	8.58	8.66	8.71
5½	9.13	9.45	9.70	9.90	10.05	10.16	10.23
5¾	10.50	10.90	11.22	11.47	11.67	11.81	11.92
6	12.00	12.48	12.87	13.19	13.44	13.64	13.79
6¼	13.61	14.19	14.67	15.07	15.39	15.64	15.83
6½	15.36	16.04	16.62	17.10	17.50	17.82	18.07
6¾	17.24	18.04	18.73	19.30	19.78	20.18	20.50
7	19.26	20.19	20.99	21.67	22.25	22.73	23.12
7¼	21.45	22.66	23.74	24.70	25.54	26.27	26.90
7½	23.38	24.75	25.97	27.06	28.03	28.87	29.61
7¾	25.39	26.92	28.29	29.53	30.62	31.60	32.46
8	27.47	29.17	30.70	32.09	33.33	34.44	35.42
8¼	29.62	31.49	33.20	34.71	36.14	37.39	38.51
8½	31.84	33.89	35.77	37.49	39.04	40.45	41.71
8¾	34.12	36.37	38.43	40.32	42.05	43.61	45.03
9	36.47	38.91	41.17	43.24	45.14	46.88	48.46
9¼	38.87	41.53	43.98	46.25	48.33	50.25	51.99
9½	41.34	44.20	46.86	49.33	51.61	53.71	55.63
9¾	43.86	46.94	49.82	52.49	54.97	57.26	59.37
10	46.44	49.75	52.84	55.73	58.41	60.90	63.21

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	3/8 Inch.	1/2 Inch.	5/8 Inch.	3/4 Inch.	7/8 Inch.	1 Inch.	1 1/8 Inch.
Inches.								
2	0.26	0.21	0.24					
2 1/4	0.39	0.30	0.35	0.37				
2 1/2	0.57	0.41	0.48	0.52	0.55			
2 3/4	0.80	0.54	0.64	0.71	0.76	0.78		
3	1.10	0.70	0.84	0.93	1.00	1.05	1.07	
3 1/4	1.46	0.88	1.06	1.20	1.29	1.36	1.41	1.43
3 1/2	1.89	1.09	1.32	1.50	1.63	1.73	1.80	1.84
3 3/4	2.42	1.32	1.61	1.85	2.02	2.16	2.26	2.33
4	3.04	1.59	1.95	2.24	2.47	2.65	2.78	2.88
4 1/4	3.77	1.88	2.32	2.68	2.97	3.20	3.38	3.51
4 1/2	4.62	2.20	2.73	3.17	3.53	3.82	4.05	4.23
4 3/4	5.60	2.56	3.18	3.71	4.14	4.50	4.80	5.03
5	6.72	2.95	3.68	4.30	4.83	5.26	5.62	5.91
5 1/4	7.99	3.37	4.22	4.95	5.57	6.10	6.53	6.89
5 1/2	9.43	3.82	4.80	5.65	6.38	7.01	7.53	7.97
5 3/4	11.04	4.32	5.44	6.41	7.26	7.99	8.62	9.14
6	12.84	4.85	6.12	7.24	8.21	9.06	9.79	10.42
6 1/4	14.84	5.41	6.85	8.12	9.24	10.22	11.06	11.80
6 1/2	17.06	6.02	7.63	9.06	10.34	11.45	12.43	13.28
6 3/4	19.50	6.66	8.46	10.07	11.51	12.78	13.90	14.88
7	22.19	7.35	9.35	11.15	12.76	14.20	15.47	16.59
7 1/4	25.13	8.08	10.29	12.29	14.09	15.71	17.14	18.41
7 1/2	28.35	8.84	11.29	13.51	15.51	17.31	18.92	20.35
7 3/4	34.08	9.16	11.80	14.24	16.48	18.55	20.44	22.16
8	37.77	9.83	12.67	15.31	17.75	20.00	22.07	23.97
8 1/4	41.71	10.51	13.57	16.41	19.05	21.50	23.76	25.83
8 1/2	45.91	11.21	14.49	17.55	20.40	23.04	25.50	27.76
8 3/4	50.37	11.92	15.43	18.71	21.78	24.63	27.28	29.74
9	55.11	12.66	16.39	19.90	23.19	26.26	29.12	31.78
9 1/4	60.12	13.41	17.38	21.12	24.64	27.93	31.01	33.88
9 1/2	65.42	14.17	18.39	22.37	26.12	29.64	32.94	36.02
9 3/4	71.00	14.95	19.42	23.65	27.63	31.39	34.91	38.22
10	76.88	15.75	20.47	24.95	29.18	33.17	36.93	40.46

Cast-iron **19** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	1.87						
3¾	2.37	2.40					
4	2.95	2.99	3.02				
4¼	3.61	3.68	3.72	3.75			
4½	4.36	4.46	4.53	4.57	4.60		
4¾	5.21	5.34	5.44	5.51	5.55	5.58	
5	6.15	6.32	6.46	6.56	6.63	6.67	6.70
5¼	7.19	7.42	7.60	7.73	7.83	7.90	7.94
5½	8.33	8.62	8.85	9.03	9.17	9.26	9.33
5¾	9.58	9.94	10.23	10.46	10.64	10.78	10.87
6	10.94	11.38	11.74	12.03	12.26	12.44	12.58
6¼	12.42	12.94	13.38	13.74	14.03	14.26	14.44
6½	14.01	14.64	15.16	15.60	15.96	16.25	16.48
6¾	15.73	16.46	17.08	17.61	18.04	18.40	18.70
7	17.56	18.41	19.14	19.77	20.29	20.73	21.09
7¼	19.53	20.51	21.36	22.09	22.71	23.24	23.68
7½	21.63	22.74	23.72	24.57	25.30	25.93	26.45
7¾	23.73	25.14	26.42	27.56	28.57	29.47	30.26
8	25.70	27.27	28.70	29.98	31.13	32.15	33.06
8¼	27.74	29.48	31.06	32.49	33.78	34.94	35.97
8½	29.84	31.76	33.50	35.09	36.54	37.84	39.00
8¾	32.02	34.11	36.03	37.79	39.39	40.84	42.15
9	34.25	36.53	38.63	40.56	42.33	43.94	45.40
9¼	36.55	39.02	41.31	43.42	45.36	47.14	48.76
9½	38.90	41.58	44.06	46.36	48.48	50.44	52.23
9¾	41.31	44.20	46.88	49.38	51.69	53.82	55.79
10	43.78	46.88	49.78	52.47	54.98	57.30	59.45

