

Public Works (1897) Department.

G.O., No. 432 W

DATED 13 February 1897

[Despatch Abstract.]

Steel Joists : Letter from the Director General
of Stores giving the weight per foot of ^{rolled} ~~cast~~ ^{in dent} ~~in dent~~
- ordered for in compliance with ~~the~~ ^{the} in dent,
forwarding a copy of "specifications for the preparation
of indents for steel joists" and a copy of Messrs
Dorman Long & Co's Handbook of Steel Sections,
Compt. with remarks to S. V. C. L. C.

T.C.
13/2/97

16/2

[illegible]

G.O.	No.	Department.	Date.	G.O.	No.	Department.	Date.

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4802	1-3-95
4873 C.	16-12-96
	46th

No.	Date.

Suggestions for the preparation in India of Indents for Rolled Joists.

(Revised June 1894.)

1. Difficulty is sometimes experienced in procuring rolled joists of the exact sections demanded. It is therefore recommended that a detailed statement, giving limits of variation and other particulars for each item, should be furnished on the Form shown on page 2.

2. Joists are tested with central loads and must show no permanent set after test. The loads are arranged so as to produce limiting stresses of 5 and $7\frac{1}{2}$ tons per square inch for iron and steel respectively.

3. Steel joists are now procured more readily than iron joists, because mild steel has so largely supplanted wrought iron. There is very little difference in the prices of the two descriptions. For instance, in May 1894, actual contract prices were as follows:—

For steel joists, 13 in. $\times$ 5 in., 5*l.* 17*s.* 6*d.* per ton.

For iron joists, 12 in. $\times$ 5 in., 6*l.* 7*s.* 6*d.* per ton.

The tensile tests are as follows:—

Iron, 21 tons per square inch, with a reduction of area of 15 per cent.

Steel, 27 to 32 tons per square inch, with an elongation of 20 per cent. in a length of 8 inches.

4. Taking the Modulus of elasticity for steel at 12,500* tons per square inch, and that for iron at 11,125† tons per square inch, the deflection of a steel joist with a limiting stress of 5.62 tons per square inch is the same as that of an iron joist of the same section, and under the same conditions with a limiting stress of 5 tons. With higher limits of stress, as $7\frac{1}{2}$ tons, the deflection is, of course, increased.

5. The annexed tables give particulars of various sections, together with constants for each, from which loads and deflections can be easily ascertained. The sections enumerated are all stated in published lists to be "stock" sections, and should therefore be readily obtainable, but special rolling and consequent delay are generally found necessary, probably because contractors will not cut stock lengths to waste.

6. In estimates of weight 2 per cent. should be added to list weights of joists to allow for variations in rolling.

* Professor T. A. Hearson, M.I.C.E.

† Molesworth's Pocket Book.

ROLLED STEEL JOISTS.

Particulars of Sections, and Constants for Load and Deflection, with a limiting Stress of 7.5 tons per square inch.

Case I.

Condition of Joist - - - - - Supported at both ends.
Arrangement of Load - - - - - Dead, uniformly distributed, weight of Joist included.

