Analysis of beam cross-sections for strength and dynamic behaviour

[1]Akshay Jamdar,[2]N.S.Nagmoti,[3]M.M.Khot

[1]Student,[2]Assistant Professor,[3]Professor,
[1]Mechanical Engineering Department,
[1]Walchand College of Engineering, Sangli, India.

Abstract : The Study deals with the how efficient is the corrugated web beam with reference to I-section beam. I' section beams are widely used in automobile chassis and in construction industry such as bridges, Slender structure etc. These applications can efficiently replaced by using corrugation of web beam. By using different shapes of corrugation of web beam, by decreasing the web thickness the strength against failure modes of the I-section beam are Bending failure by yielding, Bending failure by lateral torsional buckling, Bending failure by local buckling, Shear failure of beam is enhanced and also weight of the beam decreases which is extremely useful for various application. There are various methods of fabrication such bending, press working and welding, hot rolling and cold rolling. I-section beam from BIS (808:1989)(Reaffirmed 2004) is chosen and keeping the weight same, flange dimension same, thickness of web decreases because corrugated web require more length. Stress analysis of Trapezoidal corrugated web beam and I-section beam of as per BIS(808:1989) (Reaffirmed 2004) will be carried out to determine the stress induced at critical location. By using FEA Tools, modal analysis of different shapes of corrugated web beams and I-section beam as per BIS(808:1989) (Reaffirmed 2004) will be carried out.

***Keywords* – FEA Tools, Stress Analysis, Modal Analysis, Corrugated Web Beam.**

I. INTRODUCTION

Now a day's building and civil infrastructures are getting larger and better , the demand for horizontal structure members, which are suitable for long spans so steel require high strength but steel member even have many weaknesses, like less resistance to bucking, excessive deflection, fatigue strength, vibration. to beat these disadvantages various types corrugated web beam are developed. Some of advantages to use corrugated web beam are stability against asymmetrical loads because the shear bucking strength in-plane and Out-of- plane load is bigger than I-section beam.

Especially for the most frames of single-storey steel buildings the utilization of corrugated web beams, mainly with sinusoidal corrugation, has been increased considerably during the last years. thanks to the skinny web of two or 3 mm, corrugated web beams afford a big weight reduction compared with hot rolled profiles or welded I- sections. Buckling failure of the web is prevented by the corrugation. In construction application, the web usually In load carrying application, The web resists shear forces, while the flanges resist most of the bending moment experienced by the beam. I-shaped section may be a very efficient form for carrying both bending and shear loads within the plane of the online. On the opposite hand, the cross-section features a reduced capacity within the transverse direction, and is additionally inefficient in carrying torsion, thus, by using greater a part of the fabric for the flanges and thinner web, materials saving might be achieved without weakening the load-carrying capability of the beam. Nevertheless, because the compressive stress within the web has exceeded the juncture before the occurrence of yielding, the flat web loses its stability and deforms transversely. this might be improved by using corrugated web, an alternate to the plane web, which produces higher stability and strength without additional stiffening and use of larger thickness.

II. MODELING OF I-SECTION AND CORRUGATED WEB BEAM

By selecting structural steel as the material and having following material properties of structural steel as,
Density of Structural Steel=0.0078kg/mm3.
Poisons ratio=0.26
Y- Young's modulus of structural steel=200 GPA.
G- Modulus of Rigidity=75 GPA
L- Length of the Beam=1000mm.
A-Sectional area of beam=1140mm2
V- Volume=1140000mm2
M- Mass of the beam=8.9 kg/m.
We will have Cad models for I-section and different shapes of corrugation of web beams as follows,

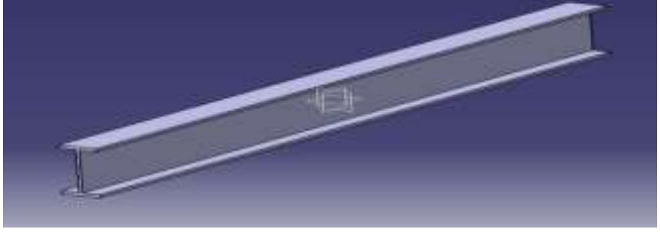

Fig 1. Model of Standard I-section beam

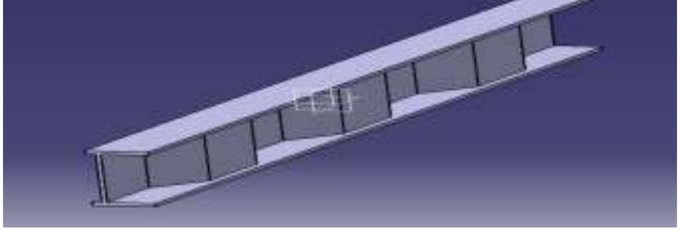

Fig 2. Model of Trapezoidal Corrugated Web Beam

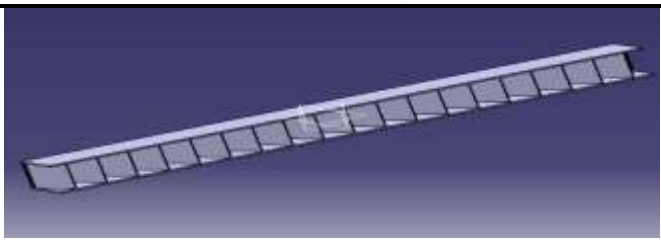

Fig 3. Model of Triangular Corrugated Web Beam

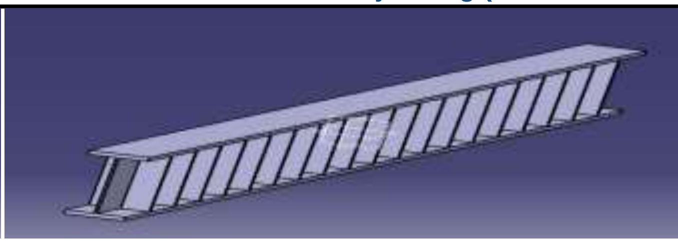

Fig 4. Model of Stiffener Corrugated Web Beam

III. Analysis

The strength of components may be a important requirement in gaining knowledge about product's performance, lifecycle and possible modes of failure. Mechanical loading, thermal stress, bolt tension, pressure conditions and rotational acceleration are number of people which will show strength requirements for materials and styles. Here we are going to determine which beam is strong for same loading condition.