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.24	0.19	0.22					
2¼	0.36	0.28	0.32	0.34				
2½	0.53	0.38	0.44	0.48	0.51			
2¾	0.74	0.50	0.59	0.65	0.69	0.72		
3	1.00	0.64	0.77	0.86	0.92	0.96	0.98	
3¼	1.33	0.81	0.97	1.10	1.19	1.25	1.29	1.31
3½	1.74	1.00	1.21	1.37	1.50	1.59	1.65	1.69
3¾	2.22	1.21	1.48	1.69	1.86	1.98	2.07	2.13
4	2.79	1.45	1.78	2.05	2.26	2.43	2.55	2.64
4¼	3.46	1.72	2.12	2.45	2.72	2.93	3.10	3.22
4½	4.24	2.02	2.50	2.90	3.23	3.50	3.71	3.88
4¾	5.13	2.34	2.92	3.40	3.80	4.13	4.40	4.61
5	6.16	2.70	3.37	3.94	4.42	4.82	5.15	5.42
5¼	7.32	3.09	3.86	4.53	5.11	5.59	5.99	6.32
5½	8.64	3.51	4.40	5.18	5.85	6.42	6.90	7.30
5¾	10.12	3.96	4.98	5.88	6.66	7.33	7.90	8.38
6	11.77	4.44	5.61	6.63	7.53	8.31	8.98	9.55
6¼	13.60	4.96	6.28	7.44	8.47	9.36	10.14	10.81
6½	15.63	5.52	6.99	8.31	9.47	10.50	11.39	12.17
6¾	17.87	6.11	7.76	9.23	10.55	11.71	12.74	13.64
7	20.34	6.74	8.57	10.22	11.70	13.01	14.18	15.20
7¼	23.03	7.40	9.43	11.27	12.92	14.39	15.71	16.87
7½	25.98	8.11	10.35	12.38	14.21	15.86	17.34	18.66
7¾	29.19	8.85	11.31	13.55	15.59	17.42	19.07	20.55
8	32.67	9.63	12.33	14.80	17.04	19.07	20.90	22.55
8¼	38.92	9.89	12.76	15.43	17.90	20.19	22.30	24.24
8½	42.87	10.55	13.63	16.51	19.18	21.66	23.96	26.08
8¾	47.07	11.24	14.53	17.62	20.50	23.18	25.66	27.96
9	51.53	11.94	15.46	18.76	21.85	24.73	27.42	29.91
9¼	56.25	12.66	16.41	19.93	23.23	26.33	29.22	31.91
9½	61.24	13.39	17.37	21.12	24.65	27.96	31.06	33.96
9¾	66.52	14.14	18.36	22.35	26.10	29.64	32.95	36.06
10	72.07	14.90	19.37	23.59	27.58	31.35	34.88	38.21

Cast-iron **20** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	1.72						
3¾	2.17	2.20					
4	2.70	2.74	2.77				
4¼	3.31	3.37	3.41	3.44			
4½	4.00	4.09	4.15	4.19	4.22		
4¾	4.77	4.90	4.99	5.05	5.09	5.11	
5	5.63	5.80	5.92	6.01	6.07	6.11	6.14
5¼	6.59	6.80	6.96	7.09	7.18	7.24	7.28
5½	7.63	7.90	8.11	8.28	8.40	8.49	8.55
5¾	8.78	9.11	9.38	9.59	9.75	9.88	9.97
6	10.03	10.43	10.76	11.03	11.24	11.40	11.53
6¼	11.38	11.86	12.27	12.60	12.86	13.07	13.24
6½	12.84	13.41	13.90	14.30	14.63	14.89	15.11
6¾	14.41	15.08	15.65	16.14	16.54	16.87	17.13
7	16.10	16.88	17.55	18.12	18.60	19.00	19.33
7¼	17.90	18.80	19.57	20.24	20.82	21.30	21.70
7½	19.82	20.85	21.74	22.52	23.19	23.76	24.24
7¾	21.86	23.03	24.05	24.95	25.73	26.40	26.97
8	24.03	25.34	26.51	27.53	28.43	29.21	29.88
8¼	26.02	27.64	29.11	30.44	31.64	32.72	33.67
8½	28.02	29.81	31.43	32.91	34.25	35.46	36.54
8¾	30.09	32.04	33.83	35.47	36.96	38.31	39.53
9	32.22	34.35	36.31	38.11	39.76	41.26	42.62
9¼	34.41	36.72	38.86	40.84	42.65	44.30	45.81
9½	36.66	39.16	41.49	43.64	45.62	47.44	49.11
9¾	38.96	41.67	44.18	46.52	48.68	50.67	52.50
10	41.32	44.23	46.95	49.48	51.82	53.99	56.00

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.22	0.18	0.20					
2¼	0.33	0.25	0.29	0.31				
2½	0.48	0.35	0.40	0.44	0.46			
2¾	0.68	0.46	0.54	0.60	0.64	0.66		
3	0.92	0.59	0.71	0.79	0.85	0.88	0.91	
3¼	1.23	0.74	0.89	1.01	1.09	1.15	1.19	1.21
3½	1.60	0.92	1.11	1.26	1.38	1.46	1.52	1.56
3¾	2.04	1.12	1.36	1.56	1.71	1.82	1.90	1.96
4	2.57	1.34	1.64	1.89	2.08	2.23	2.35	2.43
4¼	3.18	1.59	1.96	2.26	2.50	2.70	2.85	2.96
4½	3.90	1.86	2.30	2.67	2.97	3.22	3.42	3.57
4¾	4.72	2.16	2.68	3.13	3.50	3.80	4.05	4.24
5	5.67	2.48	3.10	3.63	4.07	4.44	4.74	4.99
5¼	6.74	2.84	3.56	4.17	4.70	5.14	5.51	5.82
5½	7.95	3.23	4.05	4.77	5.38	5.91	6.35	6.72
5¾	9.31	3.64	4.58	5.41	6.13	6.74	7.27	7.71
6	10.83	4.09	5.16	6.10	6.93	7.64	8.26	8.79
6¼	12.52	4.57	5.78	6.85	7.79	8.62	9.33	9.95
6½	14.39	5.08	6.44	7.65	8.72	9.66	10.49	11.20
6¾	16.45	5.62	7.14	8.50	9.71	10.78	11.72	12.55
7	18.72	6.20	7.89	9.41	10.77	11.98	13.05	13.99
7¼	21.20	6.81	8.68	10.37	11.89	13.25	14.46	15.53
7½	23.91	7.46	9.52	11.39	13.08	14.60	15.96	17.17
7¾	26.86	8.15	10.41	12.48	14.35	16.03	17.55	18.91
8	30.07	8.87	11.35	13.62	15.68	17.55	19.24	20.76
8¼	35.54	9.63	12.34	14.82	17.09	19.15	21.02	22.71
8½	40.12	9.95	12.85	15.56	18.07	20.40	22.55	24.53
8¾	44.07	10.61	13.71	16.62	19.32	21.84	24.17	26.33
9	48.28	11.28	14.60	17.71	20.61	23.32	25.85	28.19
9¼	52.73	11.96	15.50	18.82	21.94	24.85	27.57	30.09
9½	57.45	12.67	16.43	19.97	23.30	26.41	29.33	32.05
9¾	62.43	13.39	17.38	21.14	24.69	28.02	31.14	34.06
10	67.68	14.12	18.35	22.34	26.11	29.66	32.99	36.12

