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Importance of Effective Length Factors In Hot-Rolled Steel Columns

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Abstract: *Hot-rolled steel columns are very efficient structurally in carrying compression loads and moments and are commonly used in the construction of framed structures in office and industrial buildings. All members resisting axial compression would buckle if the applied axial force were large enough. The importance of effective length factors cannot be overstate, in which they stressed that the Effective length factors (K -factor) of columns must be introduce to evaluate the stability of columns in frames with rigid and semi-rigid connections. The axial load-carrying capacity for simple compression members largely depends on its slenderness, material strength, cross sectional shape and method of fabrications. Columns and their strength and behavior constitute a subject area that has received much study and discussion over the years. Theoretical investigations have been performed to study the interaction of local and overall buckling. The most valuable outcomes achieved in this research were to provide the fundamental data of ISMB Compression member. ISMB 100 design using variable k factor. For changing the length of the column section axial load carrying capacity decrease in significant amount*
Keywords: *steel columns, K –factor, axial load, effective length*

I. Introduction

Columns are reserve for the main vertical members carrying loads from the roof, floors and the walls in buildings. As an overview, a short, stocky stanchion fails by squashing or crushing of the material; and for long slender stanchion failures occur by overall buckling. Other forms of failure are torsion buckling and local buckling. The axial load-carrying capacity for simple compression members largely depends on its slenderness, material strength, cross sectional shape and method of fabrications.

Columns and their strength and behavior constitute a subject area that has received much study and discussion over the years. Experimental and theoretical investigations have been performed to study the interaction of local and overall buckling. The finite element method to analyze the nonlinear response of I-sections under axial compression and obtained the interaction buckling loads for them by an overall bifurcation analysis of a locally buckled section.

II. Compression member design according to code

The object of limit state design can be paraphrased as achievement of an acceptable probability that a part or whole of structure will not become unfit for its intended use during its life time owing to collapse, excessive deflection etc, under the actions of all loads and load effects. The acceptable limits of safety and serviceability requirements before failure occurs are called as limit state. For achieving the design objectives, the design shall be based on characteristic values for material strengths and applied loads (actions), which take into account the probability of variations in the material strengths and in the loads to be supported. The characteristic values shall be based on statistical data, if available. Where such data is not available, these shall be based on experience. The design values are derived from the characteristic values through the use of partial safety factors, both for material strengths and for loads. In the absence of special Considerations, these factors shall have the values given in this section according to the material, the type of load and the limit state being considered. The reliability of design is ensured by satisfying the requirement:

$$\text{Design action} \leq \text{Design strength}$$

Design Strength:- Common hot rolled and built-up steel members used for carrying axial compression, usually fail by flexural buckling. The buckling strength of these members is affected by residual stresses, initial bow and accidental eccentricities of load. To account for all these factors, the strength of members subjected to axial compression is defined by buckling class a, b, c, or d as given Table 7. The design compressive strength Pd, of a member is given by

$$P<P_d$$

where

$$P_d = A_c \text{ x } f_{Cd}$$

where

A_e = effective sectional area as defined, the gross sectional area shall be taken as the effective sectional area for all compression members fabricated by welding, bolting and riveting so long as the section is semi-compact or better. Holes not fitted with rivets, bolts or pins shall be deducted from gross area to calculate effective sectional area and f_{cd} = design compressive stress.

The design compressive stress, $f_{cd,}$ of axially loaded compression members shall be calculated using the following equation:

$$f_{cd} = \frac{f_y / \gamma_{m0}}{\phi + \left[\phi^2 - \lambda^2\right]^{0.5}} = \chi f_y / \gamma_{m0} \leq f_y / \gamma_{m0}$$

Where

$$\emptyset = 0.5 \left[1 + \propto (\lambda - 0.2) + \lambda^2 \right]$$

λ non-dimensional effective slenderness ratio

$$= \sqrt{f_y / f_{cc}} = \sqrt{f_y \left(\frac{KL}{r}\right)^2 / \pi^2 E}$$

$$f_{cc} = \textbf{Euler buckling stress} = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2}$$

Where K L / r = effective slenderness ratio or ratio of effective length, KL to appropriate radius of gyration, r;

α = imperfection factor given in Table 7; (IS:800:2007)

χ = stress reduction factor (see Table 8) for different buckling class, slenderness ratio and yield stress

$$= \frac{1}{\left[\phi + \left(\phi^2 - \lambda^2\right)^{0.5}\right]}$$

$\lambda_{mo} =$ partial safety factor for material strength. (IS:800:2007) 7.1.2.2

The classification of different sections under different buckling class a, b, c or d, is given in Table 01. The stress reduction factor x, and the design compressive stress fcd, for different buckling class, yield stress, and effective slenderness ratio is given in Table 8 (IS:800:2007) for convenience.