A static structural analysis gives the deflection, stresses, strains, and forces in structures or elements caused thanks to loads that don't produce significant inertia and damping effects. Element type- Solid 185 is used for 3-D modeling of solid structures. It is defined by eight nodes having three degrees of freedom at each node. We can apply most loads either on the solid model (on key-points, lines, and areas) or on the finite element model (on nodes and elements).Here to avoid singularity load is applied on entire line. For it box option is used. Loads are applied on 1/3 distance from both the ends with simply supported condition .

3.1. Strength Analysis of I-section beam

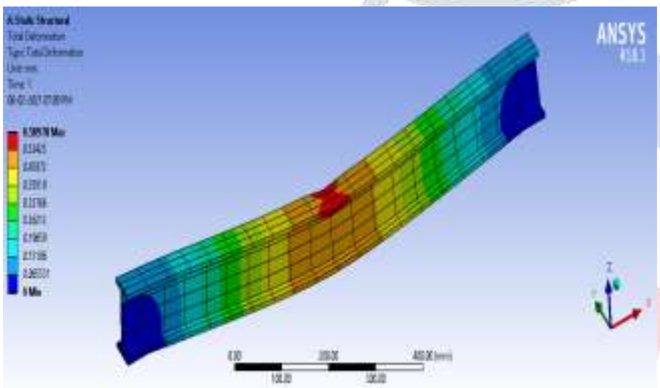

Fig 5. Maximum Vertical displacement at 9 KN