Cast-iron **21** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	1.58						
3¾	2.00	2.02					
4	2.49	2.53	2.55				
4¼	3.05	3.10	3.14	3.16			
4½	3.68	3.76	3.82	3.86	3.88		
4¾	4.39	4.51	4.59	4.65	4.68	4.71	
5	5.18	5.34	5.45	5.53	5.59	5.63	5.65
5¼	6.06	6.26	6.41	6.52	6.60	6.66	6.70
5½	7.03	7.27	7.47	7.62	7.73	7.81	7.87
5¾	8.08	8.38	8.63	8.83	8.98	9.09	9.17
6	9.23	9.60	9.90	10.15	10.34	10.50	10.61
6¼	10.48	10.92	11.29	11.59	11.84	12.03	12.18
6½	11.82	12.35	12.79	13.16	13.46	13.71	13.90
6¾	13.27	13.88	14.41	14.85	15.22	15.52	15.77
7	14.82	15.53	16.15	16.68	17.12	17.49	17.79
7¼	16.47	17.30	18.02	18.63	19.16	19.60	19.97
7½	18.24	19.19	20.01	20.73	21.34	21.87	22.31
7¾	20.12	21.19	22.14	22.96	23.68	24.30	24.82
8	22.12	23.33	24.40	25.34	26.17	26.88	27.50
8¼	24.23	25.59	26.80	27.87	28.81	29.64	30.35
8½	26.36	28.02	29.54	30.92	32.17	33.30	34.30
8¾	28.32	30.15	31.83	33.36	34.74	36.00	37.13
9	30.35	32.35	34.19	35.87	37.40	38.80	40.07
9¼	32.44	34.61	36.62	38.46	40.15	41.70	43.11
9½	34.59	36.94	39.12	41.14	42.99	44.69	46.25
9¾	36.79	39.34	41.70	43.89	45.91	47.77	49.48
10	39.06	41.79	44.34	46.71	48.91	50.95	52.82

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.20	0.16	0.19					
2¼	0.31	0.23	0.27	0.29				
2½	0.45	0.32	0.37	0.41	0.43			
2¾	0.63	0.42	0.50	0.55	0.59	0.61		
3	0.85	0.55	0.65	0.73	0.78	0.82	0.84	
3¼	1.13	0.69	0.83	0.93	1.01	1.06	1.10	1.12
3½	1.48	0.85	1.03	1.17	1.27	1.35	1.40	1.44
3¾	1.89	1.03	1.26	1.44	1.58	1.68	1.76	1.81
4	2.37	1.24	1.52	1.74	1.92	2.06	2.18	2.25
4¼	2.94	1.46	1.81	2.09	2.31	2.49	2.63	2.74
4½	3.60	1.72	2.13	2.47	2.75	2.98	3.16	3.30
4¾	4.37	1.99	2.48	2.89	3.23	3.51	3.74	3.92
5	5.24	2.30	2.87	3.35	3.76	4.10	4.38	4.61
5¼	6.23	2.62	3.29	3.86	4.34	4.75	5.09	5.37
5½	7.35	2.98	3.74	4.40	4.97	5.46	5.87	6.21
5¾	8.60	3.36	4.24	5.00	5.66	6.23	6.72	7.13
6	10.01	3.78	4.77	5.64	6.40	7.06	7.63	8.12
6¼	11.57	4.22	5.34	6.33	7.20	7.96	8.62	9.19
6½	13.29	4.69	5.95	7.07	8.06	8.93	9.69	10.35
6¾	15.20	5.19	6.60	7.85	8.97	9.96	10.83	11.60
7	17.29	5.73	7.29	8.69	9.95	11.07	12.06	12.93
7¼	19.59	6.29	8.02	9.58	10.99	12.24	13.36	14.35
7½	22.09	6.89	8.80	10.53	12.09	13.49	14.75	15.86
7¾	24.82	7.53	9.62	11.53	13.25	14.82	16.22	17.47
8	27.78	8.19	10.49	12.58	14.49	16.22	17.78	19.18
8¼	30.99	8.90	11.40	13.69	15.79	17.70	19.42	20.98
8½	34.45	9.63	12.36	14.86	17.16	19.25	21.16	22.89
8¾	38.19	10.41	13.37	16.09	18.60	20.89	22.99	24.89
9	45.32	10.67	13.80	16.73	19.47	22.03	24.40	26.60
9¼	49.53	11.32	14.67	17.80	20.74	23.49	26.05	28.43
9½	53.99	12.00	15.56	18.90	22.04	24.98	27.73	30.30
9¾	58.70	12.69	16.46	20.02	23.37	26.52	29.47	32.22
10	63.68	13.39	17.40	21.17	24.74	28.09	31.24	34.20

Cast-iron 22 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	1.46						
3¾	1.85	1.87					
4	2.30	2.33	2.35				
4¼	2.82	2.87	2.90	2.92			
4½	3.40	3.48	3.53	3.56	3.59		
4¾	4.06	4.16	4.24	4.29	4.33	4.35	
5	4.79	4.93	5.04	5.11	5.16	5.20	5.22
5¼	5.60	5.78	5.92	6.03	6.10	6.16	6.19
5½	6.49	6.72	6.90	7.04	7.14	7.22	7.27
5¾	7.47	7.75	7.97	8.15	8.29	8.40	8.48
6	8.53	8.87	9.15	9.38	9.56	9.70	9.80
6¼	9.68	10.09	10.43	10.71	10.94	11.12	11.26
6½	10.92	11.41	11.82	12.16	12.44	12.67	12.85
6¾	12.26	12.83	13.31	13.72	14.06	14.34	14.57
7	13.69	14.35	14.92	15.41	15.82	16.16	16.44
7¼	15.22	15.98	16.65	17.22	17.70	18.11	18.45
7½	16.86	17.73	18.49	19.15	19.72	20.21	20.62
7¾	18.59	19.58	20.45	21.22	21.88	22.45	22.93
8	20.44	21.55	22.54	23.42	24.18	24.84	25.41
8¼	22.39	23.64	24.76	25.75	26.62	27.39	28.05
8½	24.45	25.85	27.11	28.22	29.22	30.09	30.85
8¾	26.62	28.18	29.58	30.84	31.96	32.95	33.82
9	28.64	30.51	32.23	33.81	35.25	36.55	37.73
9¼	30.63	32.67	34.55	36.28	37.87	39.31	40.63
9½	32.68	34.90	36.95	38.83	40.57	42.16	43.62
9¾	34.79	37.19	39.41	41.46	43.36	45.11	46.71
10	36.96	39.54	41.94	44.17	46.23	48.14	49.89

