STUDY OF MANUFACTURING PROCESSES AND STRESS ANALYSIS OF I BEAMS USING ANSYS

[1]MAHESH TUGAVE, [2]MALLIKARJUN BHARATH, [3]SIDDESH CHAVARE, [4]AKSHAY BHANGALE

[1,2,3,4] SIES GRADUATE SCHOOL OF TECHNOLOGY MUMBAI, INDIA
E-mail: mahesh.tugave1893@gmail.com, mallikarjunbharath12@gmail.com, siddesh.chavare@hotmail.com, akshay_bhangale@yahoo.co.in

Abstract:- In this paper the overall study of manufacturing processes of steel I-beams and its analysis using ANSYS is presented. Section modulus of various cross sections are calculated and compared. The main purpose is to optimize the factors which include stiffness and bending and to reduce buckling in I- Beams. The finite element modeling is employed to study the use of horizontal and vertical stiffeners on inelastic buckling strength of coped beams. Various types of girders are studied with its needs and applications and also plate girder is designed. Various manufacturing processes for I- Beams are studied and compared. Different sizes of I section beams are studied analytically and compared with using ANSYS.

Keywords- Coped beam, Girder, Stiffeners, S355

I. INTRODUCTION

I-beams are steel structures widely used in construction industry. It is an important part of any type of construction. I-beams are commonly made of structural steel. Different sizes of I-beams are required depending on various light & heavy applications. The method of producing an I-beam was patented by Alphonse Halbou of the company “Forges de la Providence” in 1849. An I-beam is also known as H-beam, double T beam or universal beam.

In steel construction, when beams are connected to girders at the same elevation, beam flanges must be coped to provide sufficient clearance for proper attachment. Beams can be coped at the top, bottom, or at both flanges. When a beam is coped, the lateral torsional buckling of the beam will be affected. Cheng et al. studied both lateral and local buckling of coped beams, as well as possible strengthening of coped region. They recommended using stiffeners at the coped region in order to improve the buckling strength of coped beams. However, no theoretical data are available for stiffening coped I-beams for inelastic lateral torsional buckling. It discusses the effectiveness of using horizontal and vertical stiffeners for strengthening coped beams using ANSYS.

Up to certain limit, I beams are used for structural purposes. For long span, the weight of beam plays an important role in design. It is the main horizontal support of a structure which supports smaller beams. Girders often have an I-beam cross section for strength, but may also have a box shape, Z shape and other forms.

II. PROBLEM STATEMENT

The study of manufacturing processes used in industry and its comparison with the other process used in manufacturing of beams. It discuss about the study of effectiveness of using horizontal and vertical stiffeners for strengthening of coped beams using ANSYS. It also discusses about the analytical study of girders.

III. SECTIONS OF BEAMS

The failure of I beam is mostly in bending. We are comparing I -section with various sections by considering section modulus as a main parameter. Section modulus is direct measure of flexural strength of beam. We have compared the section modulus of various sections and the result is listed below:-

Sr no.	SECTIONS	SECTION MODULUS (%)
1	T section	25
2	Inverted T section	36
3	I section	100
4	H section	72
5	C section	86.7
6	U section	41.2
7	Inverted U section	30.3

From the above table assuming section modulus for I section to be 100%, corresponding values for other section are calculated. The section modulus is inversely proportional to bending stress. As the section modulus is maximum for I section, therefore the induced bending stress will be minimum.

IV. GIRDERS

It is the main horizontal support of a structure which supports smaller beams. Girders often have an I-Beam cross section for strength, but may also have a box shape, Z shape and other forms. Typically a girder is larger than a beam, or may support several beams. Actually there are two kinds of beam namely 'Primary beam' and 'secondary beam'. Girders comes under the category of primary beam, its main job is to directly transfer loads coming over it to columns upon which it rests. Now comes the secondary beam, its main job is to first transfer loads on it to Girders or Primary beams which in turn transfer the loads to columns supporting it.

V. PLATE GIRDERS

Stiffener plates may be attached to the girder web by welding or bolting to increase the buckling resistance of the web. Stiffness are also required to transfer the concentrated force of applied load and reactions of the web without producing local buckling.