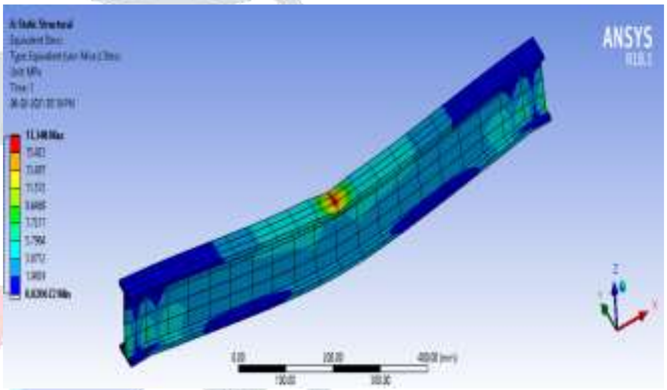

Fig 6. Von-misses stress at 9KN

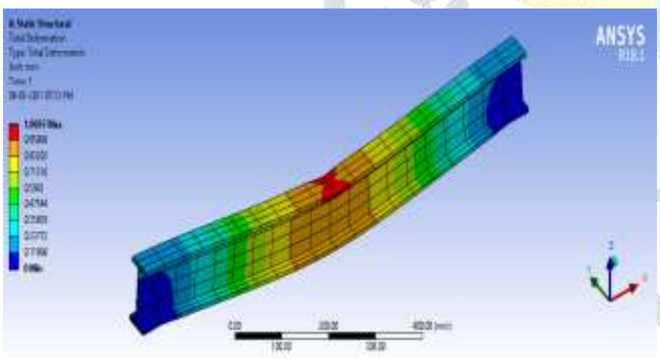

Fig 7. Maximum Vertical displacement at 18 KN

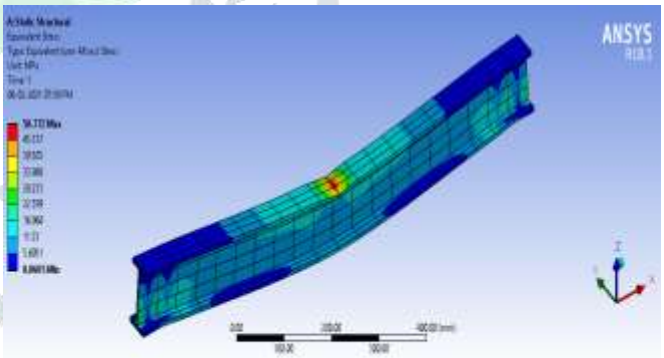

Fig 8. Von-misses stress at 18 KN

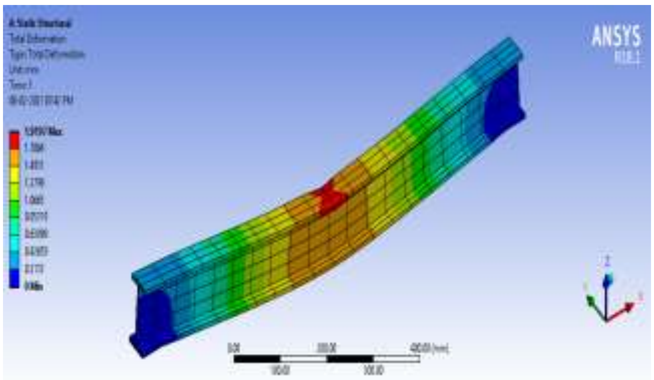

Fig 9. Maximum Vertical displacement at 27 KN

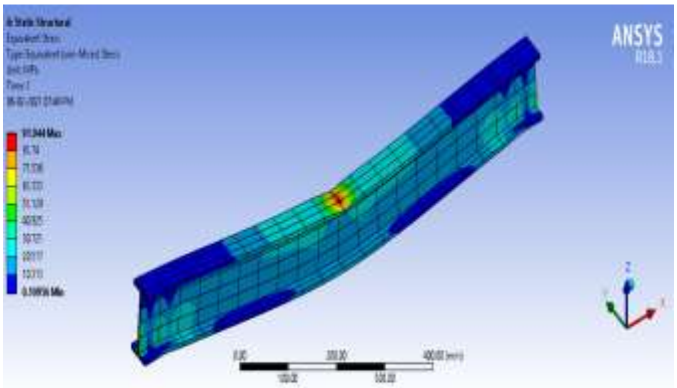

Fig 10. Von-misses stress at 27 KN

3.2. Strength Analysis of Trapezoidal corrugated web beam

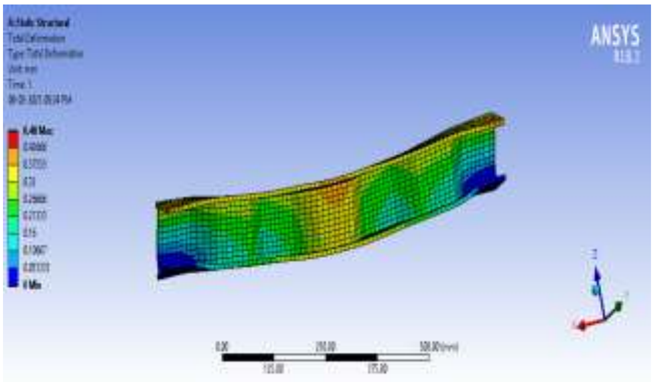

Fig 11. Maximum Vertical displacement at 9 KN

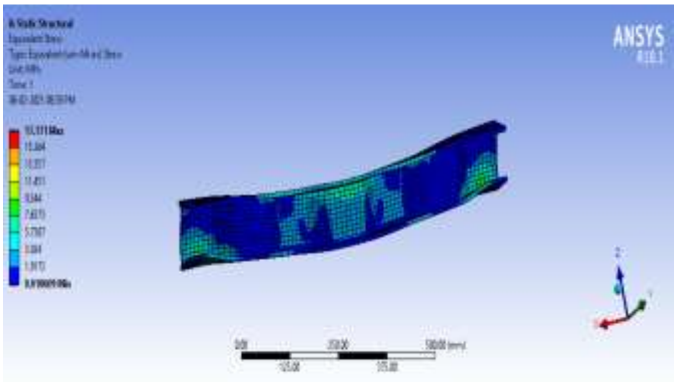

Fig 12. Von-misses stress at 9 KN

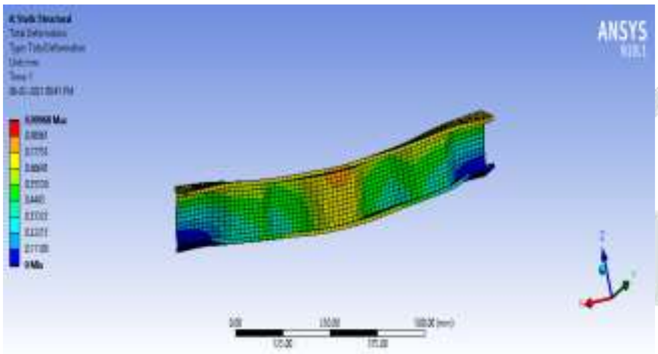

Fig 13. Maximum Vertical displacement at 18 KN

