DYNAMIC ANALYSIS OF SYMMETRICAL & UNSYMMETRICAL CHANNEL SECTION – BEAMS

[1]G.Jayasimha, [2]K. Sridevi

[1]M.Tech. Student, [2]Assistant Professor
Department of Mechanical Engineering,
ANU College of Engineering & Technology

***ABSTRACT*: In an effort to save weight while still remaining high strength, many contemporary structural systems are designed with lower margins of safety than predecessors. The criterion of minimum weight design is particularly prevalent in the design of aircraft, missile, and spacecraft vehicles. One obvious means of obtaining a high strength, minimum weight design is the use of light, thin-walled structural members of high strength alloys. Thin- walled beams of open sections such as I, Z, Channel and angle sections are frequently used for intricate structures in spacecrafts. Due to low torsional rigidity thin-walled beams of open sections, the problem of torsional vibrations and stability is of prime interest. Mechanical vibrations produce increased stress, energy loss and noise that should be considered in the design stages if these undesirable effects are to be avoided, or to be kept minimum.**

The present work particularly deals with dynamic analysis of lengthy uniform thin-walled uniform C section beams and tapered C section beams of open sections. Graphite Epoxy have been increasingly used over the past few decades in a variety of structures that require high ratio of stiffness and strength to weight. In the present thesis the dynamic behavior of a thin-walled C-section of symmetrical and un symmetrical shapes studied in detail. This model accounts for the coupling of flexural and torsional modes for arbitrary laminate and various boundary conditions are also discussed in detail. A displacement-based one-dimensional finite element model is developed to predict natural frequencies and corresponding vibration modes for a thin-walled composite beam. Numerical results are obtained for thin-walled composite beams addressing the effects of modulus ratio, height-to-thickness ratio, and boundary conditions on the vibration frequencies and mode shapes of the composites. Using ANSYS 15.0, the modal and harmonic analysis are carried out and presented in graphical form.

MODAL & DYNAMIC ANALYSIS

Modal analysis:

The modal analysis is used to determine the natural frequencies and mode shapes of a structure. The natural frequencies and mode shapes are important parameters in the design of a structure for dynamic loading conditions. They are also required to do a spectrum analysis or a mode superposition harmonic or transient analysis.

Harmonic Analysis: Any sustained cyclic load will produce a sustained cyclic response (a harmonic response) in a structural system. Harmonic response analysis gives the ability to predict the sustained dynamic behavior of the structures, thus enables to verify whether or not designs will successfully overcome resonance, fatigue, and other harmful effects of forced vibrations.

Harmonic response analysis is a technique used to determine the steady-state response of a linear structure to loads that vary sinusoidally (harmonically) with time. The idea is to calculate the structure's response at several frequencies and obtain a graph of some response quantity (usually displacements) versus frequency.

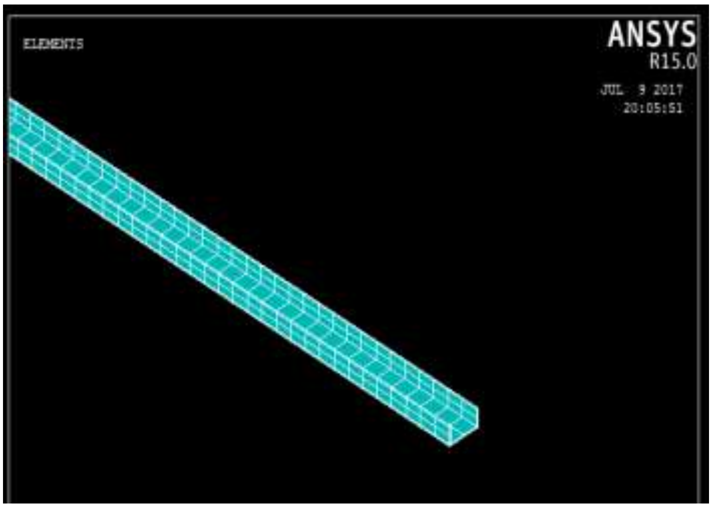
This analysis technique calculates only the steady-state, forced vibrations of a structure. The transient vibrations, which occur at the beginning of the excitation, are not accounted for in a harmonic response analysis.

