Design Tables for Simply Supported Beams with Rolled Steel I Sections

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Abstract—This paper presents the design tables for simply supported beams with rolled I steel sections. An attempt was made to reduce the effort to design economical rolled I-sections by developing design tables for various spans. Design table for each span consists of Load and corresponding safe section from bending, shear and deflection point of view for all categories of rolled I-sections. The design tables are developed for both laterally supported and laterally unsupported beams. Unit weight is taken as the criteria for choosing economic section among the safe sections from each category. This work is confined only to available rolled sections in IS 808: 1989 (steel tables)

I. INTRODUCTION

As far as the structural steel framing in building is concerned, it is sufficient to consider only the bending and shear effects for beams, as torsion is not generally predominant. For a steel beam (loaded predominantly by flexure) two essential requirements must be met to develop its full moment capacity:

[1] The elements of the beam (i.e. flange and web) should not buckle locally and
[2] The beam as a whole should not buckle laterally.

To ensure the first condition, the cross section of the flange and the web chosen must be “plastic” or “compact”. If the beam is required to have significant ductility, plastic sections must invariably be used. To avoid the lateral buckling referred to under the second condition, restraints are provided to the beam in the plane of the compression flange, and hence such beams are called “laterally restrained beams”. In the absence of any such restraints, in case of lateral buckling of beams is not accounted for in design, the designer has to provide adequate lateral supports to the compression flange. Design of beam includes determining the dimensions of cross section which can resist maximum bending moment and maximum shear force developed in the member. Therefore limiting moment of resistance and design shear strength of the section should be more than maximum bending moment and shear force respectively. Also it should satisfy maximum deflection limitations. Where in case of “laterally un supported beams “the compression flanges of beams are not provided with any lateral supports this makes the flanges to undergo torsional moments. These torsional moments reduces bending strength in compression to f_{bd} instead of f_y.