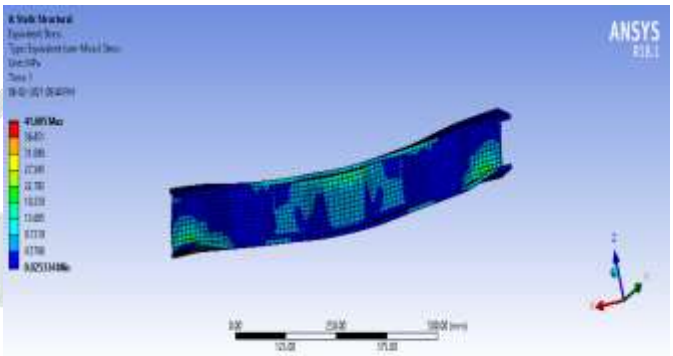

Fig 14. Von-misses stress at 18 KN

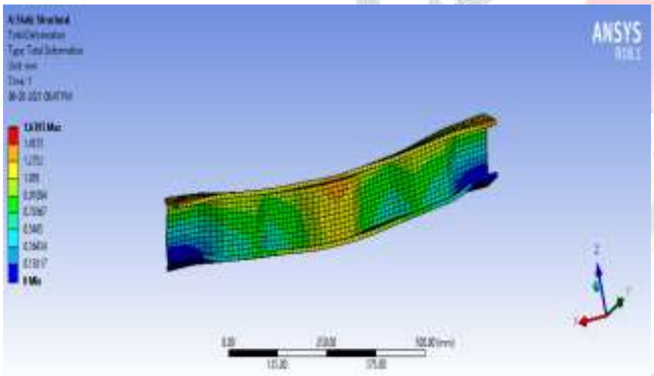

Fig 15. Maximum Vertical displacement at 27 KN

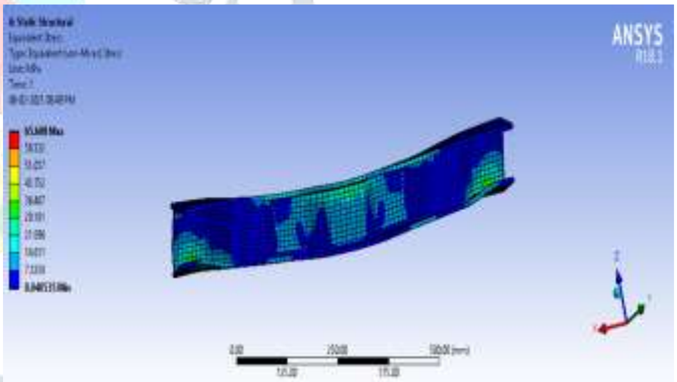

Fig 16. Von-misses stress at 27 KN

3.3. Strength Analysis of Triangular corrugated web beam

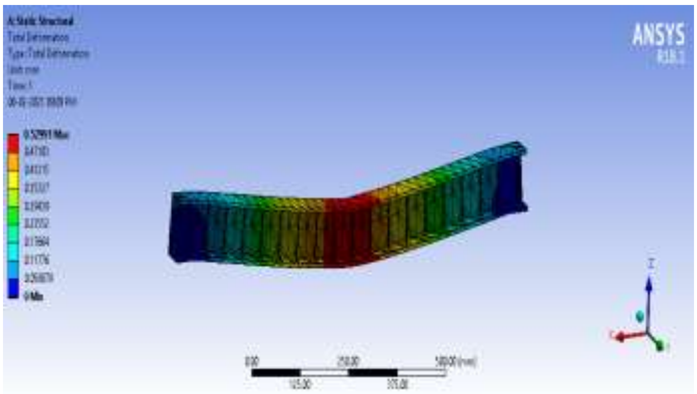

Fig 17. Maximum Vertical displacement at 9 KN

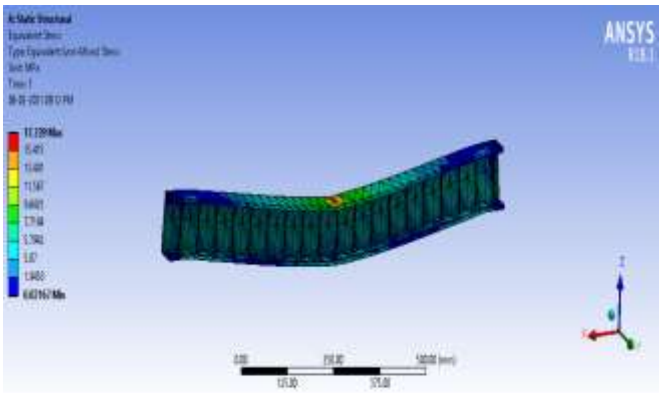

Fig 18. Von-misses stress at 9 KN

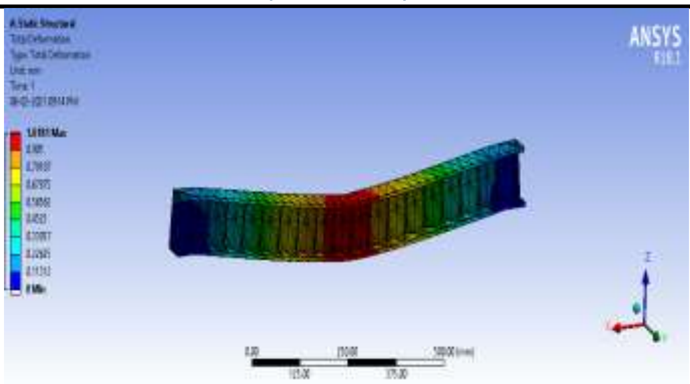

Fig 19. Maximum Vertical displacement at 18 KN

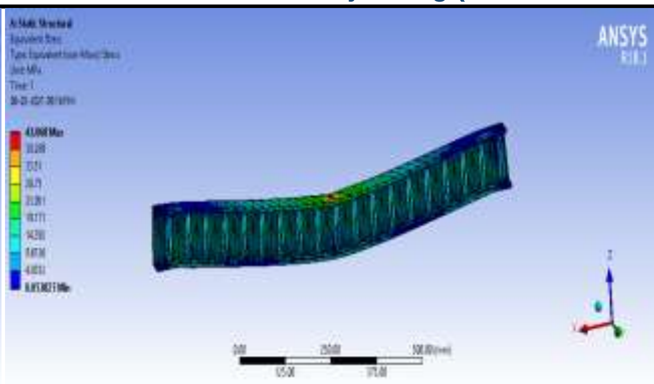

Fig 20. Von-misses stress at 18 KN

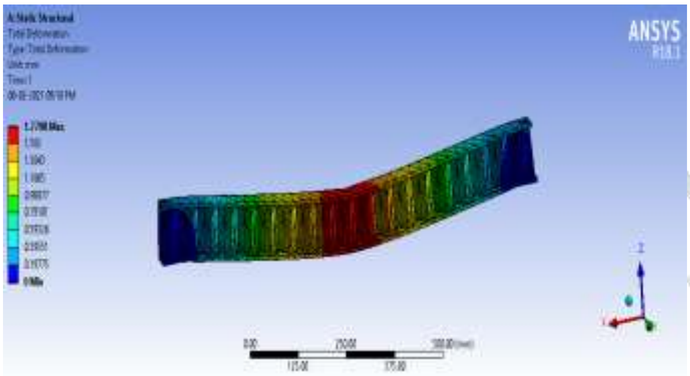

Fig 21. Maximum Vertical displacement at 27 KN

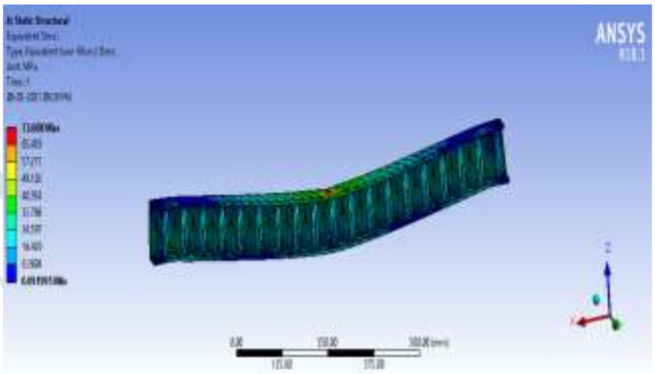