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.19	0.15	0.17					
2¼	0.29	0.22	0.25	0.27				
2½	0.41	0.30	0.35	0.38	0.40			
2¾	0.58	0.39	0.46	0.51	0.55	0.57		
3	0.79	0.51	0.60	0.67	0.72	0.76	0.78	
3¼	1.05	0.64	0.77	0.86	0.93	0.98	1.02	1.04
3½	1.37	0.79	0.95	1.08	1.18	1.25	1.30	1.33
3¾	1.75	0.96	1.17	1.33	1.46	1.56	1.63	1.68
4	2.20	1.15	1.41	1.62	1.78	1.91	2.01	2.08
4¼	2.73	1.36	1.67	1.93	2.14	2.31	2.44	2.54
4½	3.34	1.59	1.97	2.29	2.55	2.76	2.93	3.06
4¾	4.05	1.85	2.30	2.68	3.00	3.26	3.47	3.63
5	4.86	2.13	2.66	3.11	3.49	3.80	4.06	4.27
5¼	5.77	2.43	3.05	3.58	4.03	4.41	4.72	4.98
5½	6.81	2.76	3.47	4.08	4.61	5.06	5.44	5.76
5¾	7.98	3.12	3.93	4.63	5.25	5.78	6.23	6.61
6	9.28	3.50	4.42	5.23	5.94	6.55	7.08	7.53
6¼	10.72	3.91	4.95	5.87	6.68	7.38	8.00	8.52
6½	12.33	4.35	5.51	6.55	7.47	8.28	8.98	9.60
6¾	14.09	4.82	6.12	7.28	8.32	9.24	10.04	10.75
7	16.03	5.31	6.76	8.06	9.22	10.26	11.18	11.99
7¼	18.16	5.84	7.44	8.88	10.19	11.35	12.39	13.31
7½	20.49	6.39	8.16	9.76	11.21	12.51	13.67	14.71
7¾	23.01	6.98	8.92	10.69	12.29	13.74	15.04	16.20
8	25.76	7.60	9.72	11.67	13.43	15.03	16.48	17.78
8¼	28.73	8.25	10.57	12.70	14.64	16.41	18.01	19.46
8½	31.95	8.93	11.46	13.78	15.91	17.85	19.62	21.22
8¾	35.41	9.65	12.39	14.92	17.25	19.37	21.31	23.08
9	39.13	10.40	13.37	16.12	18.65	20.97	23.10	25.04
9¼	46.61	10.73	13.89	16.86	19.64	22.23	24.64	26.89
9½	50.83	11.38	14.75	17.91	20.88	23.66	26.26	28.68
9¾	55.30	12.04	15.62	18.99	22.16	25.13	27.92	30.52
10	60.01	12.72	16.51	20.09	23.47	26.64	29.62	32.41

Cast-iron **23** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	1.35						
3¾	1.71	1.73					
4	2.13	2.16	2.18				
4¼	2.61	2.66	2.69	2.71			
4½	3.15	3.22	3.27	3.31	3.32		
4¾	3.76	3.86	3.93	3.98	4.01	4.03	
5	4.44	4.57	4.67	4.74	4.79	4.82	4.84
5¼	5.19	5.36	5.49	5.59	5.66	5.71	5.74
5½	6.02	6.23	6.40	6.53	6.62	6.69	6.74
5¾	6.92	7.18	7.39	7.56	7.69	7.79	7.86
6	7.91	8.22	8.48	8.69	8.86	8.99	9.09
6¼	8.97	9.35	9.67	9.93	10.14	10.31	10.44
6½	10.13	10.58	10.96	11.27	11.53	11.74	11.91
6¾	11.37	11.89	12.34	12.72	13.04	13.30	13.51
7	12.69	13.31	13.84	14.29	14.67	14.98	15.24
7¼	14.11	14.82	15.43	15.96	16.41	16.79	17.11
7½	15.63	16.44	17.14	17.76	18.29	18.74	19.12
7¾	17.24	18.16	18.97	19.67	20.29	20.81	21.26
8	18.95	19.98	20.90	21.71	22.42	23.03	23.56
8¼	20.76	21.92	22.96	23.88	24.68	25.39	26.01
8½	22.67	23.97	25.13	26.17	27.09	27.90	28.60
8¾	24.68	26.13	27.43	28.60	29.63	30.55	31.36
9	26.81	28.41	29.85	31.16	32.32	33.36	34.28
9¼	28.96	30.88	32.65	34.28	35.76	37.12	38.35
9½	30.93	33.01	34.94	36.71	38.34	39.84	41.20
9¾	32.94	35.20	37.29	39.22	41.01	42.65	44.15
10	35.02	37.45	39.71	41.81	43.75	45.54	47.19

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.17	0.14	0.16					
2¼	0.26	0.20	0.23	0.25				
2½	0.39	0.28	0.32	0.35	0.37			
2¾	0.54	0.37	0.43	0.48	0.51	0.53		
3	0.74	0.47	0.56	0.63	0.67	0.70	0.72	
3¼	0.98	0.59	0.71	0.80	0.87	0.92	0.95	0.96
3½	1.27	0.73	0.89	1.01	1.10	1.16	1.21	1.24
3¾	1.63	0.89	1.09	1.24	1.36	1.45	1.52	1.56
4	2.05	1.07	1.31	1.50	1.66	1.78	1.87	1.94
4¼	2.54	1.26	1.56	1.80	2.00	2.15	2.27	2.36
4½	3.11	1.48	1.83	2.13	2.37	2.57	2.72	2.84
4¾	3.76	1.72	2.14	2.49	2.79	3.03	3.22	3.38
5	4.52	1.98	2.47	2.89	3.24	3.54	3.78	3.98
5¼	5.37	2.26	2.83	3.33	3.74	4.10	4.39	4.63
5½	6.34	2.57	3.23	3.80	4.29	4.71	5.06	5.36
5¾	7.42	2.90	3.65	4.31	4.88	5.37	5.79	6.15
6	8.63	3.26	4.11	4.86	5.52	6.09	6.58	7.00
6¼	9.97	3.64	4.60	5.46	6.21	6.87	7.44	7.93
6½	11.47	4.05	5.13	6.09	6.95	7.70	8.36	8.93
6¾	13.11	4.48	5.69	6.77	7.74	8.59	9.34	10.00
7	14.92	4.94	6.29	7.50	8.58	9.54	10.40	11.15
7¼	16.89	5.43	6.92	8.27	9.48	10.56	11.52	12.38
7½	19.05	5.95	7.59	9.08	10.43	11.64	12.72	13.68
7¾	21.41	6.49	8.30	9.94	11.43	12.78	13.99	15.07
8	23.96	7.07	9.05	10.85	12.50	13.99	15.33	16.54
8¼	26.73	7.67	9.83	11.81	13.62	15.26	16.75	18.10
8½	29.72	8.31	10.66	12.82	14.80	16.61	18.25	19.74
8¾	32.94	8.97	11.53	13.88	16.04	18.02	19.83	21.47
9	36.40	9.67	12.44	14.99	17.35	19.51	21.48	23.29
9¼	40.12	10.40	13.39	16.16	18.71	21.06	23.22	25.20
9½	44.10	11.17	14.39	17.37	20.14	22.69	25.05	27.21
9¾	52.18	11.44	14.83	18.03	21.03	23.85	26.48	28.94
10	56.65	12.09	15.69	19.09	22.29	25.29	28.11	30.75

Cast-iron 24 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	1.26						
3¾	1.59	1.61					
4	1.98	2.01	2.03				
4¼	2.43	2.47	2.50	2.52			
4½	2.93	3.00	3.04	3.07	3.09		
4¾	3.50	3.59	3.66	3.70	3.73	3.75	
5	4.13	4.25	4.34	4.41	4.45	4.48	4.50
5¼	4.83	4.99	5.11	5.20	5.26	5.31	5.34
5½	5.60	5.79	5.95	6.07	6.16	6.23	6.27
5¾	6.44	6.68	6.88	7.03	7.15	7.24	7.31
6	7.36	7.65	7.89	8.09	8.24	8.36	8.45
6¼	8.35	8.70	9.00	9.24	9.43	9.59	9.71
6½	9.42	9.84	10.19	10.49	10.73	10.92	11.08
6¾	10.57	11.06	11.48	11.84	12.13	12.37	12.57
7	11.81	12.38	12.87	13.29	13.64	13.94	14.18
7¼	13.13	13.79	14.36	14.85	15.27	15.62	15.92
7½	14.54	15.29	15.95	16.52	17.01	17.43	17.78
7¾	16.04	16.89	17.64	18.30	18.97	19.36	19.78
8	17.63	18.59	19.44	20.20	20.85	21.42	21.92
8¼	19.31	20.39	21.36	22.21	22.96	23.62	24.19
8½	21.09	22.30	23.38	24.34	25.20	25.95	26.61
8¾	22.96	24.31	25.52	26.60	27.56	28.42	29.17
9	24.93	26.43	27.77	28.98	30.06	31.03	31.88
9¼	27.01	28.65	30.14	31.49	32.70	33.78	34.75
9½	29.19	30.99	32.64	34.13	35.47	36.68	37.77
9¾	31.23	33.36	35.33	37.15	38.84	40.38	41.79
10	33.22	35.51	37.65	39.63	41.46	43.15	44.70