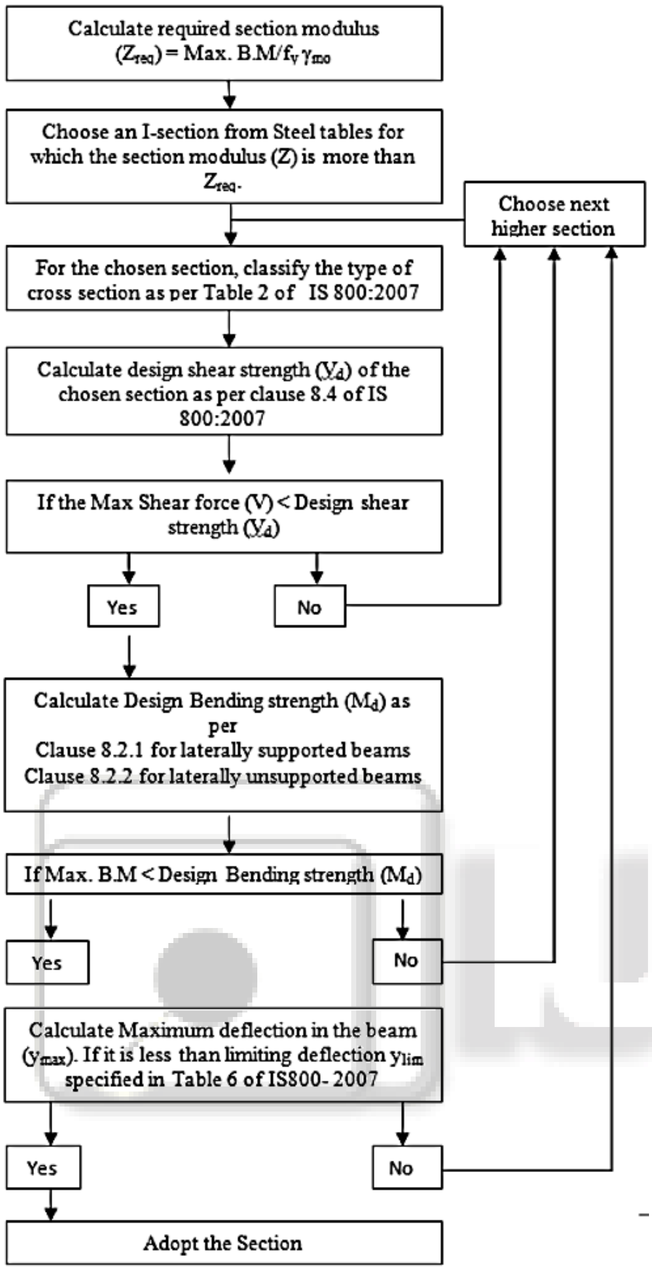
II. OBJECTIVE OF THE STUDY

As per IS 800-2007, the procedure for designing a beam consists of many steps as shown in the flow chart and it is a trial and error process. Hence in order to reduce the effort, an attempt was made to develop design tables. These design tables are prepared for both laterally supported and laterally unsupported beams. Tables consist of maximum load and safe rolled section in all categories along with their unit weights. From these design tables an optimum safe section from bending, shear and deflection can be picked out from different rolled section categories, for given live load. From all the safe sections, the one which is having least unit weight can be considered as an optimum safe section among all 65 rolled sections given inIS808:1989(steel tables)

III. PROCEUDRE FOLLOWED IN DEVELOPING DESIGN TABLES

1 Moment of resistance (Md) was calculated for all rolled steel I-sections in IS 808: 1989 (steel tables) from Cl.8.2.1for laterally supported and 8.2.2 for laterally unsupported in IS800-2007.
2 Design Shear strength (Vd) was calculated for all rolled steel I-sections in steel tables from Clause 8.4.1 in IS800: 2007.
3 For the section to be safe in Shear, Maximum Shear force (V) should be less than or equal to Design Shear strength (Vd). Therefore for a given span, maximum load for the section to be safe in shear (wv) can be calculated by equating V to Vd. (V = wv l/2)
4 Similarly for the section to be safe in bending, Maximum bending moment (M) should be less than or equal to Design Bending Strength (Md).Therefore for a given span, maximum load for the section to be safe in bending (wb) can be calculated by equating M to Md. (M= wb l2/8)
5 Similarly maximum load from deflection point of view (wy) can also be calculated by equating maximum deflection to the limiting value specified in IS800-2007.
6 Therefore safe load for the section is the least of wv, wb and wy.
7 From this safe load the unit weight of the section is deducted which gives the safe live load for that particular section.
8 The same procedure is followed for 4m,5m,6m,7m,8m,spans and Safe loads are determined for all beam sections.
9 Now the Design tables are prepared by arranging all the safe loads in ascending order and safe beam sections along with their unit weights.
10 Hence an optimum beam section can be directly chosen among the different beam sections which can sustain a particular amount of load with least unit weight from these Design tables.

