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Design Aids for Beams with Varing Conditions in Accordance With IS: 800-2007

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Abstract— In India, IS: 800 is the code of practice for general construction in steel. The IS: 800-1984 was based on elastic method of design. To reflect the latest developments and the state of the art, the third revision of IS: 800 is released in 2007. The IS: 800-2007 is based on limit state method of design. The design of different structural elements based on limit state method involves many tedious equations.

Design is basically a trial and error process, initially a section is assumed and it is checked for its capacity to withstand the applied load. In case of design of steel structural elements according to IS: 800-2007, no sufficient design tools are available for the initial selection. In this paper, effort is made to develop design charts for beams with varying conditions in accordance with IS: 800-2007. Computer programs are developed using C language to find design capacities of beams. Graphs are drawn for the span verses design capacities of the considered steel I-sections. Two main types of beams are considered as laterally supported beams and laterally un-supported beams. This work is confined to available rolled I-sections in IS: 800-2007. Results are presented for the design of beams, using proposed charts. Set of conclusions are drawn based on the design charts. The use of design charts for beams will be very useful and save time of the practicing Structural Engineers.

Keywords— *IS: 800-2007, beam design, design charts*

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I. Introduction

Code of practice provides the minimum requirements that a design has to satisfy. In India, the bureau of Indian standards is the statutory body that publishes the codes of practice to be followed in the professional practice. The code of practice for general construction in steel is IS: 800. The IS: 800-1984 was based on elastic method of design. To reflect the latest developments and the state of the art, the third revision of IS: 800 is released in 2007. The IS: 800-2007 is based on limit state method of design.

In limit state method of design, the reliability of design is ensured by satisfying the requirement:

Design action ≤ Design strength.

For buildings hot rolled I-sections are commonly used as beams. Design of beam includes determining the dimensions of cross section which can resist maximum bending moment and maximum shear force respectively. The IS: 800-2007 has recommended design procedures for members subjected to flexure, mainly in four categories. These are:

1) Laterally supported beam with low and high shear
2) Laterally unsupported beam producing lateral torsional buckling
3) Beam under uniaxial/ biaxial bending along with axial force, i.e. beam-column
4) Plate girders

In this paper the first two categories are highlighted.

II . Objective

Design is basically a trial and error process, initially a section is assumed and it is checked for its capacity to withstand the applied load. The equations given in the IS: 800-2007 code, are complex for designer's use. Checking the selected section for design bending capacity and shear capacity is repetitive. In case of design of steel structural elements according to IS: 800-2007, no sufficient design tools are available for the initial selection. So to make the design procedure less tedious, in this paper, effort is made to develop design charts for beams with varying conditions in accordance with IS: 800-2007. Computer programs are developed using C language to find design capacities of beams. Graphs are drawn for the span verses design capacities of the considered steel I-sections. Two main types of beams are considered as laterally supported beams and laterally un-supported beams. This work is confined to available rolled I-sections in IS: 800-2007.

III. Flow chart for preparing Design charts

A. For Laterally Supported Beam

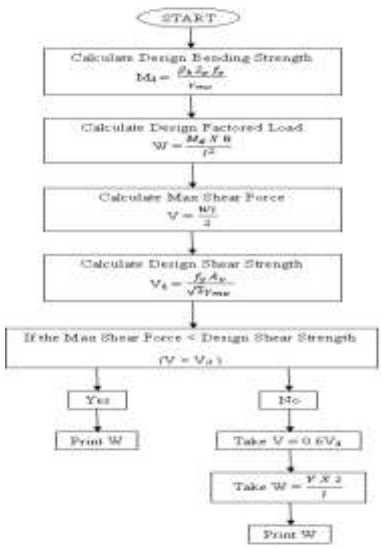

Fig.1 Flow chart for preparing design chart of laterally supported beams

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B. For Laterally Unsupported Beam