RESULTS & DISCUSSION:

Modal analysis on Symmetrical C- section Beam

Dimensions of the Beam section:

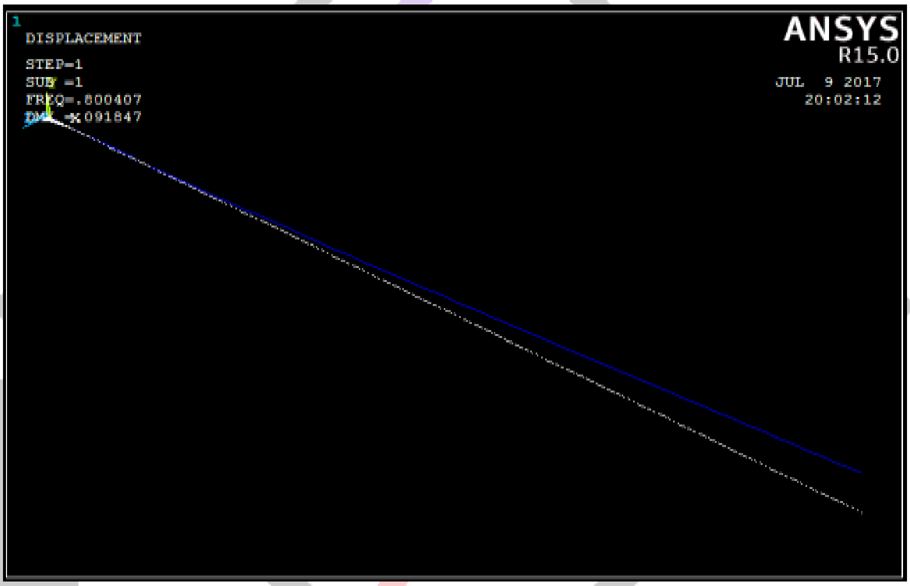
Length of the Beam	$l = 8m$,
Width of top flange	$b_1 = 0.1m$,
Width of bottom flange	$b_2 = 0.1m$,
Width of web	$b_3 = 0.20m$,
Thickness of top flange	$t_1 = 0.01m$,
Thickness of top flange	$t_2 = 0.01m$,
Thickness of web	$t_3 = 0.01m$,
Cross section Area	$A = 0.0036\ m^2$.