Fig 22. Von-misses stress at 27 KN

3.4. Strength Analysis of Stiffener corrugated web beam

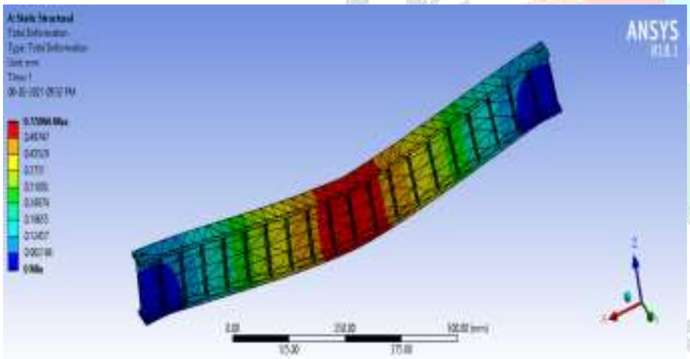

Fig 23. Maximum Vertical displacement at 9 KN

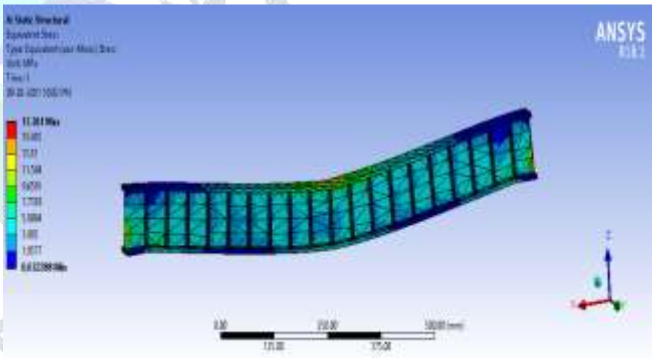

Fig 24. Von-misses stress at 9 KN

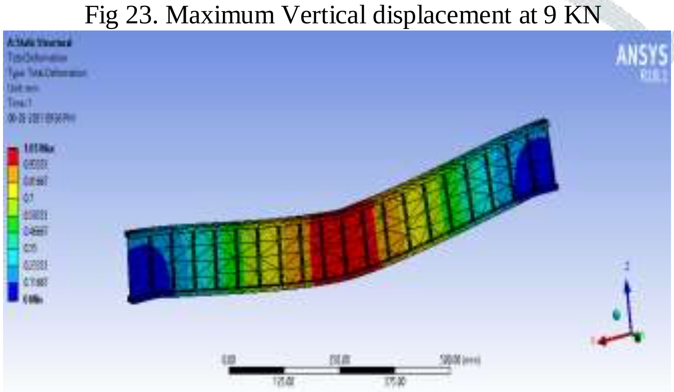

Fig 25. Maximum Vertical displacement at 18 KN

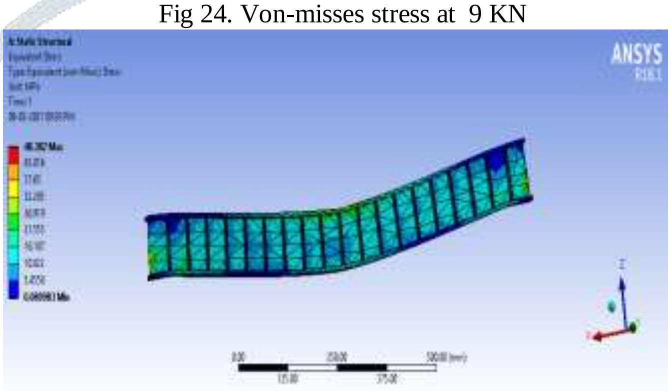

Fig 26. Von-misses stress at 18 KN

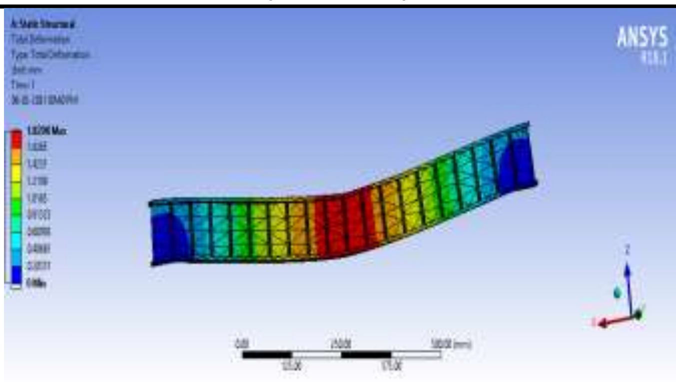

Fig 27. Maximum Vertical displacement at 27 KN

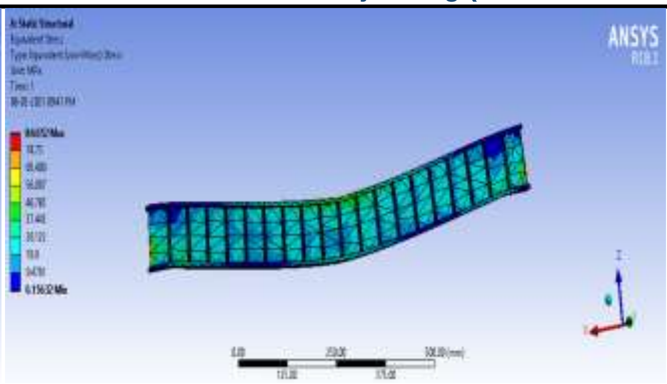

Fig 28. Von-misses stress at 27 KN

IV. Modal Analysis

Modal analysis is administered to work out frequency and mode shapes of a given free-free beam using finite element analysis based software ansys.