Section.	Weight per Lineal Foot.	Thickness of Web.	Moment of Inertia.	Constants.	
				For Load.	For Deflection.
Inches.	Lb.	Inches.	Quartic Inches.		
19 $\frac{3}{4}$ x 7 $\frac{1}{4}$	96	$\frac{11}{16}$	1715.48	868.60	.C91
18 x 7	75	$\frac{5}{16}$	1153.00	640.55	.10
17 $\frac{3}{4}$ x 6 $\frac{3}{4}$	80	$\frac{625}{16}$	1163.05	655.21	.101
16 x 6	64.5	$\frac{64}{16}$	731.02	456.88	.1125
16 x 5	50	$\frac{51}{16}$	556.01	347.50	.1125
15 $\frac{3}{4}$ x 6 $\frac{1}{2}$	62	$\frac{9}{16}$	704.58	447.33	.114
15 x 6	61	$\frac{72}{16}$	621.36	414.24	.12
15 x 5 $\frac{1}{2}$	56.5	$\frac{9}{16}$	572.64	381.76	.12
15 x 5	42	$\frac{45}{16}$	416.56	277.70	.12
14 x 6	57	$\frac{59}{16}$	513.76	366.97	.1286
14 x 6	45	$\frac{435}{16}$	418.45	298.89	.1286
13 $\frac{7}{8}$ x 5 $\frac{1}{2}$	46	$\frac{7}{16}$	419.63	299.73	.13
13 x 5	40	$\frac{51}{16}$	291.79	224.45	.138
12 x 6	54	$\frac{60}{16}$	358.89	299.07	.15
12 x 6	42	$\frac{42}{16}$	296.02	246.68	.15
12 x 5	43	$\frac{58}{16}$	271.71	226.43	.15
12 x 5	32	$\frac{48}{16}$	183.60	153.00	.15
11 $\frac{3}{8}$ x 5	37	$\frac{42}{16}$	242.46	205.25	.152
10 x 6	45.5	$\frac{58}{16}$	215.14	215.14	.18
10 x 5	35	$\frac{52}{16}$	156.99	156.99	.18
10 x 5	29	$\frac{47}{16}$	127.05	127.05	.18
10 x 4 $\frac{1}{2}$	31.5	$\frac{41}{16}$	149.07	149.07	.18
9 $\frac{7}{8}$ x 6	41	$\frac{42}{16}$	200.23	202.76	.182
9 $\frac{7}{8}$ x 5	27	$\frac{36}{16}$	125.90	127.50	.182
9 $\frac{1}{2}$ x 4 $\frac{1}{2}$	37	$\frac{516}{16}$	160.84	163.91	.184
9 $\frac{1}{2}$ x 4	22	$\frac{33}{16}$	80.54	88.87	.198
9 x 7	58	$\frac{79}{16}$	218.48	242.75	.20
9 x 3 $\frac{3}{4}$	24.25	$\frac{44}{16}$	85.50	95.00	.20
8 x 6	36	$\frac{48}{16}$	114.14	142.67	.225
8 x 6	32	$\frac{7}{16}$	101.25	126.56	.225
8 x 5	31.25	$\frac{45}{16}$	96.58	121.07	.225
8 x 4	25	$\frac{42}{16}$	74.17	92.97	.225
8 x 4	18	$\frac{329}{16}$	52.90	66.13	.225
7 $\frac{7}{8}$ x 5	27	$\frac{375}{16}$	82.48	104.74	.2286
7 $\frac{7}{8}$ x 4	19	$\frac{5}{16}$	56.16	71.31	.2286
7 x 3 $\frac{3}{4}$	20	$\frac{41}{16}$	44.61	63.72	.257
7 x 3 $\frac{1}{2}$	16	$\frac{25}{16}$	38.80	55.43	.257
6 $\frac{1}{4}$ x 3 $\frac{1}{2}$	18	$\frac{36}{16}$	33.11	52.97	.288
6 $\frac{1}{4}$ x 2	9.5	$\frac{25}{16}$	15.81	25.29	.288
6 $\frac{1}{8}$ x 5 $\frac{1}{2}$	24	$\frac{7}{16}$	40.47	66.40	.294
6 x 5	26	$\frac{54}{16}$	43.84	73.06	.30
6 x 4 $\frac{1}{2}$	19	$\frac{434}{16}$	30.04	50.06	.30
6 x 3 $\frac{3}{4}$	13	$\frac{25}{16}$	26.79	44.65	.30
6 x 3	16	$\frac{34}{16}$	26.69	44.48	.30
6 x 3	13	$\frac{322}{16}$	20.89	34.81	.30
6 x 2	12.25	$\frac{39}{16}$	17.12	28.53	.30
5 $\frac{1}{2}$ x 2	11	$\frac{36}{16}$	13.41	24.35	.327
5 $\frac{1}{2}$ x 1 $\frac{1}{2}$	9	$\frac{368}{16}$	8.79	16.75	.327
5 $\frac{1}{2}$ x 4 $\frac{1}{2}$	17.5	$\frac{7}{16}$	23.14	45.15	.351
5 x 5	25.5	$\frac{49}{16}$	30.49	60.98	.36
5 x 4 $\frac{1}{2}$	23.75	$\frac{43}{16}$	27.32	54.64	.36
5 x 4 $\frac{1}{8}$	17	$\frac{44}{16}$	19.59	39.18	.36
5 x 3	15.25	$\frac{40}{16}$	17.17	34.34	.36
5 x 3	13	$\frac{35}{16}$	14.68	29.86	.36
5 x 3	10	$\frac{25}{16}$	11.93	23.86	.36
4 $\frac{3}{4}$ x 1 $\frac{3}{4}$	9.25	$\frac{37}{16}$	8.08	17.01	.379
4 $\frac{3}{4}$ x 1 $\frac{1}{2}$	6.5	$\frac{298}{16}$	5.25	11.05	.379
4 $\frac{1}{8}$ x 2 $\frac{1}{8}$	7.5	$\frac{21}{16}$	7.67	16.36	.384