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.16	0.13	0.15					
2¼	0.25	0.19	0.22	0.23				
2½	0.36	0.26	0.30	0.33	0.35			
2¾	0.50	0.34	0.40	0.45	0.47	0.49		
3	0.69	0.44	0.52	0.59	0.63	0.66	0.67	
3¼	0.91	0.55	0.66	0.75	0.81	0.85	0.88	0.90
3½	1.19	0.68	0.83	0.94	1.02	1.09	1.13	1.16
3¾	1.52	0.83	1.01	1.16	1.27	1.35	1.42	1.46
4	1.91	1.00	1.22	1.40	1.55	1.66	1.75	1.81
4¼	2.37	1.18	1.45	1.68	1.86	2.01	2.12	2.20
4½	2.90	1.38	1.71	1.99	2.21	2.39	2.54	2.65
4¾	3.51	1.60	1.99	2.32	2.60	2.83	3.01	3.15
5	4.21	1.85	2.31	2.70	3.03	3.30	3.53	3.71
5¼	5.01	2.11	2.64	3.10	3.49	3.82	4.10	4.32
5½	5.91	2.40	3.01	3.54	4.00	4.39	4.72	5.00
5¾	6.92	2.71	3.41	4.02	4.55	5.01	5.40	5.73
6	8.05	3.04	3.84	4.54	5.15	5.68	6.14	6.53
6¼	9.31	3.39	4.29	5.09	5.79	6.41	6.94	7.40
6½	10.70	3.77	4.79	5.68	6.48	7.18	7.80	8.33
6¾	12.23	4.18	5.31	6.32	7.22	8.01	8.72	9.33
7	13.92	4.61	5.86	6.99	8.00	8.90	9.70	10.40
7¼	15.76	5.06	6.46	7.71	8.84	9.85	10.75	11.55
7½	17.78	5.55	7.08	8.47	9.73	10.86	11.87	12.77
7¾	19.97	6.06	7.74	9.27	10.67	11.92	13.05	14.06
8	22.36	6.59	8.44	10.13	11.66	13.05	14.30	15.43
8¼	24.94	7.16	9.17	11.02	12.71	14.24	15.63	16.88
8½	27.72	7.75	9.94	11.96	13.81	15.49	17.03	18.42
8¾	30.73	8.37	10.76	12.95	14.97	16.81	18.50	20.03
9	33.96	9.02	11.60	13.99	16.18	18.20	20.04	21.73
9¼	37.43	9.71	12.49	15.07	17.46	19.65	21.67	23.51
9½	41.15	10.42	13.42	16.21	18.79	21.17	23.37	25.38
9¾	45.12	11.16	14.39	17.40	20.18	22.77	25.15	27.34
10	49.36	11.93	15.40	18.64	21.64	24.43	27.01	29.39

Cast-iron **25** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	1.17						
3¾	1.49	1.50					
4	1.85	1.88	1.89				
4¼	2.27	2.31	2.34	2.35			
4½	2.74	2.80	2.84	2.87	2.88		
4¾	3.26	3.35	3.41	3.45	3.48	3.50	
5	3.85	3.97	4.05	4.11	4.16	4.18	4.20
5¼	4.51	4.65	4.76	4.85	4.91	4.95	4.98
5½	5.22	5.41	5.55	5.66	5.75	5.81	5.85
5¾	6.01	6.23	6.42	6.56	6.67	6.76	6.82
6	6.86	7.14	7.36	7.55	7.69	7.80	7.89
6¼	7.79	8.12	8.39	8.62	8.80	8.95	9.06
6½	8.79	9.18	9.51	9.78	10.01	10.19	10.34
6¾	9.86	10.32	10.71	11.04	11.32	11.54	11.72
7	11.02	11.55	12.01	12.40	12.73	13.00	13.23
7¼	12.25	12.86	13.39	13.85	14.24	14.57	14.85
7½	13.56	14.26	14.88	15.41	15.87	16.26	16.59
7¾	14.96	15.76	16.46	17.07	17.60	18.06	18.45
8	16.44	17.34	18.14	18.84	19.46	19.99	20.45
8¼	18.01	19.02	19.92	20.72	21.42	22.04	22.57
8½	19.67	20.80	21.81	22.71	23.51	24.21	24.82
8¾	21.42	22.68	23.81	24.82	25.72	26.51	27.21
9	23.26	24.65	25.91	27.04	28.05	28.95	29.74
9¼	25.20	26.73	28.12	29.38	30.51	31.52	32.42
9½	27.23	28.92	30.45	31.84	33.09	34.22	35.23
9¾	29.36	31.20	32.89	34.42	35.81	37.07	38.20
10	31.39	33.60	35.45	37.13	38.67	40.06	41.31

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.15	0.12	0.14					
2¼	0.23	0.18	0.20	0.22				
2½	0.34	0.24	0.28	0.31	0.32			
2¾	0.47	0.32	0.38	0.42	0.44	0.46		
3	0.64	0.41	0.49	0.55	0.59	0.61	0.63	
3¼	0.85	0.52	0.62	0.70	0.76	0.80	0.82	0.84
3½	1.11	0.64	0.77	0.88	0.96	1.02	1.06	1.08
3¾	1.42	0.78	0.95	1.08	1.19	1.27	1.32	1.36
4	1.79	0.93	1.14	1.31	1.45	1.55	1.63	1.69
4¼	2.21	1.10	1.36	1.57	1.74	1.88	1.98	2.06
4½	2.71	1.29	1.60	1.86	2.07	2.24	2.37	2.48
4¾	3.29	1.50	1.87	2.17	2.43	2.64	2.81	2.95
5	3.94	1.73	2.16	2.52	2.83	3.09	3.30	3.47
5¼	4.69	1.98	2.47	2.90	3.27	3.58	3.83	4.04
5½	5.53	2.24	2.82	3.32	3.74	4.11	4.42	4.68
5¾	6.48	2.53	3.19	3.76	4.26	4.69	5.05	5.36
6	7.53	2.84	3.59	4.25	4.82	5.32	5.75	6.11
6¼	8.71	3.18	4.02	4.76	5.42	5.99	6.49	6.92
6½	10.01	3.53	4.48	5.32	6.06	6.72	7.29	7.79
6¾	11.44	3.91	4.97	5.91	6.75	7.50	8.15	8.73
7	13.02	4.31	5.49	6.54	7.49	8.33	9.07	9.73
7¼	14.75	4.74	6.04	7.21	8.27	9.21	10.06	10.80
7½	16.63	5.19	6.62	7.92	9.10	10.16	11.10	11.94
7¾	18.68	5.67	7.24	8.68	9.98	11.15	12.21	13.15
8	20.91	6.17	7.89	9.47	10.91	12.21	13.38	14.44
8¼	23.33	6.70	8.58	10.31	11.89	13.32	14.62	15.79
8½	25.94	7.25	9.30	11.19	12.92	14.49	15.93	17.23
8¾	28.75	7.83	10.06	12.11	14.00	15.73	17.30	18.74
9	31.77	8.44	10.86	13.09	15.14	17.02	18.75	20.33
9¼	35.02	9.08	11.69	14.10	16.33	18.38	20.27	22.00
9½	38.49	9.75	12.56	15.16	17.58	19.81	21.86	23.75
9¾	42.21	10.44	13.46	16.27	18.88	21.30	23.53	25.58
10	46.18	11.16	14.41	17.43	20.24	22.85	25.27	27.50