FLOW CHART OF GENERAL DESIGN PROCEDURE FOR STEEL BEAMS AS PER IS800-2007



span(m)	safe load (KN/m)	ISLB	unit (kg/m)	ISMB	unit (kg/m)	ISWB	unit (kg/m)	ISHB	unit wt (kg/m)
5	0.39	75	6.1	100	11.5	150	17.0	150	27.1
5	0.95	100	8.0	100	11.5	150	17.0	150	27.1
5	1.47	125	11.9	100	11.5	150	17.0	150	27.1
5	2.38	125	11.9	125	13.0	150	17.0	150	27.1
5	2.63	150	14.2	125	13.0	150	17.0	150	27.1
5	4.09	150	14.2	150	14.9	150	17.0	150	27.1
5	4.31	175	16.7	150	14.9	150	17.0	150	27.1
5	4.99	175	16.7	175	19.3	150	17.0	150	27.1
5	6.57	175	16.7	175	19.3	175	22.1	150	27.1
5	7.62	200	19.8	175	19.3	175	22.1	150	27.1
5	8.67	200	19.8	200	25.4	175	22.1	150	27.1
5	9.05	200	19.8	200	25.4	175	22.1	150 (2)	30.6
5	9.16	200	19.8	200	25.4	200	28.8	150 (2)	30.6
5	9.70	200	19.8	200	25.4	200	28.8	150 (3)	34.6
5	10.23	200	19.8	200	25.4	200	28.8	200	37.3
5	13.48	225	23.5	200	25.4	200	28.8	200	37.3
5	15.14	225	23.5	225	31.2	200	28.8	200	37.3
5	15.84	250	27.9	225	31.2	200	28.8	200	37.3
5	20.83	250	27.9	225	31.2	225	33.9	200	37.3
5	21.80	250	27.9	250	37.3	225	33.9	200	37.3
5	22.47	250	27.9	250	37.3	225	33.9	200 (2)	40.0
5	22.56	250	27.9	250	37.3	225	33.9	225	43.1
5	23.75	275	33.0	250	37.3	225	33.9	225	43.1
5	28.21	275	33.0	250	37.3	250	40.9	225	43.1
5	31.16	300	37.7	250	37.3	250	40.9	225	43.1
5	32.01	300	37.7	300	44.2	250	40.9	225	43.1
5	33.19	300	37.7	300	44.2	250	40.9	225 (2)	46.8
5	35.18	300	37.7	300	44.2	250	40.9	250	51.0
5	36.11	325	43.1	300	44.2	250	40.9	250	51.0
5	46.96	325	43.1	300	44.2	300	48.1	250	51.0
5	47.19	325	43.1	350	52.4	300	48.1	250	51.0
5	48.51	325	43.1	350	52.4	300	48.1	250 (2)	54.7
5	49.59	325	43.1	350	52.4	300	48.1	300	58.8
5	52.70	350	49.5	350	52.4	300	48.1	300	58.8
5	64.17	350	49.5	350	52.4	350	56.9	300	58.8
5	64.20	350	49.5	400	61.6	350	56.9	300	58.8
5	66.44	400	56.9	400	61.6	350	56.9	300	58.8
5	69.35	400	56.9	400	61.6	350	56.9	300 (2)	63.0
5	71.83	400	56.9	400	61.6	350	56.9	350	67.4
5	79.39	400	56.9	400	61.6	400	66.7	350	67.4
5	84.92	450	65.4	400	61.6	400	66.7	350	67.4
5	87.58	450	65.4	450	72.4	400	66.7	350	67.4
5	91.54	450	65.4	450	72.4	400	66.7	350 (2)	72.4
5	93.17	450	65.4	450	72.4	400	66.7	400	77.4
5	101.26	450	65.4	450	72.4	450	79.4	400	77.4
5	110.79	500	75.0	450	72.4	450	79.4	400	77.4
5	112.41	500	75.0	500	86.9	450	79.4	400	77.4
5	117.46	500	75.0	500	86.9	450	79.4	400 (2)	82.2
5	127.25	500	75.0	500	86.9	450	79.4	450	87.2
5	128.24	500	75.0	500	86.9	500	95.2	450	87.2
5	139.97	550	86.3	500	86.9	500	95.2	450	87.2
5	146.78	550	86.3	500	86.9	500	95.2	450 (2)	92.5
5	150.02	550	86.3	500	86.9	500	95.2	-	-
5	161.19	550	86.3	550	103.7	500	95.2	-	-

5	168.40	600	99.5	550	103.7	500	95.2	-	-
5	193.97	600	99.5	550	103.7	550	112.5	-	-
5	199.93	600	99.5	600	122.6	550	112.5	-	-
5	219.77	-	-	600	122.6	550	112.5	-	-
5	251.24	-	-	600	122.6	600	133.7	-	-
5	285.97	-	-	-	-	600	133.7	-	-
5	311.57	-	-	-	-	600 (2)	145.1	-	-

Table 1 for Span 5 of Laterally supported beams

NOTE: The table has to be read in the following manner, for the given span and live load the beam sections which are safe for that particular amount of live load are checked out in horizontal direction and the beam section which is having least amount of unit weight is taken as an optimum section, in some cases there would be a slight difference in the unit weights of different beam sections in that case the beam with less unit weight and with less depth is considered as optimum section.