A. Design Of Plate Girder

Problem Formulation

Yield stress of steel, f_y = 250 N/mm^2

Material factor for steel, γ_m = 1.15

Dead Load factor, γ_{fd} = 1.35

Imposed load factor, $\gamma_{f\lambda}$=1.50

Dead Load

Uniformly distributed load, w_d = 20 kN/ m (Including self-weight)

Concentrated load, W_{1d}= 200 kN

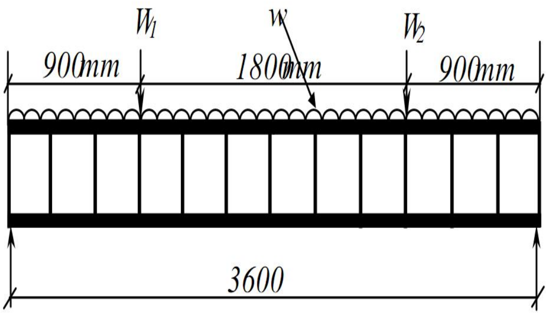
Concentrated load, W_{2d}= 200 kN

Live load:

Uniformly distributed load, w_λ = 35 kN/m

Concentrated load, $W_{1\lambda}$ = 400 kN

Concentrated load, $W_{2\lambda}$ = 400 kN

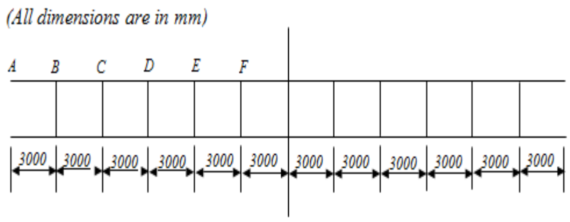


Result:

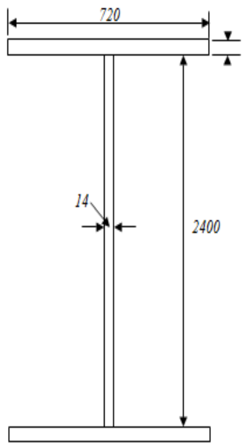
Deformation limit = L/360 = 36/360 =0 .1 m

Sr No	Particulars	Theoretical Result	ANSYS Result
1	Equivalent Stress	$1.7833*10^9$ Pa	$1.0655*10^9$ Pa
2	Shear Stress	$6.848*10^7$ Pa	$7.0303*10^7$ Pa
3	Total Deformation	0.0542 m	0.04822 m

Final Girder Dimensions:



