Lateral-Torsional Buckling Of Steel Beam

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Abstract

Lateral Torsional Buckling (LTB) is a failure criteria for beams in flexure. The AISC defines Lateral Torsional Buckling as: the buckling mode of a flexural member involving deflection normal to the plane of bending occurring simultaneously with twist about the shear center of the cross-section. LTB occurs when the compression portion of a beam is no longer sufficient in strength and instead the beam is restrained by the tension portion of the beam (which causes deflection or twisting to occur). The design buckling (bending) resistance moment of laterally unsupported beams are calculated as per Section 8.2.2,IS 800:2007 of the code. If the non-dimensional slenderness $\lambda LT \leq 0.4$, no allowance for lateral-torsional buckling is necessary. ANNEX E (CL.8.2.2.1,IS 800:2007) of the code gives the method of calculating *Mcr*,, the elastic lateral torsional buckling moment for different beam sections, considering loading and a support condition as well as for non-prismatic members. Elastic critical moment Mcr can be obtained using FE modeling techniques. The effects of various parameters such as shear force, bending moment are to be studied analytically.

***Keywords**:* Lateral torsional buckling, finite element method, simply supported steel I-beam

1. Introduction

There are two types of beam one is Laterally supported beam and other is Laterally unsupported beam .In laterally supported beams full lateral support is provided by RC slab. But in some cases it is not possible to provide this ideal condition. In Industrial structures, many times steel beams or beams used in framework support equipment and machinary. Also, the floor in Industrial building may comprise steel plates, which may not provide lateral restraint. Therefore such cases acquire design of beam as laterally unsupported . Gantry Girder is the classic example of Laterally Unsupported Beam. This girder is subjected to the moving load due to travelling crane running on rails connected to top flange, and therefore it lacks lateral support over the length .The reduction in bending strength depends on cross-sectional dimensions, length of compression flange, type of restraint support and type of cross-section such as doubly symmetric, monosymmetric or asymmetric. Lateral Torsional Buckling (LTB) is a failure criteria for beams in flexure. The AISC defines Lateral Torsional Buckling as: the buckling mode of a flexural member involving deflection normal to the plane of bending occurring simultaneously with twist about the shear center of the cross-section. LTB occurs when the compression portion of a beam is no longer sufficient in strength and instead the beam is restrained by the tension portion of the beam (which causes deflection or twisting to occur).If the laterally unrestrained length of the compression flange of the beam is relatively longer then a phenomenon known as lateral buckling or lateral torsional buckling of the beam may take place therefore the beam would fail well before it can attain its full moment capacity.

2. Significance Of Study

Lateral-torsional buckling is a limit-state of structural usefulness where the deformation of a beam changes from predominantly in-plane deflection to a combination of lateral deflection and twisting while the load capacity remains first constant, before dropping off due to large deflections. The analytical aspects of determining the lateral-torsional buckling strength are quite complex, and close form solutions exist only for the simplest cases.

The various factors affecting the lateral-torsional buckling strength are:

- Distance between lateral supports to the compression flange.
- Restraints at the ends and at intermediate support locations (boundary conditions).
- Type and position of the loads.
- Moment gradient along the length.
- Type of cross-section.
- Non-prismatic nature of the member.
- Material properties.
- Magnitude and distribution of residual stresses.
- Initial imperfections of geometry and loading.

They are discussed here briefly:

The distance between lateral braces has considerable influence on the lateral torsional buckling of the beams. The restraints such as warping restraint, twisting restraint, and lateral deflection restraint tend to increase the load carrying capacity. If concentrated loads are present in between lateral restraints, they affect the load carrying capacity. If this concentrated load applications point is above shear centre of the cross-section, then it has a destabilizing effect. On the other hand, if it is below shear centre, then it has stabilizing effect. For a beam with a particular maximum moment-if the variation of this moment is non-uniform along the length the load carrying capacity is more than the beam with same maximum moment uniform along its length. If the section is symmetric only about the weak axis (bending plane), its load carrying capacity is less than doubly symmetric sections. For doubly symmetric sections, the torque-component due to compressive stresses exactly balances that due to the tensile stresses. However, in a mono-symmetric beam there is an imbalance and the resistant torque causes a change in the effective torsional stiffeners, because the shear centre and centroid are not in one horizontal plane. This is known as "Wagner Effect". If the beam is non-prismatic within the lateral supports and has reduced width of flange at lesser moment section the lateral buckling strength decreases. The effect of residual stresses is to reduce the lateral buckling capacity. If the compression flange is wider than tension flange lateral buckling strength increases and if the tension flange is wider than compression flange, lateral buckling strength decreases. The residual stresses and hence its effect is more in welded beams as compared to that of rolled beams. The initial imperfections in geometry tend to reduce the load carrying capacity.The design buckling (Bending) resistance moment of laterally unsupported beams are calculated as per Section **8.2.2** of the code. If the non-dimensional slenderness $\lambda LT \leq 0.4$, no allowance for lateral-torsional buckling is necessary. ANNEX **E (CL.8.2.2.1,IS 800:2007)** of the code gives the method of calculating *Mcr*,, the elastic lateral torsional buckling moment for difficult beam sections, considering loading and a support condition as well as for non-prismatic members.