Cast-iron **26** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	1.10						
3¾	1.39	1.41					
4	1.73	1.76	1.77				
4¼	2.12	2.16	2.18	2.20			
4½	2.56	2.62	2.66	2.68	2.70		
4¾	3.05	3.13	3.19	3.23	3.26	3.27	
5	3.61	3.71	3.79	3.85	3.89	3.91	3.93
5¼	4.22	4.35	4.46	4.54	4.59	4.63	4.66
5½	4.89	5.06	5.19	5.30	5.38	5.43	5.47
5¾	5.62	5.83	6.00	6.14	6.24	6.32	6.38
6	6.42	6.68	6.89	7.06	7.19	7.30	7.38
6¼	7.29	7.59	7.85	8.06	8.23	8.37	8.47
6½	8.22	8.59	8.90	9.15	9.36	9.53	9.67
6¾	9.23	9.65	10.02	10.33	10.59	10.80	10.97
7	10.31	10.80	11.23	11.60	11.91	12.16	12.37
7¼	11.46	12.03	12.53	12.96	13.32	13.63	13.89
7½	12.69	13.34	13.92	14.42	14.84	15.21	15.52
7¾	14.00	14.74	15.40	15.97	16.47	16.90	17.26
8	15.38	16.22	16.97	17.63	18.20	18.70	19.13
8¼	16.85	17.80	18.64	19.38	20.04	20.61	21.11
8½	18.40	19.46	20.40	21.25	21.99	22.65	23.22
8¾	20.04	21.21	22.27	23.22	24.06	24.80	25.46
9	21.76	23.06	24.24	25.29	26.24	27.08	27.83
9¼	23.57	25.01	26.31	27.48	28.54	29.48	30.33
9½	25.47	27.05	28.48	29.79	30.96	32.02	32.96
9¾	27.46	29.19	30.77	32.20	33.50	34.68	35.73
10	29.55	31.43	33.16	34.74	36.17	37.47	38.65

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.14	0.12	0.13					
2¼	0.22	0.17	0.19	0.20				
2½	0.32	0.23	0.26	0.29	0.30			
2¾	0.44	0.30	0.35	0.39	0.42	0.43		
3	0.60	0.39	0.46	0.51	0.55	0.58	0.59	
3¼	0.80	0.48	0.58	0.66	0.71	0.75	0.77	0.79
3½	1.04	0.60	0.73	0.82	0.90	0.95	0.99	1.01
3¾	1.33	0.73	0.89	1.02	1.11	1.19	1.24	1.28
4	1.67	0.87	1.07	1.23	1.36	1.46	1.53	1.59
4¼	2.08	1.03	1.28	1.47	1.63	1.76	1.86	1.93
4½	2.54	1.21	1.50	1.74	1.94	2.10	2.23	2.33
4¾	3.08	1.41	1.75	2.04	2.28	2.48	2.64	2.77
5	3.70	1.62	2.02	2.37	2.66	2.90	3.09	3.25
5¼	4.40	1.85	2.32	2.72	3.06	3.35	3.60	3.79
5½	5.19	2.10	2.64	3.11	3.51	3.85	4.14	4.39
5¾	6.07	2.37	2.99	3.53	4.00	4.40	4.74	5.03
6	7.06	2.67	3.37	3.98	4.52	4.99	5.39	5.73
6¼	8.17	2.98	3.77	4.47	5.08	5.62	6.09	6.49
6½	9.38	3.31	4.20	4.99	5.69	6.30	6.84	7.31
6¾	10.73	3.67	4.66	5.54	6.33	7.03	7.65	8.19
7	12.21	4.04	5.14	6.14	7.02	7.81	8.51	9.13
7¼	13.83	4.44	5.66	6.76	7.76	8.64	9.43	10.13
7½	15.60	4.87	6.21	7.43	8.53	9.52	10.41	11.20
7¾	17.52	5.31	6.79	8.14	9.36	10.46	11.45	12.34
8	19.61	5.78	7.40	8.88	10.23	11.45	12.55	13.54
8¼	21.88	6.28	8.05	9.67	11.15	12.49	13.71	14.81
8½	24.32	6.80	8.72	10.49	12.11	13.59	14.94	16.16
8¾	26.96	7.35	9.44	11.36	13.13	14.75	16.23	17.57
9	29.80	7.92	10.18	12.27	14.20	15.97	17.59	19.06
9¼	32.84	8.52	10.96	13.22	15.32	17.24	19.01	20.63
9½	36.10	9.14	11.78	14.22	16.49	18.58	20.50	22.27
9¾	39.59	9.79	12.63	15.26	17.71	19.97	22.06	23.99
10	43.31	10.47	13.51	16.35	18.99	21.43	23.70	25.79

Cast-iron **27** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	1.03						
3¾	1.30	1.32					
4	1.62	1.65	1.66				
4¼	1.99	2.03	2.05	2.06			
4½	2.40	2.45	2.49	2.52	2.53		
4¾	2.86	2.94	2.99	3.03	3.05	3.07	
5	3.38	3.48	3.55	3.61	3.65	3.67	3.69
5¼	3.95	4.08	4.18	4.25	4.31	4.35	4.37
5½	4.58	4.74	4.87	4.97	5.04	5.10	5.14
5¾	5.27	5.47	5.63	5.76	5.86	5.93	5.98
6	6.02	6.26	6.46	6.62	6.75	6.85	6.92
6¼	6.83	7.12	7.36	7.56	7.72	7.85	7.95
6½	7.71	8.05	8.34	8.58	8.78	8.94	9.07
6¾	8.65	9.05	9.40	9.69	9.93	10.13	10.29
7	9.66	10.13	10.53	10.88	11.17	11.41	11.61
7¼	10.75	11.28	11.75	12.15	12.50	12.79	13.03
7½	11.90	12.52	13.05	13.52	13.92	14.27	14.56
7¾	13.13	13.82	14.44	14.98	15.45	15.85	16.19
8	14.43	15.22	15.92	16.53	17.07	17.54	17.94
8¼	15.80	16.69	17.48	18.18	18.80	19.33	19.80
8½	17.26	18.25	19.14	19.93	20.62	21.24	21.78
8¾	18.79	19.90	20.89	21.77	22.56	23.26	23.88
9	20.41	21.63	22.73	23.72	24.61	25.40	26.10
9¼	22.11	23.45	24.67	25.77	26.77	27.65	28.44
9½	23.89	25.37	26.71	27.93	29.04	30.03	30.91
9¾	25.76	27.38	28.86	30.20	31.42	32.52	33.51
10	27.71	29.48	31.10	32.58	33.92	35.14	36.25