Table 01: Imperfection Factor, (Clauses 7.1.1 and 7.1.2.1 of IS:800:2007)

Buckling Class	a	b	c	d
α	0.21	0.34	0.49	0.76

Effective Length of Compression Members

The effective length KL, is calculated from the actual length L, of the member, considering the rotational and relative translational boundary conditions at the ends. The actual length shall be taken as the length from centre-to-centre of its intersections with the supporting members in the plane of the buckling deformation. In the case of a member with a free end, the free standing length from the center of the intersecting member at the supported end, shall be taken as the actual length.

III. Analysis And Design

In the present work a ISMB-100 toISMB-600 design according to the IS:800:2007 limit state based subjected to axial load.the selected column section design for ultimate load carrieng capacity. The load baring capacity of column determined by using the differnt end conditions. Obtain factored axial load on the column section ISMB400. The height of the column is 3.0m and it is pin-ended. Fy = 250 N/mm2 ; e = 2 x105N/mm2 ; γm = 1.10

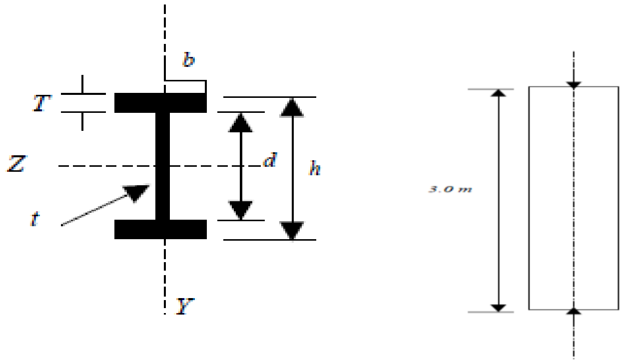

Figure 02: Cross-section of Steel Column

Cross-section properties:

Flange thickness	= T = 12.7 mm
Overall height of ISHB400	= h = 400 mm
Clear depth between flanges	= d = 400 – (12.7 * 2) = 374.6 mm
Thickness of web	= t = 10.6 mm
Flange width	= 2b = b_f = 250 mm
Hence, half Flange Width	= b = 125 mm
Self –weight	= w = 0.822 kN/m
Area of cross-section	= A = 10466 mm2
Radius of gyration about x	= r_x = 166.1 mm
Radius of gyration about y	= r_y = 51.6 mm

IV. Result

This work has presented a investigation into the behavior of column section under the axial load and lateral load. Aiming at improving the knowledge and understanding of behavior and hence the effect of compression member subjected to lateral load, both design according to IS: 800 code and finite element analysis were conducted under varying lateral load conditions. The most valuable outcomes achieved in this research were to provide the fundamental data of ISMB Compression member. ISMB 100 design using variable k factor. For changing the length of the column section axial load carrying capacity decrease in significant amount 178.43 KN to 58.98 KN for length 2.5m to 5m and k is 0.65, the axial load capacity decreased 20% with increment each 0.5m height in 2.5m but after 3.5m height the axial load constant decrease in the range of 10% (from 3.5m to 5 m). Similarly for the all section member (ISMB 125, ISMB 150, ISMB 175, ISMB 200, ISMB 225.After the section ISMB 225 the axial load capacity decreased 10% throughout up to 5m height. In ISMB450 the axial load capacity decreased 8 % throughout up to 5m height and ISMB500, 550 the axial load capacity decreased 6.5 %. For ISMB 600 it reduce 5% throughout up to 5m height. The ultimate axial load interaction curves for ISMB sections of column girders indicate that the effect of compressive load on the decrease of shear capacities is more considerable than vice versa. However, the reduction in the shear ultimate capacity is greatly influenced in longer columns due to the presence of flexural moment at the column base.