4.1 Mode shapes of I section beam

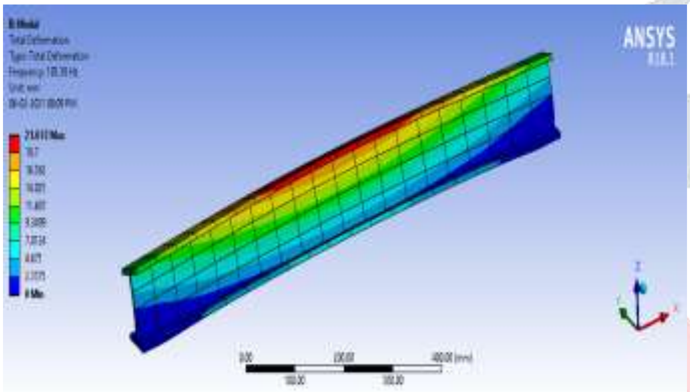

Fig 29. First Mode of I-Section Beam

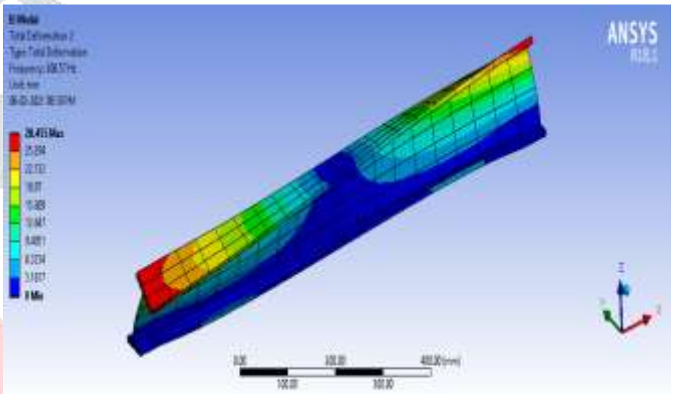

Fig 30. Second Mode of I-Section Beam

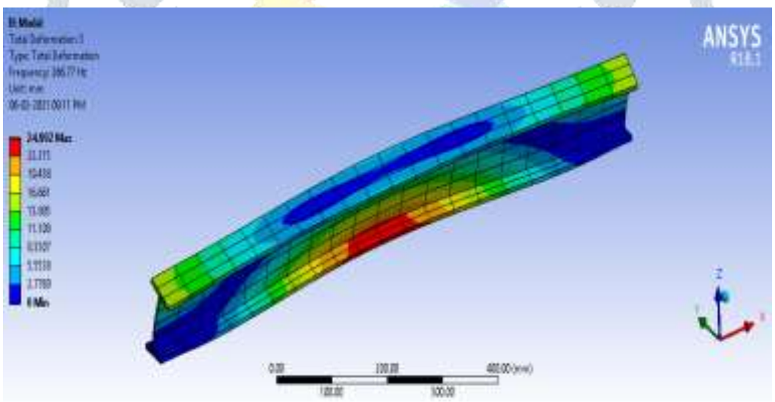

Fig 31. Third Mode of I-Section Beam

4.2 Mode shapes of Trapezoidal corrugated web beam

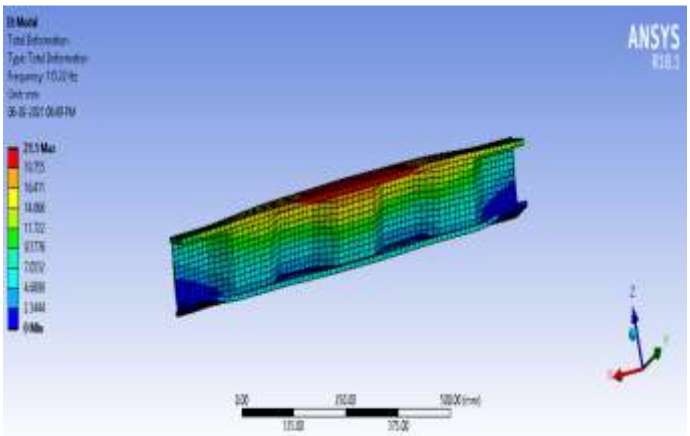

Fig 32. First Mode of Trapezoidal corrugated web Beam

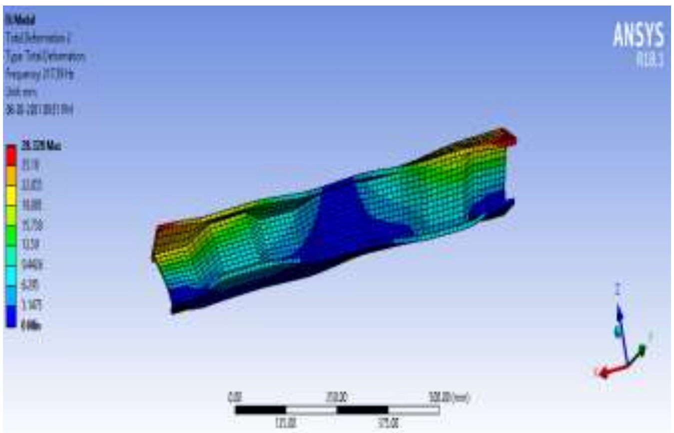

Fig 33. Second Mode of Trapezoidal corrugated web Beam

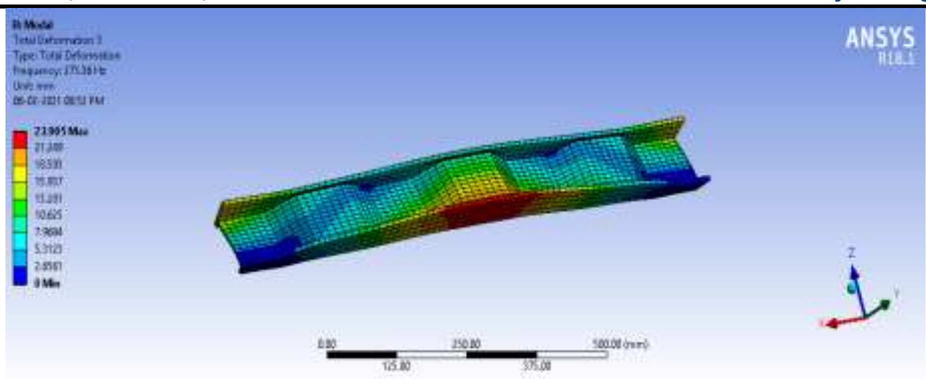

Fig 33. Third Mode of Trapezoidal corrugated web Beam

4.3 Mode shapes of Triangular corrugated web beam

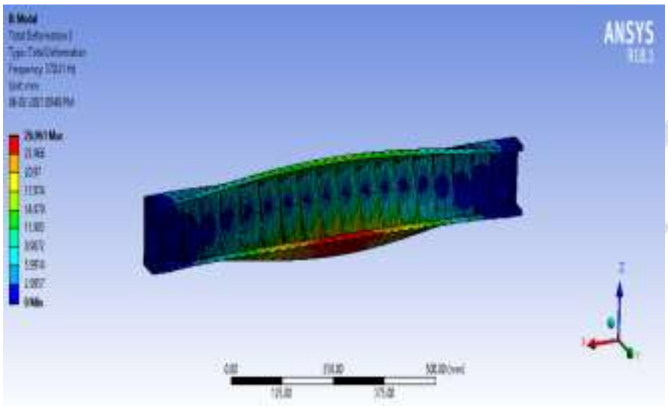

Fig 34. First Mode of Triangular corrugated web Beam

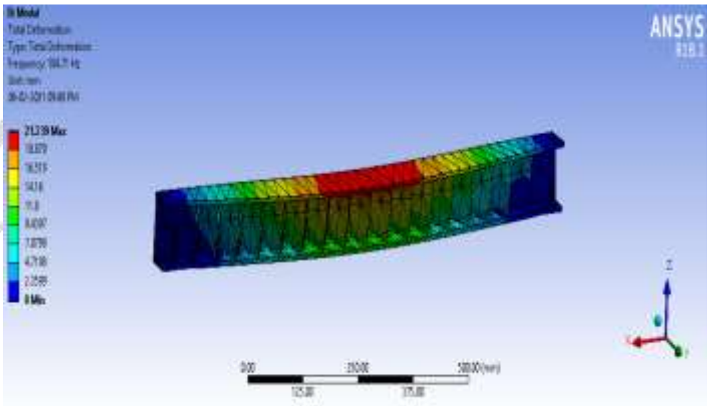

Fig 35. Second Mode of Triangular corrugated web Beam

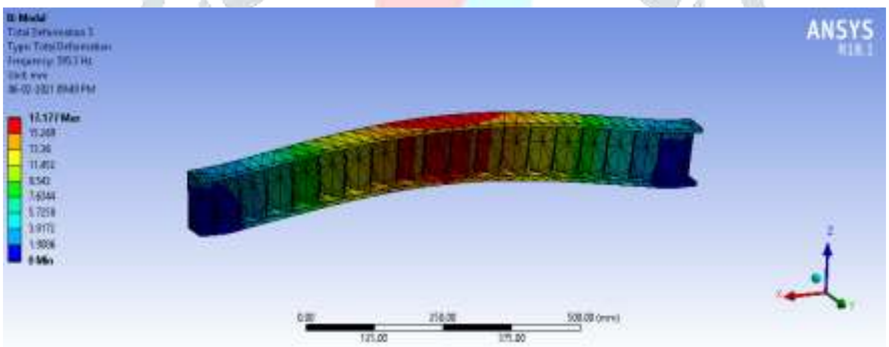

Fig 36. Third Mode of Triangular corrugated web Beam

4.4 Mode shapes of Stiffener corrugated web beam

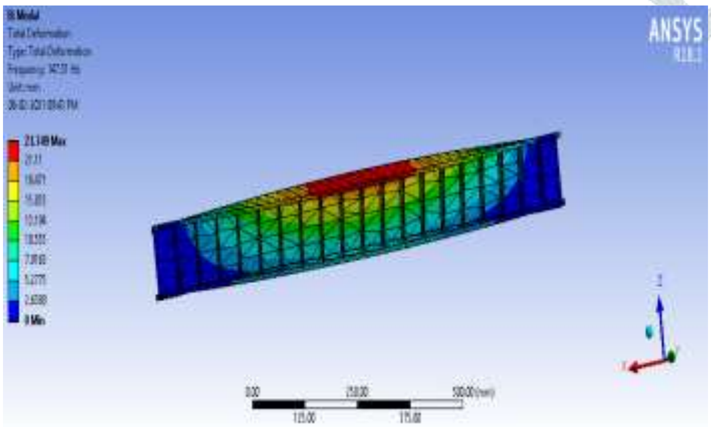

Fig 37. First Mode of Stiffener corrugated web beam

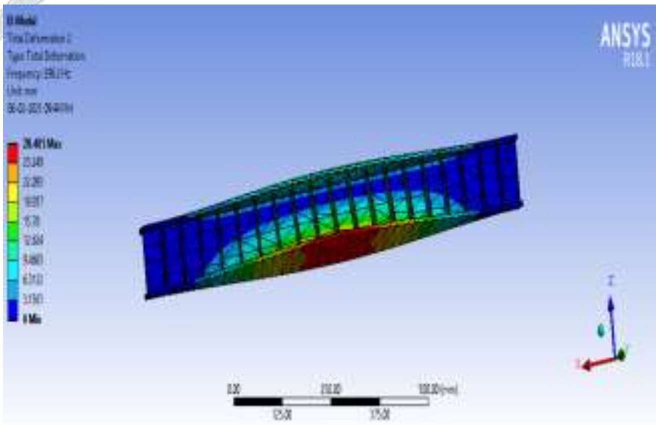

Fig 38. Second Mode of Stiffener corrugated web beam

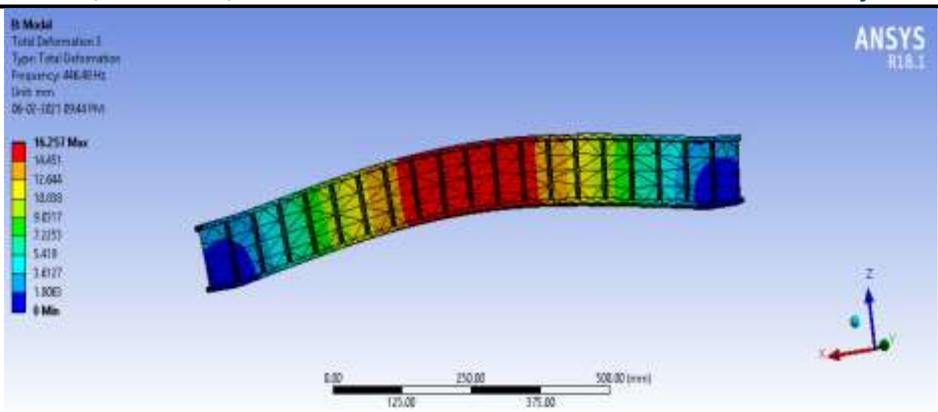

Fig 39. Third Mode of Stiffener corrugated web beam

V. RESULTS AND DISCUSSION

Table 4.1: Stresses and deflections are calculated and compared below for I-Section beam and different corrugation of beams.

Type of Beam	Load (KN)	Total Deflection (mm)	Von Misses Stress (Mpa)
I-section beam	9	0.58	17.34
	18	1.06	50.77
	27	1.91	91.94
Trapezoidal corrugated web beam	9	0.48	17.17
	18	0.99	41.005
	27	1.63	65.60
Triangular corrugated web beam	9	0.52	17.33
	18	1.01	43.06
	27	1.77	73.60
Stiffener corrugated web beam	9	0.55	17.61