3. Scope Of Research Studies

1.To study the behavior of Lateral Torsional Buckling Of Beam
2.Factors affecting lateral torsional buckling
3.Manually and Analytically comparison of Elastic critical moment of various steel sections.
4.To propose a realistic analysis by using Elastic critical moment formula which is given in IS 800 : 2007 (Annexure E) & by FE modeling technique.

3.1. Methodology

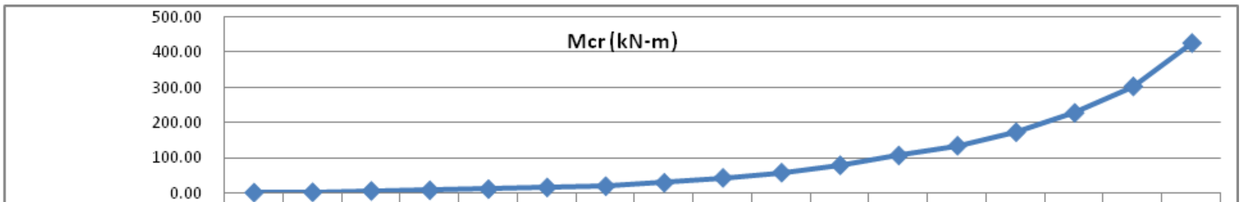
In technical papers I seen that there are various types of works done on the analysis of lateral torsional buckling in various ways such as analytically, experimentally, manually by using some softwares etc.So, referring from all these papers some steps to be taken to analyse lateral torsional buckling of steel beam by using Indian Standard codes IS 800 :2007 .In which ANNEX E gives the formulae for the calculation of elastic critical moment which is useful to calculate the effect of lateral torsional buckling in terms of moment. From all this one problem of simply supported of 6m span with uniformly distributed load of 50 kN/m. This calculation is done by manually by using procedure which is given in some text book such as Design of steel structures (BY RAMCHANDRA),Limit design of steel structures (M.R.Shiyekar),Design of steel structures (BY SUBRAMANYAM).From this calculation of elastic critical moment manually. Analyse the beam by using ANSYS SOFTWARE in which design the steel section by using some methods such as directly take the section from section menu which is given left side of the ANSYS programme give their properties then analyse the beam by applying uniformly distributed load. Analyse the various effects such as shear force, bending moment, crtical moment. This critical moment values are compared with the manually calculation

4.problem statement:-

In this study, simply supported beam (I-section) is selected. Analysis of various I sections (i.e ISLB, ISMB, ISWB) was carried out in ANSYS. All the sections were run for different spans of 4m, 4.5m, 5m, 5.5m and 6m in ANSYS as well as the results for Mcr were obtained by IS method in spreadsheet.