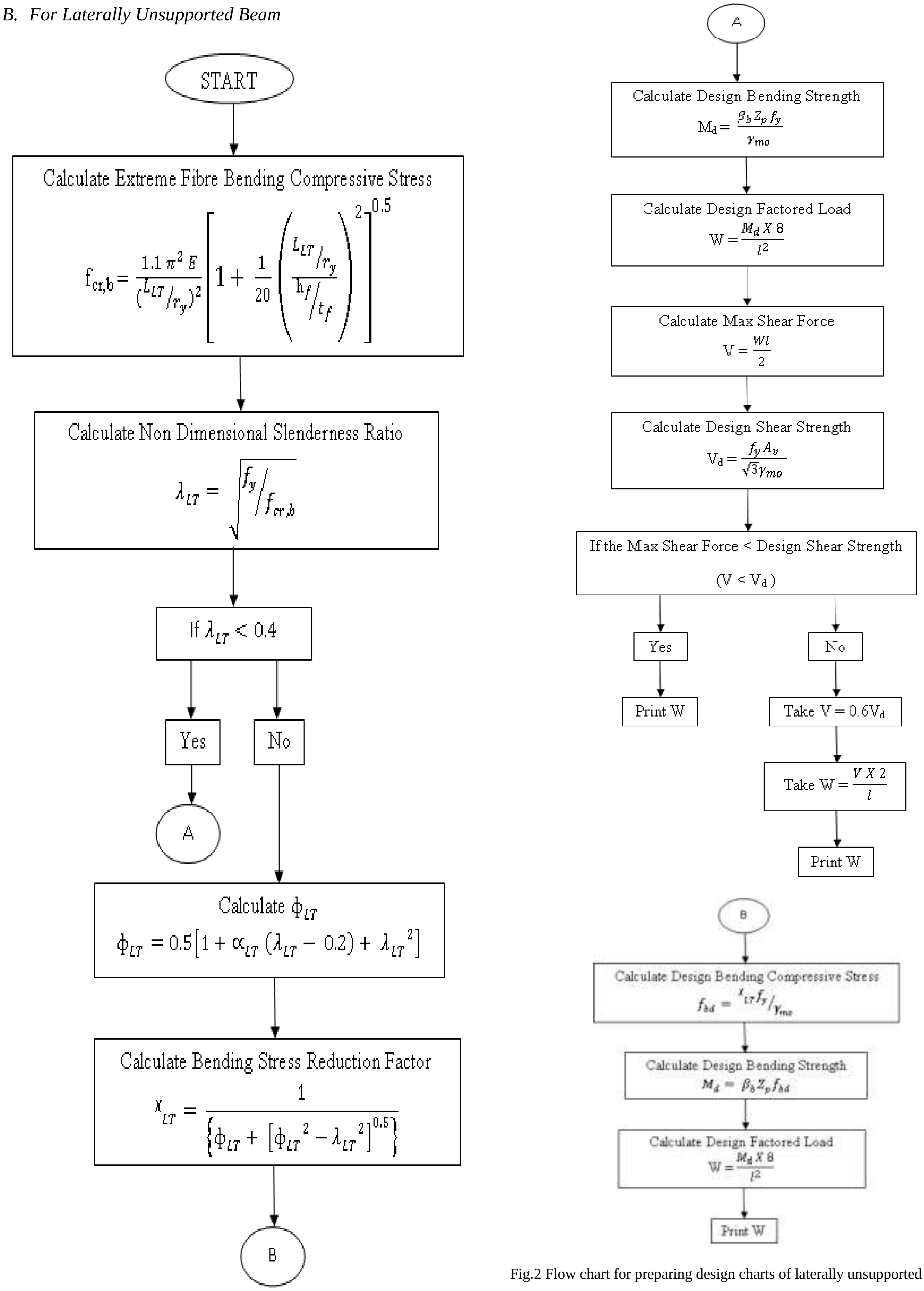

Fig.2 Flow chart for preparing design charts of laterally unsupported beams

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IV. DESIGN CHARTS FOR BEAMS

A. For Laterally Supported Beam

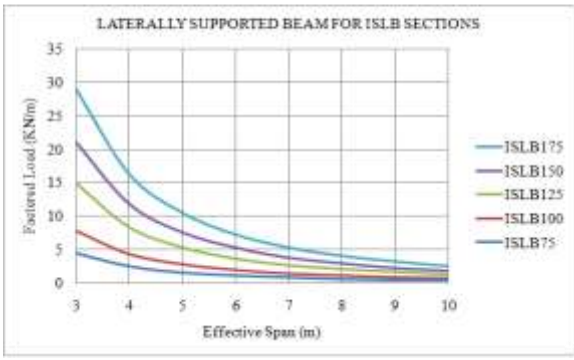

Fig.3 Factored load vs. effective span for laterally supported ISLB beams

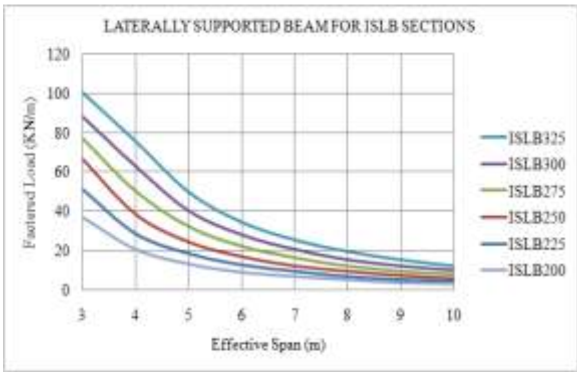

Fig.4 Factored load vs. effective span for laterally supported ISLB beams

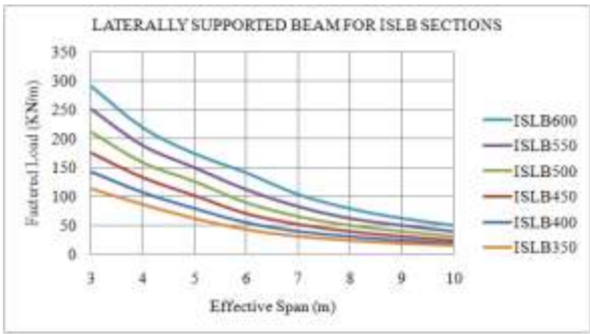

Fig.5 Factored load vs. effective span for laterally supported ISLB beams

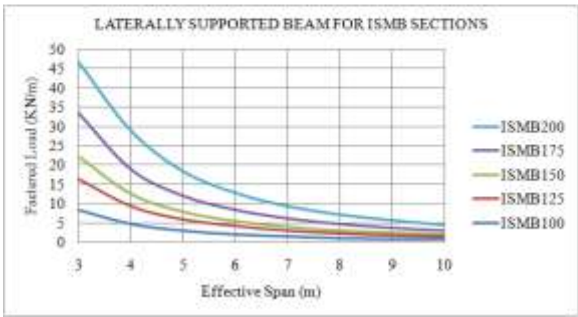

Fig.6 Factored load vs. effective span for laterally supported ISMB beams

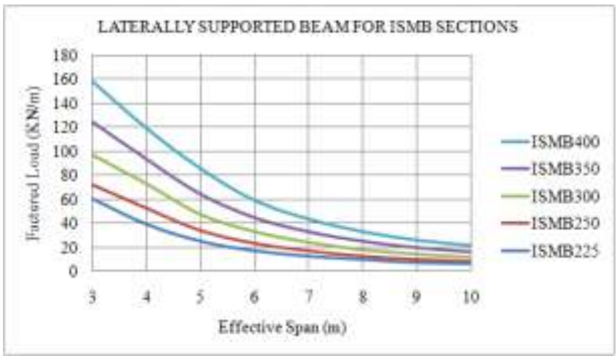

Fig.7 Factored load vs. effective span for laterally supported ISMB beams

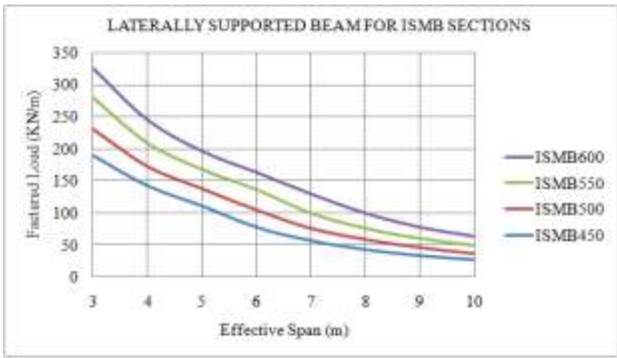

Fig.8 Factored load vs. effective span for laterally supported ISMB beams

B. For Laterally Unsupported Beam

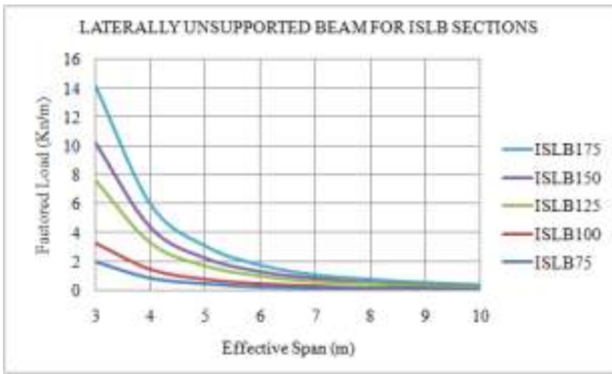

Fig.9 Factored load vs. effective span for laterally unsupported ISLB beams

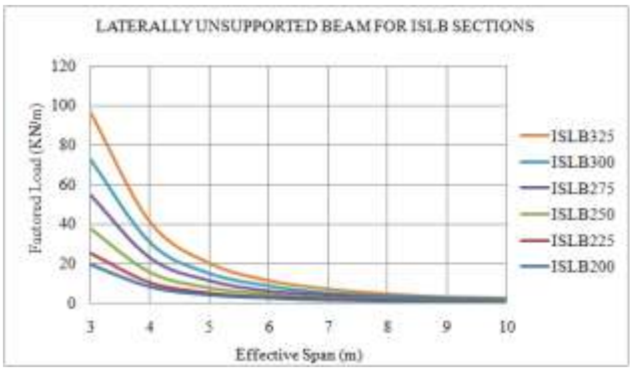

Fig.10 Factored load vs. effective span for laterally unsupported ISLB beams

Fig.11 Factored load vs. effective span for laterally unsupported ISLB beams

Fig.12 Factored load vs. effective span for laterally unsupported ISMB beams

Fig.13 Factored load vs. effective span for laterally unsupported ISMB beams

Fig.14 Factored load vs. effective span for laterally unsupported ISMB beams

V. DESIGN OF BEAM USING DESIGN CHARTS

A. *For Laterally Supported Beam*