(a) Longitudinal section of plate girder



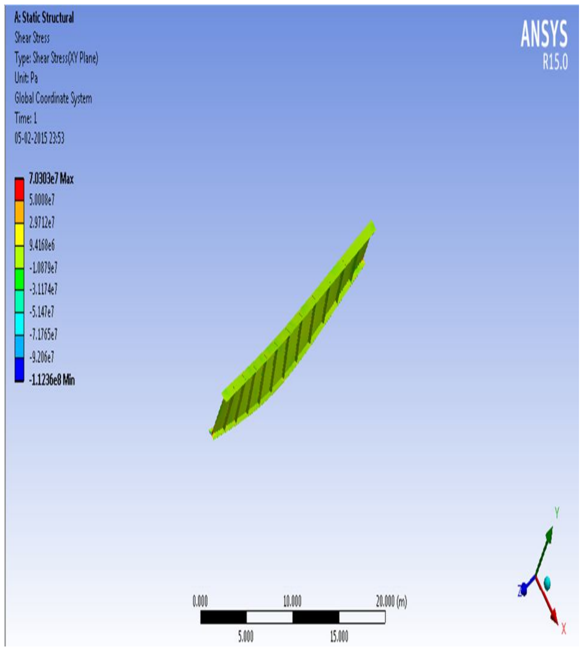


Fig. 1 Shear Stress for Plate Girder

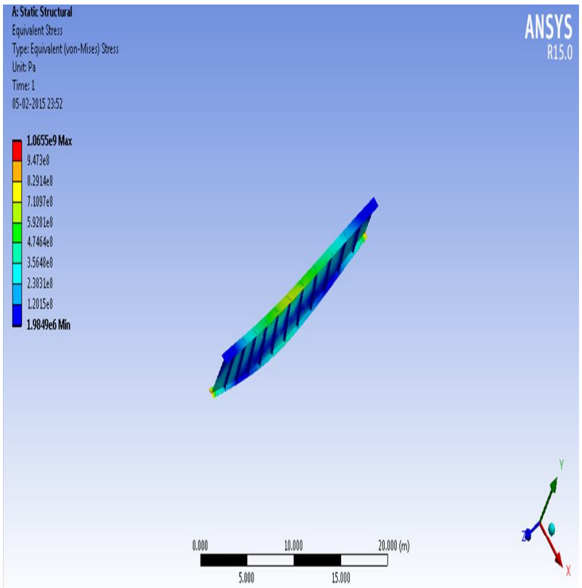


Fig.2 Equivalent Stress for Plate Girder

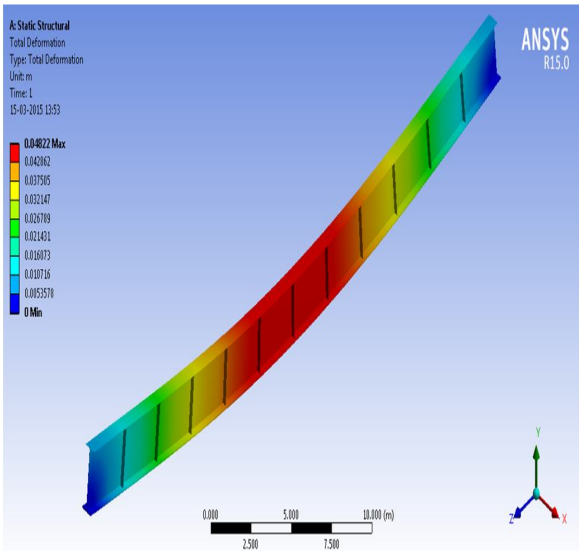


Fig.3 Total Deformation for Plate Girder

VI. ANALYSIS OF STIFFENERS IN COPED BEAM

In steel construction, when beams are connected to girders at the same elevation, beam flanges must be coped to provide sufficient clearance for proper attachment. Beams can be coped at the top, bottom, or at both flanges. When a beam is coped, the lateral torsional buckling of the beam will be affected.

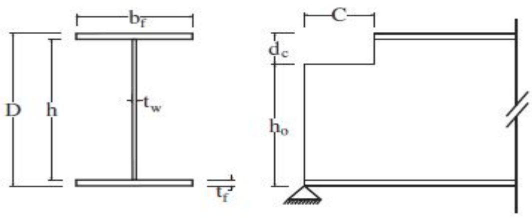


Fig.4 Coped Details designation

Loading Conditions:
P =200kN
Dimensions:
D = 216 mm, bf = 125 mm, tw = 5 mm
tf = 8mm, h/tw = 40

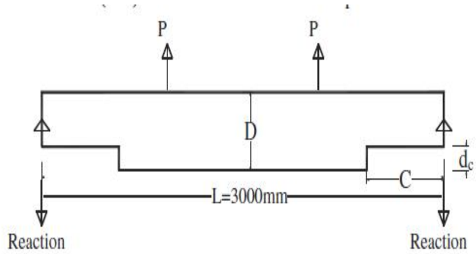


Fig. 5 End Condition for Coped Beam

Thickness of stiffeners = thickness of flange
Width of stiffeners = half the width of stiffeners.

1. Horizontal stiffeners

c = 180 mm, dc/D = 0.10

2. Both horizontal and vertical stiffeners

dc/D = 0.5, c = 180 mm
Result:

Sr No.	Particulars	Without Stiffeners	Horizontal Stiffeners	Both Stiffeners
1	Damage	47084	36660	32118
2	Equivalent Stress(MPa)	421.05	393.28	379.36
3	Safety Factor	0.5937	0.6356	0.6590
4	Total deformation (mm)	3.125	1.7726	5.0728
5	Total Life (cycles)	21239	27278	31135

I. Beam Analysis

A. C60 (Carbon Steel):

Carbon steel, also called plain steel is a metal alloy, a combination of two elements, iron and carbon, where other element are present in quantities too small to affect the properties. The only other alloying elements allowed in plain-carbon steel are manganese (0.75%max), silicon (0.40%max), and chromium (0.40% max) .