Section.	Weight per Lineal Foot.	Thickness of Web.	Moment of Inertia.	Constants.	
				For Load.	For Deflection.
Inches.	Lb.	Inches.	Quartic Inches.		
4 $\frac{3}{8}$ x 3	14	.42	13.35	28.86	.39
4 $\frac{1}{8}$ x 3	10	.23	8.42	20.41	.436
4 x 3	12.75	.39	9.32	23.3	.45
4 x 2	5.5	$\frac{3}{16}$	4.23	10.6	.45
4 x 1 $\frac{3}{4}$	8.5	.37	5.48	13.7	.45
3 $\frac{1}{2}$ x 3	10.75	.30	6.26	17.88	.514
3 $\frac{1}{2}$ x 1 $\frac{1}{2}$	6	.28	3.04	8.68	.514
3 $\frac{1}{2}$ x 1 $\frac{5}{8}$	4	.17	1.80	5.76	.576
3 $\frac{1}{8}$ x 3 $\frac{1}{8}$	8	.25	3.67	11.98	.588
3 x 3	10.25	.30	4.34	14.46	.60
3 x 1 $\frac{1}{4}$	5	.31	1.74	5.80	.60

To use the Tables:—

(i.) To find the Load and corresponding Deflection for a given section of joist with a given span:—

(a) Divide the constant for load by the distance *in feet* from centre to centre of bearings*; the quotient is the total distributed load *in tons*, including the weight of the joist†

(b) Multiply the constant for deflection by the square of the distance *in feet* from centre to centre of bearings* and divide the result by 100, the quotient is the deflection in inches.

(ii.) To select a joist for a given external load (*i.e.*, load exclusive of weight of joist) and given span:—

Multiply the load *in tons* by the distance *in feet* from centre to centre of bearings* and take a section against which the constant for load is slightly higher than the result. The weight of the joist† should then be added to the external load, and the section tried as in (i.) for load and deflection.

Cases II. to VIII.

(iii.) To ascertain loads, &c., for joists under different conditions and with different arrangements of loads, the constants in the tables must be multiplied by the factors given below for each particular case before proceeding as in (i.) or (ii.) above.

Case.	Condition of Joist.	Arrangement of Load (dead in all cases).	Factors to be applied to	
			Load constant.	Deflection constant.
II	Fixed at one end, free at the other	Concentrated at free end - -	$\frac{1}{8}$	25.6
III		Uniformly distributed - -	$\frac{1}{4}$	9.6
IV	Supported both ends - -	Concentrated at centre - -	$\frac{1}{2}$	1.6
V	Fixed both ends - -	Ditto - -	1	.4
VI	Ditto - -	Uniformly distributed - -	$1\frac{1}{2}$	.2
VII	Fixed at one end, supported at the other - -	Concentrated at centre - -	$\frac{2}{3}$	.7152
VIII		Uniformly distributed - -	1	.4176

* In Cases II. and III. substitute "centre of bearing of fixed end to free end" for "centre to centre of bearings."

† In Cases II and IV, Total load = External load + $\frac{1}{2}$ weight of joist.

" " V " VII " " = " " " + $\frac{2}{3}$ " "

In these four cases the whole weight of the joist is not added to the external load to make up the total load because the calculation will be made for a concentrated load, whereas the weight of the joist is uniformly distributed. The calculated deflections will in these four cases be slightly excessive.

Notes.

(a) The constants given in the tables can readily be adapted to suit other limits of stress than those which have been used (5 and 7.5 tons per square inch for iron and steel respectively), *e.g.*, if it be desired to limit the stress in a steel joist to 6 tons per square inch, the constants must be multiplied by $\frac{6}{7.5}$ or 0.8 before the load and deflection are determined. A higher stress than 5 tons per square inch is not recommended for iron joists.