Ex 1. For a laterally supported beam of effective span 5 m loaded with factored load 100 KN/m, the economical section is ISLB 450

Checks-

i) Check for bending strength

$$M_d = \frac{\beta_b Z_p f_y}{\gamma_{mo}}$$

Substituting the values of β_b, Z_p, f_y and γ_{mo}

M_d =318.49 KNm > M Hence OK

ii) Check for shear strength

$$V_d = \frac{f_y A_v}{\sqrt{3}\gamma_{mo}}$$

Substituting the values of f_y, A_v and γ_{mo}

V_d = 507.81 KN > V Hence OK

iii) Check for deflection

$$\delta = \frac{5wL^4}{384EI_{zz}}$$

Substituting the values of working load w, L, E and I_{zz}

δ = 9.85 mm < span/300 Hence OK

B. *For Laterally Unsupported Beam*

Ex 1. For a laterally unsupported beam of effective span 5 m loaded with factored load 100 KN/m, the economical section is ISLB 600.

Checks-

i) Check for bending strength

$$M_d = \beta_b Z_p f_{bd}$$

Substituting the values of β_b, Z_p, and f_{bd}

M_d = KNm > M Hence OK

ii) Check for shear strength

$$V_d = \frac{f_y A_v}{\sqrt{3}\gamma_{mo}}$$

Substituting the values of f_y, A_v and γ_{mo}

V_d = 507.81 KN > V Hence OK

iii) Check for deflection

$$\delta = \frac{5wL^4}{384EI_{zz}}$$

Substituting the values of working load w, L, E and I_{zz}

δ = 9.85 mm < span/300 Hence OK

VI CONCLUSION

This paper presents the design charts for simply supported beams, with rolled I steel sections. These design graphs can be used as design aids for selecting steel sections for beams. The use of design charts for beams will be very useful and save time of the practicing Structural Engineers. Proposed design charts will reduce the efforts and time to design economical rolled I sections. The design charts prepared are taking care of design bending capacity and shear capacity checks.