Steel with a low carbon content has the same properties as iron, soft but easily formed. As carbon content rises the metal becomes harder and stronger but less ductile and more difficult to weld.

B. S355 (Structural Steel)

Structural steel is steel construction material, a profile, formed with a specific shape or cross section and certain standards of chemical composition and mechanical properties. Structural steel shape, size, composition, strength, storage, etc., is regulated in most industrialized countries. Structural steel members, such as I-beams, have high second moments of area, which allow them to be very stiff in respect to their cross-sectional area. Typical grades are described as 'S275J2' or 'S355K2W'. In these examples, 'S' denotes structural rather than engineering steel; 275 or 355 denotes the yield strength in Newton per square millimetre or the equivalent mega Pascal.

C. For Various Loads And Span

Considering UDL (uniform distributed load) load to be 10, 20, 30 kN\m and span to be 6, 8, 10 m. The analytical design is carried out by taking standard dimensions from PSG Design data book and found out the various values of stress and deformation.

i. Maximum Span Length for Constant Load:

a. For C60

For load w = 10 kN\m

Span (m)	Induced stress (MPa)	Design stress (MPa)
6	56.7	84
8	56.74	84
10	51.84	84
12	66.08	84
14	69.2	84
16	83.03	84
18	105.08	84

For load w = 20 kN\m

Span (m)	Induced stress (MPa)	Design stress (MPa)
6	58.13	84
8	50.84	84
10	50.71	84
12	93.4	84

For load w = 30 kN\m

Span (m)	Induced stress (MPa)	Design stress (MPa)
6	59.48	84
8	54.73	84
10	97.3	84

b. For S355

For load w = 10 kN\m

Span (m)	Induced stress (MPa)	Design stress (MPa)
6	51.23	71
8	48.23	71
10	48.65	71
12	50.85	71
14	69.21	71
16	83.03	71

For load w = 20 kN\m

Span (m)	Induced stress (MPa)	Design stress (MPa)
6	52.34	71
8	51.56	71
10	49.65	71
12	93.4	71

For load w = 30 kN\m

Span (m)	Induced stress (MPa)	Design stress (MPa)
6	55.65	71
8	51.19	71
10	97.3	71

ii. Maximum Load For Constant Span

a. For C60

For span L= 6m

Load (kN\m)	Induced stress (MPa)	Design stress (MPa)
10	56.7	84
20	58.13	84
30	59.48	84
40	72.09	84
50	63.56	84
60	76.27	84
70	81.73	84
80	93.4	84

For span L= 8m

Load (kN\m)	Induced stress (MPa)	Design stress (MPa)
10	56.74	84
20	50.84	84
30	50.73	84
40	83.03	84
50	103.78	84

For span L= 10m

Load (kN\m)	Induced stress (MPa)	Design stress (MPa)
10	51.84	84
20	50.73	84
30	90.73	84

b. For S355

For span L= 6m

Load (kN\m)	Induced stress (MPa)	Design stress (MPa)
10	51.23	71
20	52.34	71
30	55.65	71
40	50.85	71
50	63.56	71
60	70.05	71
70	81.73	71

For span L= 8m

Load (kN\m)	Induced stress (MPa)	Design stress (MPa)
10	48.23	71
20	51.56	71
30	51.19	71
40	83.03	71

For span L= 10m

Load (kN\m)	Induced stress (MPa)	Design stress (MPa)
10	48.65	71
20	49.65	71
30	97.3	71