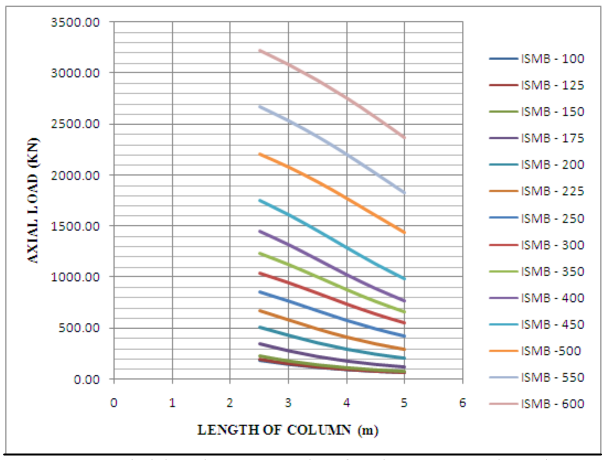

Figure 03: Axial load vs Length of column member, k = 0.65

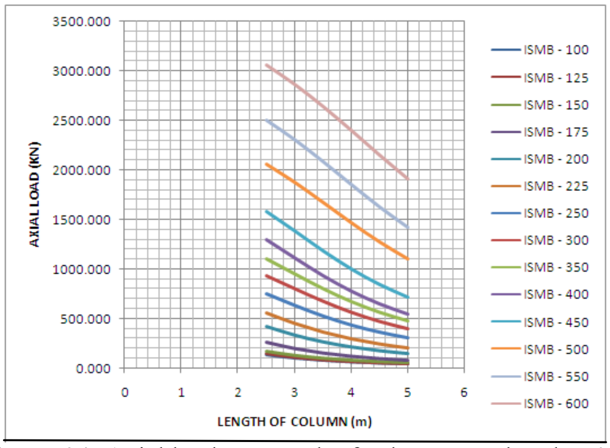

Figure 04: Axial load vs Length of column member, k = 0.8

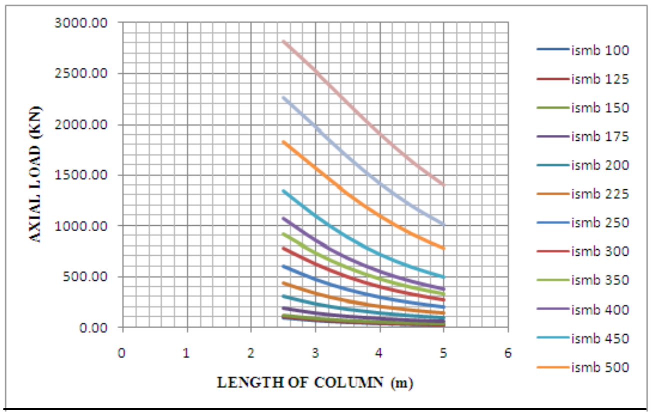

Figure 05: Axial load vs Length of column member, k = 1

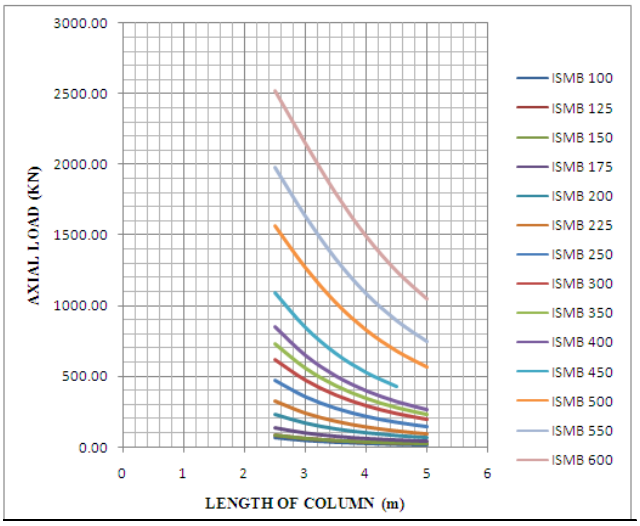

Figure 06: Axial load vs Length of column member, k = 1.2

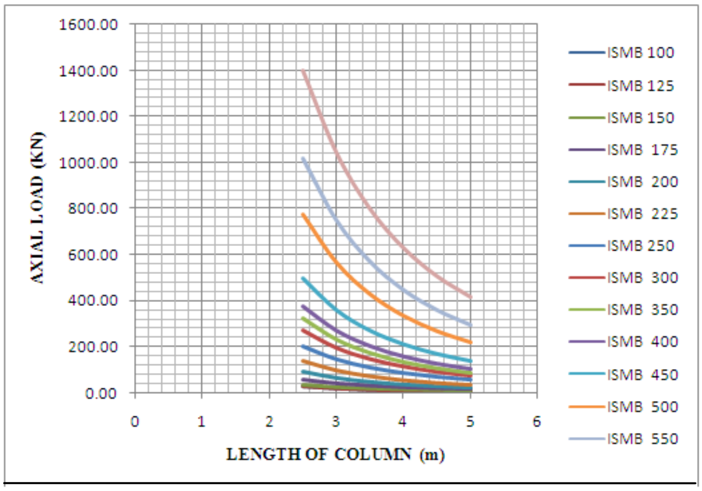

Figure 07: Axial load vs Length of column member, k = 2

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