(b) If the deflection calculated from the tables be greater than can be allowed, and if the circumstances do not permit the use of a deeper section or of a heavier section of the same depth, the load calculated from the tables must be reduced in the proportion of the allowable to the calculated deflection and the number of joists increased, *e.g.*, if the allowable deflection be 0.5 inch and the calculated deflection 0.6 inch, the load should be reduced to $\frac{5}{6}$ ths of the calculated load; the stress would of course be reduced in the same proportion.

(c) If the deflection be limited to $\frac{1}{40}$ th of an inch per foot run of the joist, the minimum depth (with the limits of stress used in the Tables) should be as follows for Case I., viz. :—

For iron joists, .54 inch } for each foot of distance between centres of bearings;
 „ steel „ .72 „ }
e.g., if the distance from centre to centre of bearings were 10 feet and the deflection were limited to $\frac{1}{40}$ or $\frac{1}{4}$ inch, the minimum depth of an iron joist, Case I., should be 5.4 inches

APPENDIX.

The tabular constants have been calculated from the following data :—

Symbols.

W = Total distributed load in tons, including the weight of the joist.

L = Distance in feet from centre to centre of bearings.

S = Limiting stress in tons per square inch (5 for iron; 7½ for steel).

d = Depth of joist in inches.

V = Deflection in inches.

E = Modulus of elasticity in tons per square inch (11125 for iron; 12500 for steel).

*I = Moment of inertia of section of joist (from dimensions in inches).

* When the thickness of the web is known as well as the depth, breadth, and weight per foot lineal, the Moment of Inertia for the section may be very approximately determined as follows :—

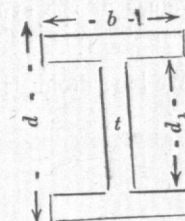
Let A = area of the section in square inches.

„ w = weight „ „ in lb. per foot lineal.

Then for Iron $A = \frac{3}{10}w$ because 1 foot lineal of wrought iron 1" x 1" weighs 3½ lb.

and for Steel $A = \frac{w}{3.4}$ „ 1 „ „ steel „ „ 3.4 lb.

Assume the flanges to be of equal thickness throughout, *i.e.*, that the section is rectangular, as shown in figure,—



Then $I = \frac{1}{12} (bd^3 - (b-t)d_1^3)$, and d_1 is the only dimension that is not given.

From the figure, $A = bd - (b-t)d_1$

$$\text{whence } d_1 = \frac{bd - A}{b - t}$$

and as $A = \frac{3}{10}w$ for iron or $\frac{w}{3.4}$ for steel, d_1 can be found and the value of I determined.

In manufacturers lists of joists, it is generally stated that joists can be rolled about 10 per cent. heavier than list weights; the extra weight in such cases is obtained by slightly opening the rolls and thus thickening the web, and the consequent addition to the tabular constant for load is $\frac{xd}{6}$ for an iron joist and $\frac{xd}{4.08}$ for a steel joist, x being the extra weight in lb. per foot lineal of the joist and d its depth in inches. The calculation is as follows :—

Let C = increase in area (in square inches) due to increase of x lb. in weight.

Then $\frac{C}{d}$ = increase in thickness of web.

For the rectangle $d \times \frac{C}{d}$ $\left\{ \begin{aligned} I &= \frac{1}{12} d^3 \times \frac{C}{d} = \frac{Cd^2}{12} \\ \text{and from equation (1) on page 8, } WL &= \frac{4SI}{3d} = \frac{SCd}{9} \end{aligned} \right.$

For Iron, $S=5$, $C=\frac{3}{10}x$, and $WL=\frac{xd}{6}$.

For Steel, $S=7.5$, $C=\frac{x}{3.4}$, and $WL=\frac{xd}{4.08}$.

Formulae.