For example: from the above laterally supported design table,

Safe live load = 50.0 KN/m,

The beam sections which are safe for this amount of load are ISLB 325, ISMB350, and ISWB 300 ISHB 300. Among all these sections ISLB 325, is having least amount of unit weight of 43.10 kg/m . Hence for 50 KN/m load ISLB325 is considered as an optimum section.

As a sample only one design table for span 5m is attached in this paper , similar to the above table, design tables have been prepared for3m, 4m, 6m, 7m, 8m span. For spans greater than 8m the load resisted by beam sections are very small, hence for these spans built up sections have to be designed, our concept is to design simple beams hence we excluded the span values greater than 8m.

Here ISWB 600(2) represents depth of 600 with second higher unit weight. Similarly the other sections

Span = 5m

span(m)	safe live load (KN/m)	ISLB	unit wt (kg/m)	ISMB	unit wt (kg/m)	ISWB	unit wt (kg/m)	ISHB	unit wt (kg/m)
5	0.24	75	6.1	100	11.5	150	17.0	150	27.1
5	0.61	100	8.0	100	11.5	150	17.0	150	27.1
5	0.94	125	11.9	100	11.5	150	17.0	150	27.1
5	1.55	125	11.9	125	13.0	150	17.0	150	27.1
5	1.71	150	14.2	125	13.0	150	17.0	150	27.1
5	2.34	150	14.2	150	14.9	150	17.0	150	27.1
5	2.58	175	16.7	150	14.9	150	17.0	150	27.1
5	3.22	175	16.7	175	19.3	150	17.0	150	27.1
5	3.27	200	19.8	175	19.3	150	17.0	150	27.1
5	4.25	200	19.8	175	19.3	175	22.1	150	27.1
5	4.59	200	19.8	200	25.4	175	22.1	150	27.1
5	5.69	225	23.5	200	25.4	175	22.1	150	27.1
5	5.76	225	23.5	200	25.4	175	22.1	150(2)	30.6
5	5.96	250	27.9	200	25.4	175	22.1	150(2)	30.6
5	6.00	250	27.9	200	25.4	200	28.8	150(2)	30.6
5	6.35	250	27.9	200	25.4	200	28.8	150(3)	34.6
5	7.97	250	27.9	200	25.4	200	28.8	200	37.3
5	8.39	250	27.9	225	31.2	200	28.8	200	37.3
5	10.46	275	33.0	225	31.2	200	28.8	200	37.3
5	11.67	275	33.0	225	31.2	225	33.9	200	37.3
5	12.02	275	33.0	250	37.3	225	33.9	200	37.3
5	14.41	300	37.7	250	37.3	225	33.9	200	37.3
5	14.84	300	37.7	250	37.3	225	33.9	200(2)	40.0
5	15.32	300	37.7	250	37.3	225	33.9	225	43.1
5	16.00	300	37.7	250	37.3	250	40.9	225	43.1
5	16.84	325	43.1	250	37.3	250	40.9	225	43.1
5	21.19	325	43.1	300	44.2	250	40.9	225	43.1
5	21.97	325	43.1	300	44.2	250	40.9	225(2)	46.8
5	22.10	325	43.1	300	44.2	250	40.9	250	51.0
5	22.73	350	49.5	300	44.2	250	40.9	250	51.0
5	23.46	350	49.5	350	52.4	250	40.9	250	51.0
5	29.83	350	49.5	350	52.4	300	48.1	250	51.0
5	31.08	400	56.9	350	52.4	300	48.1	250	51.0
5	31.29	400	56.9	400	61.6	300	48.1	250	51.0
5	31.97	400	56.9	400	61.6	300	48.1	250(2)	54.7
5	32.16	400	56.9	400	61.6	350	56.9	250(2)	54.7
5	37.71	400	56.9	400	61.6	350	56.9	300	58.8
5	41.11	450	65.3	400	61.6	350	56.9	300	58.8
5	43.77	450	65.3	450	72.4	350	56.9	300	58.8
5	48.85	450	65.3	450	72.4	400	66.7	300	58.8
5	49.98	500	75.0	450	72.4	400	66.7	300	58.8
5	52.41	500	75.0	450	72.4	400	66.7	300(2)	63.0
5	56.70	500	75.0	450	72.4	400	66.7	350	67.4
5	58.11	500	75.0	500	86.9	400	66.7	350	67.4
5	63.73	500	75.0	500	86.9	450	79.4	350	67.4
5	65.93	550	86.3	500	86.9	450	79.4	350	67.4
5	68.58	550	86.3	500	86.9	450	79.4	350(2)	72.4
5	80.77	550	86.3	500	86.9	450	79.4	400	77.4
5	83.79	550	86.3	500	86.9	500	95.2	400	77.4
5	84.12	600	99.5	500	86.9	500	95.2	400	77.4
5	84.22	600	99.5	500	86.9	500	95.2	400(2)	82.2
5	87.30	600	99.5	550	103.7	500	95.2	400(2)	82.2
5	104.	600	99.5	550	103.	500	95.2	450	87.2