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.13	0.11	0.12					
2¼	0.20	0.16	0.18	0.19				
2½	0.30	0.21	0.25	0.27	0.29			
2¾	0.42	0.28	0.33	0.37	0.39	0.40		
3	0.57	0.36	0.43	0.48	0.52	0.54	0.56	
3¼	0.75	0.46	0.55	0.62	0.67	0.70	0.73	0.74
3½	0.98	0.56	0.68	0.78	0.85	0.90	0.93	0.95
3¾	1.25	0.68	0.84	0.95	1.05	1.12	1.17	1.20
4	1.57	0.82	1.01	1.16	1.28	1.37	1.44	1.49
4¼	1.95	0.97	1.20	1.38	1.54	1.65	1.75	1.82
4½	2.39	1.14	1.41	1.64	1.82	1.97	2.09	2.19
4¾	2.90	1.32	1.64	1.92	2.14	2.33	2.48	2.60
5	3.48	1.52	1.90	2.22	2.50	2.72	2.91	3.06
5¼	4.13	1.74	2.18	2.56	2.88	3.15	3.38	3.57
5½	4.88	1.98	2.48	2.92	3.30	3.62	3.90	4.12
5¾	5.71	2.23	2.81	3.32	3.76	4.13	4.46	4.73
6	6.64	2.51	3.16	3.74	4.25	4.69	5.07	5.39
6¼	7.68	2.80	3.54	4.20	4.78	5.28	5.72	6.10
6½	8.82	3.11	3.95	4.69	5.35	5.92	6.43	6.87
6¾	10.09	3.45	4.38	5.21	5.95	6.61	7.19	7.70
7	11.48	3.80	4.84	5.77	6.60	7.34	8.00	8.58
7¼	13.00	4.18	5.32	6.36	7.29	8.12	8.87	9.52
7½	14.66	4.57	5.84	6.99	8.02	8.95	9.79	10.53
7¾	16.47	4.99	6.38	7.65	8.80	9.83	10.76	11.60
8	18.44	5.44	6.96	8.35	9.62	10.76	11.80	12.73
8¼	20.57	5.90	7.57	9.09	10.48	11.74	12.89	13.93
8½	22.87	6.39	8.20	9.86	11.39	12.78	14.04	15.19
8¾	25.34	6.91	8.87	10.68	12.34	13.87	15.26	16.52
9	28.01	7.44	9.57	11.54	13.35	15.01	16.53	17.92
9¼	30.87	8.00	10.30	12.43	14.40	16.21	17.87	19.39
9½	33.94	8.59	11.07	13.37	15.50	17.46	19.27	20.94
9¾	37.21	9.20	11.87	14.35	16.65	18.78	20.74	22.55
10	40.71	9.84	12.70	15.37	17.85	20.15	22.27	24.24

Cast-iron 28 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	0.97						
3¾	1.23	1.24					
4	1.53	1.55	1.56				
4¼	1.87	1.90	1.93	1.94			
4½	2.26	2.31	2.34	2.37	2.38		
4¾	2.69	2.76	2.81	2.85	2.87	2.89	
5	3.18	3.27	3.34	3.39	3.43	3.45	3.46
5¼	3.72	3.84	3.93	4.00	4.05	4.08	4.11
5½	4.31	4.46	4.58	4.67	4.74	4.79	4.83
5¾	4.96	5.14	5.29	5.41	5.50	5.57	5.62
6	5.66	5.89	6.07	6.22	6.34	6.44	6.51
6¼	6.42	6.70	6.92	7.11	7.26	7.38	7.47
6½	7.25	7.57	7.84	8.07	8.25	8.41	8.52
6¾	8.13	8.51	8.83	9.11	9.33	9.52	9.67
7	9.09	9.52	9.90	10.22	10.50	10.72	10.91
7¼	10.10	10.61	11.05	11.43	11.75	12.02	12.25
7½	11.19	11.76	12.27	12.71	13.09	13.41	13.68
7¾	12.34	13.00	13.57	14.08	14.52	14.90	15.22
8	13.56	14.30	14.96	15.54	16.05	16.49	16.86
8¼	14.86	15.69	16.43	17.09	17.67	18.17	18.61
8½	16.22	17.16	17.99	18.73	19.39	19.97	20.47
8¾	17.67	18.70	19.63	20.47	21.21	21.87	22.45
9	19.19	20.33	21.37	22.30	23.13	23.88	24.53
9¼	20.78	22.05	23.19	24.23	25.16	25.99	26.74
9½	22.46	23.85	25.11	26.26	27.30	28.23	29.06
9¾	24.21	25.74	27.13	28.39	29.54	30.57	31.50
10	26.05	27.71	29.24	30.63	31.89	33.04	34.07

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.13	0.10	0.12					
2¼	0.19	0.15	0.17	0.18				
2½	0.28	0.20	0.23	0.26	0.27			
2¾	0.39	0.26	0.31	0.35	0.37	0.38		
3	0.53	0.34	0.41	0.45	0.49	0.51	0.52	
3¼	0.71	0.43	0.52	0.58	0.63	0.66	0.69	0.70
3½	0.92	0.53	0.64	0.73	0.80	0.84	0.88	0.90
3¾	1.18	0.64	0.79	0.90	0.99	1.05	1.10	1.13
4	1.48	0.77	0.95	1.09	1.20	1.29	1.36	1.40
4¼	1.84	0.92	1.13	1.30	1.45	1.56	1.65	1.71
4½	2.25	1.07	1.33	1.54	1.72	1.86	1.97	2.06
4¾	2.73	1.25	1.55	1.81	2.02	2.20	2.34	2.45
5	3.27	1.44	1.79	2.10	2.35	2.56	2.74	2.88
5¼	3.89	1.64	2.05	2.41	2.71	2.97	3.18	3.36
5½	4.59	1.86	2.34	2.75	3.11	3.41	3.67	3.88
5¾	5.38	2.10	2.65	3.12	3.54	3.89	4.20	4.45
6	6.26	2.36	2.98	3.53	4.00	4.42	4.77	5.08
6¼	7.23	2.64	3.34	3.96	4.50	4.98	5.39	5.75
6½	8.31	2.93	3.72	4.42	5.04	5.58	6.06	6.47
6¾	9.50	3.25	4.12	4.91	5.61	6.23	6.77	7.25
7	10.81	3.58	4.56	5.43	6.22	6.92	7.54	8.08
7¼	12.25	3.94	5.02	5.99	6.87	7.65	8.35	8.97
7½	13.81	4.31	5.50	6.58	7.56	8.43	9.22	9.92
7¾	15.52	4.71	6.02	7.21	8.29	9.26	10.14	10.93
8	17.37	5.12	6.56	7.87	9.06	10.14	11.11	11.99
8¼	19.37	5.56	7.13	8.56	9.87	11.06	12.14	13.12
8½	21.54	6.02	7.73	9.29	10.73	12.04	13.23	14.31
8¾	23.88	6.51	8.36	10.06	11.63	13.06	14.37	15.56
9	26.39	7.01	9.02	10.87	12.57	14.14	15.57	16.88
9¼	29.08	7.54	9.71	11.71	13.56	15.27	16.84	18.27
9½	31.97	8.09	10.43	12.59	14.60	16.45	18.16	19.72
9¾	35.06	8.67	11.18	13.52	15.68	17.69	19.54	21.25
10	38.36	9.27	11.97	14.48	16.81	18.98	20.99	22.84