For distributed loads, ends of joists supported (Case I.),—

$$\frac{1}{8} WL \times 12 = \frac{SI \times 2}{d}.$$

$$\dagger \text{ or } WL = \frac{4SI}{3d} \quad (1) \text{ which is constant for each section for any fixed value of } S.$$

$$\text{and } W = \frac{4SI}{3dL} \quad (2).$$

$$V = \frac{5}{384} \times \frac{WL^3 \times 12^3}{EI} \quad (3).$$

$$\text{From (2) and (3) } \frac{V}{L^2} = \frac{30S}{dE} \quad (4) \text{ which is constant for each depth of joist for any fixed values of } S \text{ and } E.$$

For Iron $S=5$. $E=11125$,—

$$\text{From (1) } WL = \frac{20I}{3d}. \quad (\text{Tabular constant for load.})$$

$$\text{From (4) } \frac{100V}{L^2} = \frac{1.35}{d}. \quad (\text{Tabular constant for deflection.})$$

For Steel $S=7.5$. $E=12500$.

$$\text{From (1) } WL = \frac{10I}{d}. \quad (\text{Tabular constant for load.})$$

$$\text{From (4) } \frac{100V}{L^2} = \frac{1.8}{d}. \quad (\text{Tabular constant for deflection.})$$

† When the only particulars available are those generally given in manufacturers lists, viz., depth, breadth, and weight in lb. per foot lineal the constant for load may be approximately calculated from the following formula:— $WL=0.11(w-0.36d)Sd$, the values of the symbols being as given in the text. In Part IV. of "Notes on Building Construction" (Longmans, 1891), it is stated that this formula "will be found on trial to give fairly good results."

‡ The object of multiplying by 100 is to save long decimals in the tabular constants for deflection.

It is requested that in any further communication on this subject the under-mentioned letter and number may be quoted, and the reply addressed to

*The Director General of Stores,
India Office,
Whitehall,
London, S.W.*

S.13995.

India Office,

Whitehall,

London, S.W.

13th January 1897.

Sir,

With reference to the indent for rolled steel joists received with your letter No. 3152 W dated 3rd November 1896, I have the honour to inform you that as the weight per foot of the joists is not stated in the indent it has been arranged to supply the 8" x 4" joists at 25 lbs: per foot and the 6" x 4½" at 20 lbs: per foot.

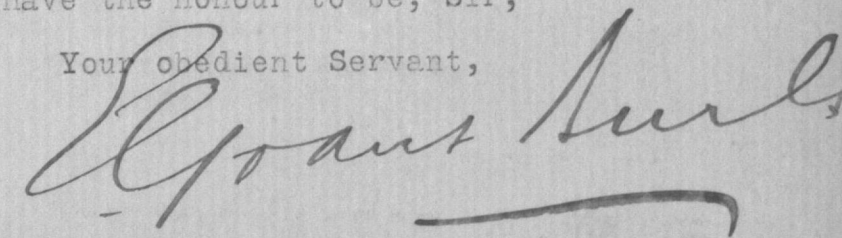
With regard to the 6" x 4" joists asked for I have to state that these are not rolled in steel and that 6" x 4½" joists at 20 lbs: per foot have therefore been ordered instead.

It is desirable that indents for joists should always state the weight per foot of the sections asked for and I therefore enclose a copy of "Suggestions for the preparation of indents for rolled joists" and a copy of Messrs Dorman, Long & Co's: Handbook of Steel Sections which it is thought will be of assistance in preparing future indents.

* By book post.

I have the honour to be, Sir,

Your obedient Servant,



Director General of Stores.

The Secretary to Government,

Public Works Department,

Madras.

Y 28347. 3 rms.—2/96. 1.262.

P.W. 1285/97

DUPLICATE

S.13995.

13th January 1897.

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I have the honour to be, Sir,

Your obedient Servant,

E. GRANT BURLS!

Director General of Stores.

The Secretary to Government,
Public Works Department,
Madras.

Duplicate
P.W. 1285/97
Recd. 11/2/97
432 W
13-2-97

12th January 1997

With reference to the request for police report
concerning the theft of the car from the garage
I have the honour to inform you that the report
of the police is not stated in the report to have been
arranged to supply the car to the police at the time
and the car is at the time of the report.
With regard to the car and the person asked for I have
checked that there are not listed in the report on a
plate as to that person that there have been no
contact.
It is desirable that the person for the car should
also the report on the car and the person asked for and I
enclosed a copy of the report for the person
of the report for the car and a copy of the report
and a copy of the report of the person who is in the
will be of assistance in preparing the report.
I have the honour to be,
Your obedient servant,
Director General of Police.

The Secretary to Government,
Police Force Department,
Kuala Lumpur.