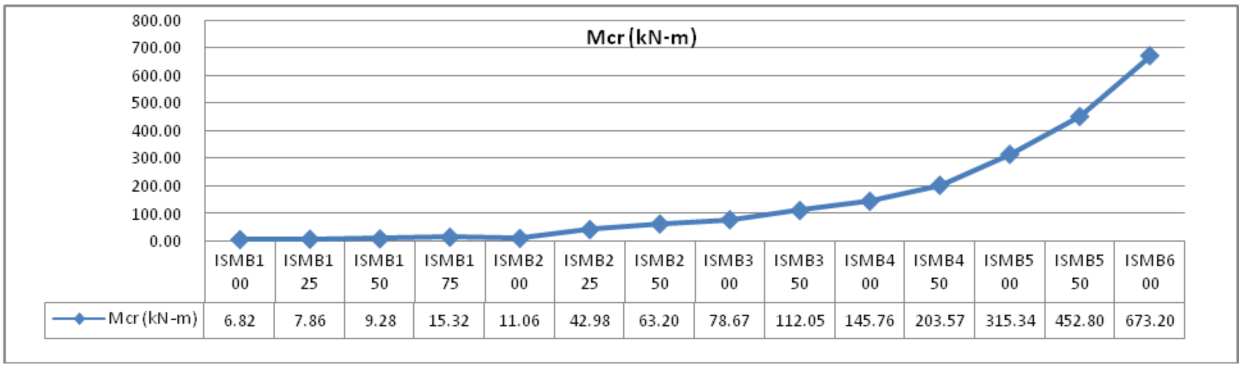
5. Result And Discussion

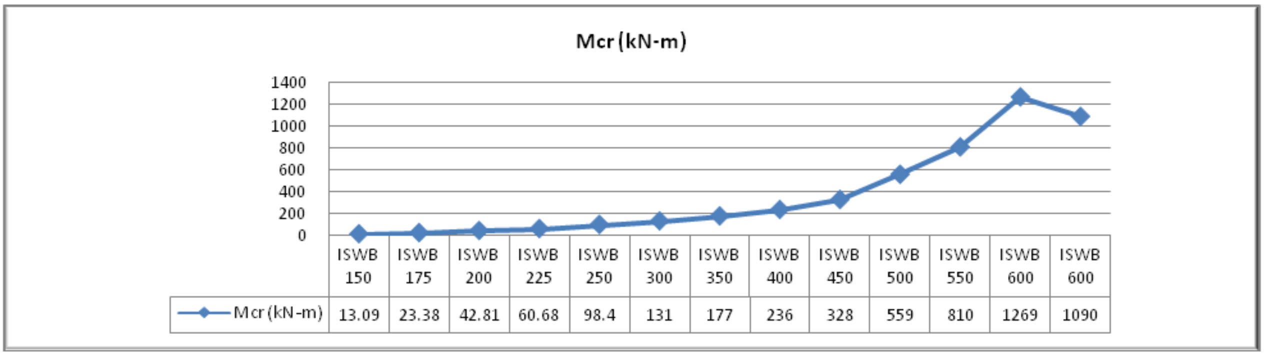
After analyzing simply supported I-steel beam as mentioned in problem statement. Mcr are calculated as follows

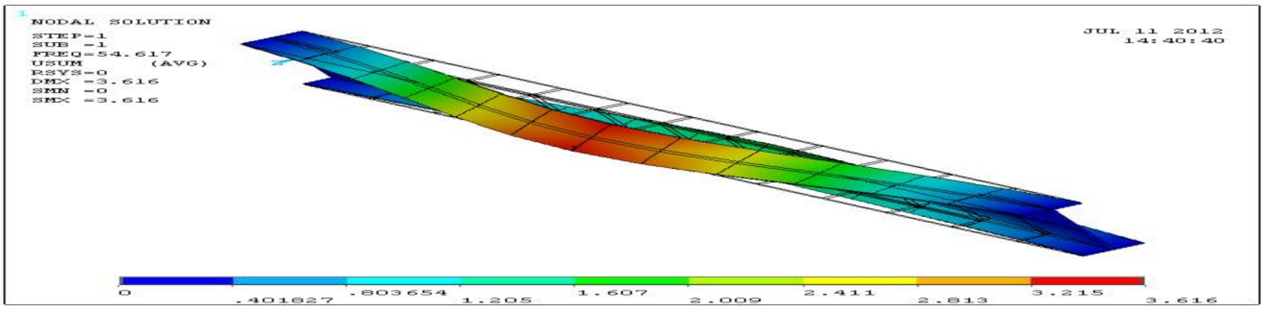


	ISLB75	ISLB100	ISLB125	ISLB150	ISLB175	ISLB200	ISLB225	ISLB250	ISLB275	ISLB300	ISLB325	ISLB350	ISLB400	ISLB450	ISLB500	ISLB550	ISLB600
Mcr (kN-m)	1.70	2.72	6.50	8.43	11.52	16.43	19.94	29.58	43.55	58.40	79.46	107.1	134.9	173.3	228.1	303.3	426.5

5.1 ISLB □ □ □ □ □ □ □







6. Concluding Remark

From all this some of the most important remarks in the study are outlined as follows:

1.Finite element can be used to determine Elastic lateral torsional buckling moment.

2.The proposed analysis can lead to a more uniform factor of safety for the structural system, because it can capture the strength of the structural system as well as the individual members directly.

3.This analysis is also used to strengthen the Gantry beam like structural member against lateral torsional buckling .

4.Variation in buckling modes does not affect the buckling load value in first set.

5.Lateral torsional buckling effect should not be neglected.

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