	64	0		0	7				
5	108.17	600	99.5	550	103.7	500	95.2	450(2)	92.5
5	114.07	600	99.5	550	103.7	500	95.2	-	-
5	117.49	-	-	550	103.7	500	95.2	-	-
5	122.12	-	-	600	122.6	500	95.2	-	-
5	164.11	-	-	600	122.6	550	112.5	-	-
5	165.35	-	-	600	122.6	600	133.7	-	-
5	219.85	-	-	-	-	600	133.7	-	-
5	244.72	-	-	-	-	600(2)	145.1	-	-

Table 2: for Span 5 of Laterally unsupported beams

NOTE: The table has to be read in the following manner. For the given span and live load the beam sections which are safe for that particular amount of live load are checked out in horizontal direction and the beam section which is having least amount of unit weight is taken as an optimum section, in some cases there would be a slight difference in the unit weights of different beam sections in that case the beam with less unit weight and with less depth is considered as optimum section.

For example: from the above laterally un supported design table,

Safe live load = 12 KN/m,

Span = 5m

The beam sections which are safe for this amount of load are ISLB 275, ISMB 250, ISWB 225,ISHB 200. Among all these sections ISLB 275, is having least amount of unit weight of 33.0 kg/m and ISWB 225 is having a unit weight of 33.9 kg/m. Hence for 50 KN/m load ISWB 225 is considered as an optimum section, because as there is no much difference between the unit weights of ISLB 275 and ISWB 225 but the depth of ISWB 225 is less than the depth of ISLB 275, here depth becomes the criteria for selecting an optimum section.

As a sample, only one design table for span5m is attached in this paper, similar to the above, design tables have been prepared for 3m, 4m, 6m, 7m, 8m span. For spans greater than 8m the load resisted by beam sections are very small, hence for these spans built up sections have to be designed, our concept is to design simple beams hence we excluded the span values greater than 8m. Here ISWB 600(2) represents depth of 600 with second higher unit weight. Similarly the other sections

IV. CONCLUSIONS

With the help of Design Tables developed in this work, for a given load and span of simply supported beam with uniformly distributed load on entire span, with laterally supported and unsupported conditions, the most optimum section among all available rolled sections can be selected which is safe in bending, shear and also in deflection

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