Cast iron **29** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	0.91						
3¾	1.15	1.17					
4	1.44	1.46	1.47				
4¼	1.76	1.79	1.81	1.83			
4½	2.13	2.17	2.21	2.23	2.24		
4¾	2.54	2.60	2.65	2.68	2.71	2.72	
5	2.99	3.08	3.15	3.20	3.23	3.25	3.26
5¼	3.50	3.61	3.70	3.77	3.81	3.85	3.87
5½	4.06	4.20	4.31	4.40	4.47	4.51	4.55
5¾	4.67	4.84	4.99	5.10	5.19	5.25	5.30
6	5.33	5.55	5.72	5.86	5.98	6.06	6.13
6¼	6.05	6.31	6.52	6.70	6.84	6.95	7.04
6½	6.83	7.13	7.39	7.60	7.78	7.92	8.03
6¾	7.66	8.02	8.32	8.58	8.79	8.97	9.11
7	8.56	8.97	9.33	9.63	9.89	10.10	10.28
7¼	9.52	9.99	10.41	10.76	11.07	11.32	11.54
7½	10.54	11.08	11.56	11.97	12.33	12.63	12.89
7¾	11.62	12.24	12.79	13.27	13.68	14.04	14.34
8	12.78	13.48	14.09	14.64	15.12	15.53	15.89
8¼	14.00	14.78	15.48	16.10	16.64	17.12	17.54
8½	15.28	16.16	16.95	17.65	18.27	18.81	19.29
8¾	16.64	17.62	18.50	19.28	19.98	20.60	21.15
9	18.08	19.16	20.13	21.01	21.79	22.49	23.11
9¼	19.58	20.77	21.85	22.83	23.70	24.49	25.19
9½	21.16	22.47	23.66	24.74	25.71	26.59	27.38
9¾	22.81	24.25	25.56	26.75	27.83	28.80	29.68
10	24.54	26.11	27.54	28.85	30.04	31.12	32.10

Cylindrical Pillars of

Safe weight, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	⅞ Inch.	1 Inch.	1⅛ Inch.
Inches.								
2	0.12	0.10	0.11					
2¼	0.18	0.14	0.16	0.17				
2½	0.26	0.19	0.22	0.24	0.25			
2¾	0.37	0.25	0.30	0.33	0.35	0.36		
3	0.50	0.32	0.38	0.43	0.46	0.48	0.49	
3¼	0.67	0.41	0.49	0.55	0.60	0.63	0.65	0.66
3½	0.87	0.50	0.61	0.69	0.75	0.80	0.83	0.85
3¾	1.11	0.61	0.74	0.85	0.93	0.99	1.04	1.07
4	1.40	0.73	0.90	1.03	1.14	1.22	1.28	1.33
4¼	1.74	0.86	1.07	1.23	1.37	1.47	1.55	1.62
4½	2.13	1.01	1.26	1.46	1.62	1.76	1.86	1.94
4¾	2.58	1.18	1.46	1.71	1.91	2.07	2.21	2.31
5	3.09	1.35	1.69	1.98	2.22	2.42	2.59	2.72
5¼	3.68	1.55	1.94	2.28	2.56	2.80	3.01	3.17
5½	4.34	1.76	2.21	2.60	2.94	3.22	3.46	3.67
5¾	5.08	1.99	2.50	2.95	3.34	3.68	3.96	4.21
6	5.91	2.23	2.81	3.33	3.78	4.17	4.50	4.79
6¼	6.83	2.49	3.15	3.73	4.25	4.70	5.09	5.43
6½	7.85	2.77	3.51	4.17	4.75	5.27	5.72	6.11
6¾	8.97	3.07	3.89	4.63	5.29	5.88	6.39	6.84
7	10.21	3.38	4.30	5.13	5.87	6.53	7.12	7.63
7¼	11.56	3.71	4.73	5.66	6.48	7.22	7.88	8.47
7½	13.04	4.07	5.19	6.21	7.13	7.96	8.70	9.36
7¾	14.65	4.44	5.68	6.80	7.82	8.74	9.57	10.31
8	16.40	4.84	6.19	7.43	8.55	9.57	10.49	11.32
8¼	18.29	5.25	6.73	8.08	9.32	10.44	11.46	12.38
8½	20.33	5.69	7.29	8.77	10.13	11.36	12.49	13.51
8¾	22.54	6.14	7.89	9.50	10.98	12.33	13.57	14.69
9	24.91	6.62	8.51	10.26	11.87	13.35	14.70	15.94
9¼	27.45	7.12	9.16	11.06	12.80	14.41	15.89	17.25
9½	30.18	7.64	9.84	11.89	13.78	15.53	17.14	18.62
9¾	33.10	8.19	10.56	12.76	14.80	16.70	18.45	20.05
10	36.21	8.75	11.30	13.67	15.87	17.92	19.81	21.56

Cast-iron **30** *feet long.*

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1⅜ Inch.	1½ Inch.	1⅝ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	0.86						
3¾	1.09	1.10					
4	1.36	1.38	1.39				
4¼	1.66	1.69	1.71	1.73			
4½	2.01	2.05	2.08	2.10	2.12		
4¾	2.39	2.46	2.50	2.53	2.55	2.57	
5	2.83	2.91	2.97	3.02	3.05	3.07	3.08
5¼	3.31	3.41	3.49	3.56	3.60	3.63	3.65
5½	3.83	3.97	4.07	4.15	4.22	4.26	4.29
5¾	4.41	4.57	4.71	4.81	4.89	4.96	5.00
6	5.03	5.23	5.40	5.53	5.64	5.72	5.78
6¼	5.71	5.95	6.16	6.32	6.46	6.56	6.64
6½	6.45	6.73	6.97	7.18	7.34	7.48	7.58
6¾	7.23	7.57	7.86	8.10	8.30	8.47	8.60
7	8.08	8.47	8.81	9.09	9.34	9.54	9.70
7¼	8.98	9.43	9.82	10.16	10.45	10.69	10.89
7½	9.95	10.46	10.91	11.30	11.64	11.93	12.17
7¾	10.97	11.56	12.07	12.52	12.91	13.25	13.54
8	12.06	12.72	13.31	13.82	14.27	14.66	15.00
8¼	13.21	13.95	14.61	15.20	15.71	16.16	16.55
8½	14.43	15.26	16.00	16.66	17.24	17.76	18.21
8¾	15.71	16.63	17.46	18.20	18.86	19.45	19.96
9	17.06	18.08	19.00	19.83	20.57	21.23	21.82
9¼	18.48	19.61	20.63	21.55	22.38	23.12	23.78
9½	19.97	21.21	22.33	23.35	24.27	25.10	25.84
9¾	21.53	22.89	24.12	25.25	26.27	27.19	28.02
10	23.17	24.65	26.00	27.24	28.36	29.38	30.30