VIII. Comparison of Theoretical and ANSYS results

i. For C60

Sr No	Load KN/m	Span meter	Total Deformation millimeter		Deflection Limit L/360 mm	Shear Stress Mega Pascal		Equivalent Stress (Pascal)*10^7	
			Theoretical	ANSYS	-	Theoretical	ANSYS	Theoretical	ANSYS
1	10	6	1.7143	1.9899	16.67	1.505	1.5350	5.67	4.5480
2	10	8	1.626	1.8416	22.22	1.056	0.7216	5.674	3.1795
3	10	10	1.844	2.1052	27.78	1.886	2.5054	5.148	2.6467
4	20	6	1.6776	2.2433	16.67	1.371	1.3456	5.813	5.7048
5	20	8	1.7021	1.8617	22.22	1.281	0.9589	5.084	3.8716
6	20	10	1.8182	1.7148	27.78	1.333	0.4646	5.076	2.8545
7	30	6	1.7168	1.4405	16.67	1.898	1.3456	5.948	4.9173
8	30	8	1.5684	1.7148	22.22	1.905	1.9009	5.473	5.0438

ii. For S355

Sr No	Load KN/m	Span meter	Total Deformation millimeter		Deflection Limit L/360 mm	Shear Stress (Mega Pascal)		Equivalent Stress (Pascal)*10^7	
			Theoretical	ANSYS		Theoretical	ANSYS	Theoretical	ANSYS
1	10	6	1.722	1.6087	16.67	0.808	0.9159	5.123	3.5998
2	10	8	1.556	1.6165	22.22	1.046	0.8228	4.823	3.2636
3	10	10	1.854	1.6562	27.78	2.823	2.9805	4.865	2.3288
4	20	6	1.6984	1.7441	16.67	1.505	1.2851	5.234	5.1986
5	20	8	1.7985	1.8235	22.22	1.365	0.6442	5.156	4.3126
6	20	10	1.6776	1.7115	27.78	1.306	0.4647	4.965	2.8545
7	30	6	1.7068	1.8224	16.67	1.891	1.1317	5.565	6.0210
8	30	8	1.5635	1.4465	22.22	1.429	0.6907	5.119	3.5655

CONCLUSION

The overall study of manufacturing processes of steel I-beams and its analysis using ANSYS is presented. Section modulus of various cross sections are calculated and compared. It is observed from that the induced bending stress in I – section is minimum compared to other sections. The factors like stiffness & bending is optimized by introduction of stiffeners at suitable positions. Also an alternative material for C60 is found out i.e. S355. The advantage of C60 over S355 is that C60 is suitable only for high span and high load applications whereas S355 material can be used for both low load low span & medium load medium span applications, the cost of S355 material is less compared to C60 and also having good machinability and weldability. Girders are also introduced because it has great advantage over I beams that it can be made of any length with good stability and optimum strength. In our project we checked the suitability, consistency of data using authentic formula and functions available in our academic syllabus.

REFERENCES

Abdelrahim K. Dessouki, Sherif A. Ibrahim, Seham A. El-Sa'eed, "Experimental and finite element study on the inelastic lateral buckling behavior of coped I-beams", 16 June, 2014

[1] MerihKucukler, Leroy Gardner, Lorenzo Macorini, "A stiffness reduction method for the in plane design of structural steel", 22 May, 2014.

[2] A.K.Dessouki, A.B. AbdelRahim, D.O. Abdul Hameed, "Bending strength of singlysymmetric overhanging floor I-beams", 18 March, 2014

[3] Kristo Mela, Markku Heinisuo, 2014, "Weight and cost optimization of welded high strength steel beams", 18 August, 2014.

[4] H.R. Naderian, H.R.Ronagh, M.Azhari, "Elastic distortional buckling of doubly symmetric steel I-section beams with slender webs", 23 May, 2014.

[5] A.DEYLAMI, M. GHOLIPAOUR, "Modification of Moment Connection of I- Beam to Double-I Built- Up Column by Reinforcing Column Cover Plate", July, 2011.

[6] Amr M.I. Sweedan, "Elastic lateral stability of I-shaped cellular steel beams", 25 August, 2010.

[7] Michael C.H. Yam, Cheng Fang, Angus C.C. Lamc, J.J. Roger Cheng, "Local failures of coped steel beams", 5 July, 2014.

[8] R. K. Bansal, "A Textbook of Strength of Materials", first edition, 2006, Laxmi Publication.

★★★