VII. NOTATIONS

A	Area of cross section
E	Modulus of elasticity for steel
f_{bd}	Design bending compressive stress corresponding to lateral buckling
$f_{cr,b}$	Extreme fibre bending compressive stress corresponding to elastic lateral buckling moment
f_y	Characteristic yield strength
h_f	Centre to centre distance between flanges
L	Actual length of column, beam
L_{LT}	Effective length for lateral torsional buckling
M	Factored applied moment
M_d	Design bending strength of the section
M_{dv}	Design bending strength under high shear
M_{fd}	Plastic design strength of the area of cross section excluding the shear area, considering partial safety factor γ_{mo}
M_z	Factored applied moments about the major axis of the cross section
r_y	Radius of gyration about the minor axis
t_w	Thickness of the web
t_f	Thickness of flange
V	Factored applied shear force as governed by web yielding or web buckling
V_d	Shear strength as governed by web yielding or web buckling
Z_e	Elastic Section modulus
Z_p	Plastic Section modulus
γ_{mo}	The partial safety factor against yield stress and buckling
γ_{m1}	Partial safety factor against ultimate stress
Λ	Non-dimensional effective slenderness ratio
λ_{LT}	Non-dimensional slenderness ratio in lateral bending
X	Stress reduction factor for different buckling class, slenderness ration and yield stress
χ_{Lt}	Bending stress reduction factor to account for lateral torsional buckling
$\propto_{LT}$	The imperfection parameter

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