	18	1.05	48.38
	27	1.82	84.05

In this paper we studied the varied properties of beam like its load carrying capacity, modes of failure, natural frequencies. The deflection observed in the I-section beam is more than the other different shapes of corrugated web beam in given loading condition by using ANSYS results. Both beams are again tested to work out natural frequencies. We found three natural frequencies by FEA. These frequencies are tabulated in following table 5.2. As we see from results that the natural frequency of corrugated web beams is more than the standard I-Section beam.

Table 5.2: Comparison of natural frequency for I-Section beam and other different shapes of corrugation of web beam.

Type of Beam	Mode No	Natural Frequency(Hz) using Ansys
I-section beam	1	103.38
	2	206.57
	3	266.77
Trapezoidal corrugated web beam	1	113.22
	2	217.39
	3	273.36
Triangular corrugated web beam	1	184.71
	2	370.21
	3	393.30
Stiffener corrugated web beam	1	147.51
	2	296.20
	3	446.48

VI. CONCLUSION AND FUTURE SCOPE

FEA results of loading and deflection are with some variation for I-Section and other corrugated web beam, hence we can replace I-section beam with different shapes of corrugated web beam. Stress induced in the I-section beam are 15% to 20% more than the other different shapes of corrugated web beam at the same loading condition with references to the ANSYS software. The shear stresses are dependent upon the area of contact between the flange and web, for trapezoidal beam more area of contact is present as compare to I-section beam. The natural frequency of corrugated web beams is more than the standard I-Section which helps to avoid the resonance with earth-quick frequencies.

VII. REFERENCES

[1] Chan et. al. "Finite element analysis of corrugated web beams under bending", Journal of Constructional Steel Research 58 (3December2001) P1391–1406.

[2] Khalid et. al. "Bending behaviour of corrugated web beams" Journal of Materials Processing Technology 150 (3Feb2004)P 242–254.

[3] Jae-Yuel oh et. ac. "Accordion effect of prestressed steel beams with corrugated webs " Thin –walled structures 57(4April2012) P49-61.

[4] Lincy Pabraham et. ac. "Behaviour of Encased Cold-formed Trapezoidally Corrugated web beam" International Journal of Engineering science and research technology ISSN-2277- 9655(October2013)P2657-2663.

[5] R.Divahar et. ac. "Lateral Buckling of cold formed steel beam with Trapezoidal corrugated web" International Journal of Civil engineering and technology, Volume 5,Issue3,March(2014)P217-225.

[6] Yogesh Shinde et.ac. "Vibration Analysis of Cantilever beam with Single Crack using experimental method" International Journal of Engineering research and technology(IJERT) ISSN:2278- 0181,Vo.3Issue(5May-2014) P1644-1648.

[7] Magnucka et. al. "Mathematical modeling of shearing effect for sandwich beams with sinusoidal corrugated cores", Applied mathematical modeling 39(25November2014) P2796-2808.

[8] Mohammadi et. al. "An equivalent model for trapezoidal corrugated cores based on homogenization method" composite structure 131(6May2015) P160-170.

[9] Jian Jiang et. ac. " Local bucking of compression flanges of H-beam with corrugated webs" journal of constructional Research 112 (18May2015) P69-79.

[10] Indian standard dimensions for hot rolled steel beam, column, channel and angle section , IS 808:1989 (Reaffirmed 2004).

[11] Fatimah De'nan , Nor Salwani Hashim "Study on Triangular web profile steel beam section" (IJRET) ISSN: 2319-1163.