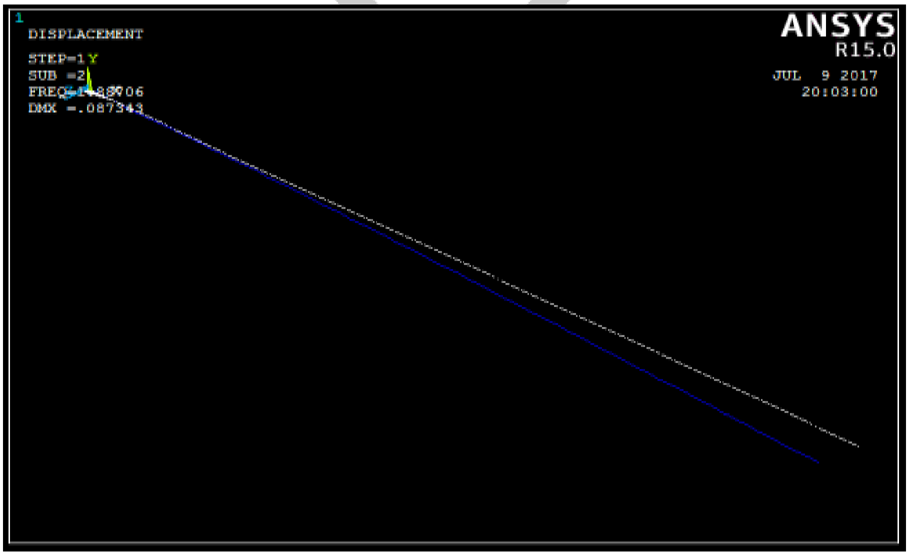
Cross section of beam with elements

MODES OF C- SECTION FOR GRAPHITE EPOXY

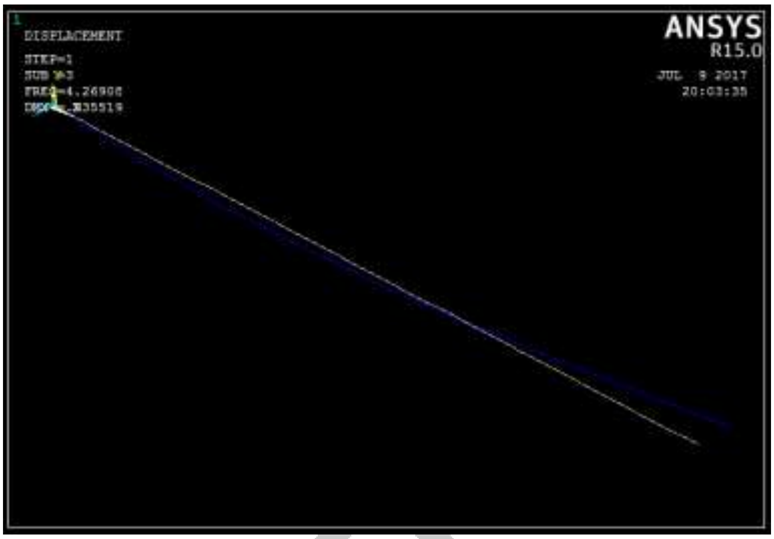
MODE – 1



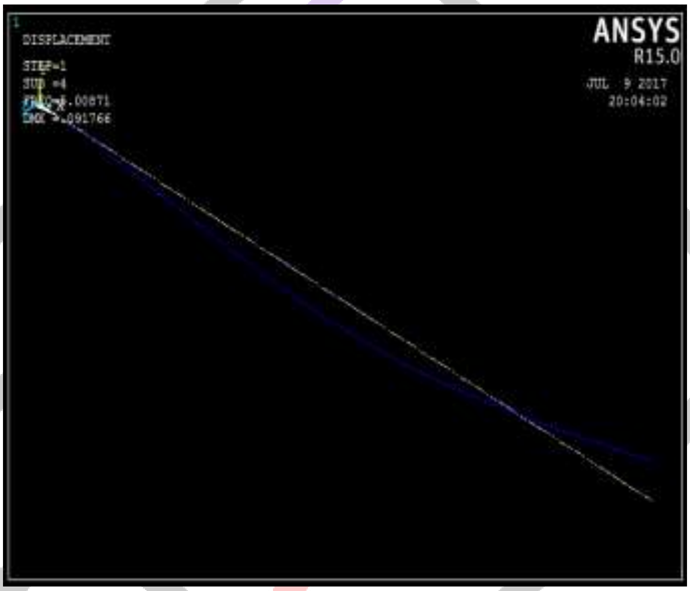
MODE – 2



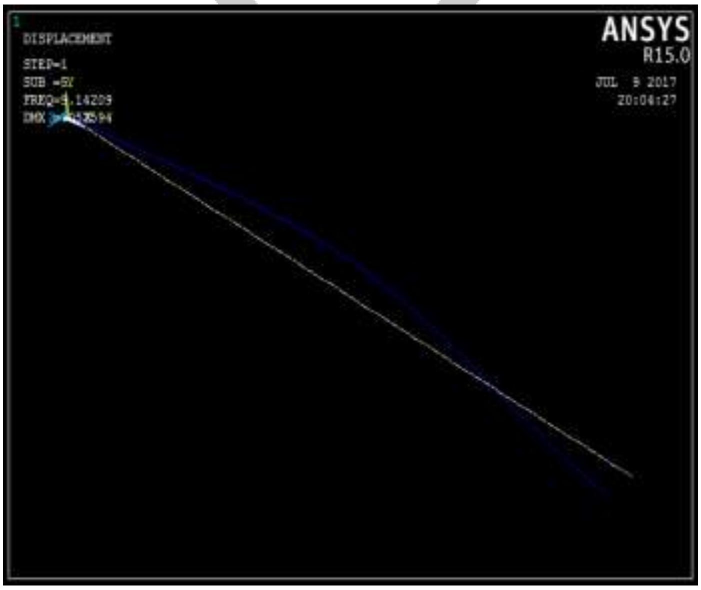
MODE – 3



MODE – 4



MODE – 5

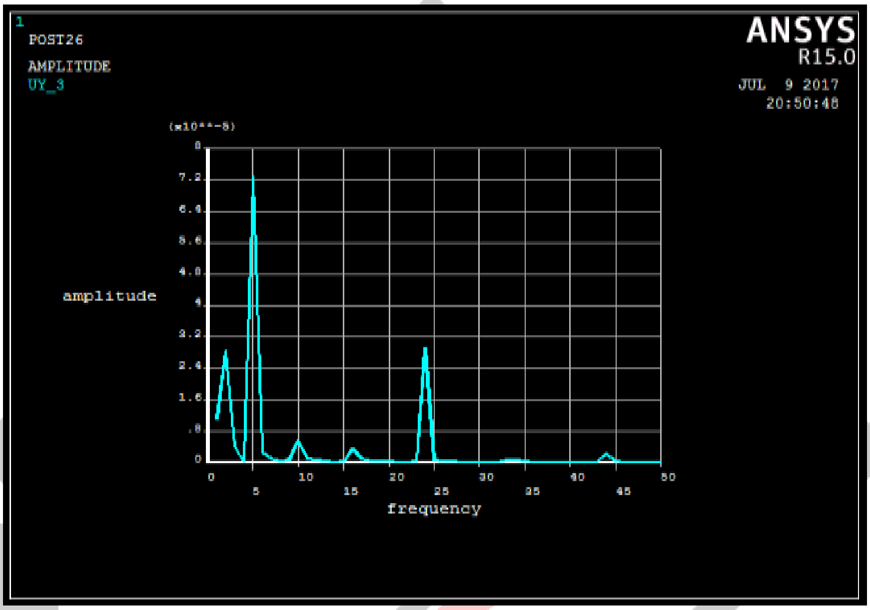


Frequency values for different modes

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	0.080041	1	1	1
2	1.8871	1	2	2
3	4.2691	1	3	3
4	5.0087	1	4	4
5	9.1421	1	5	5

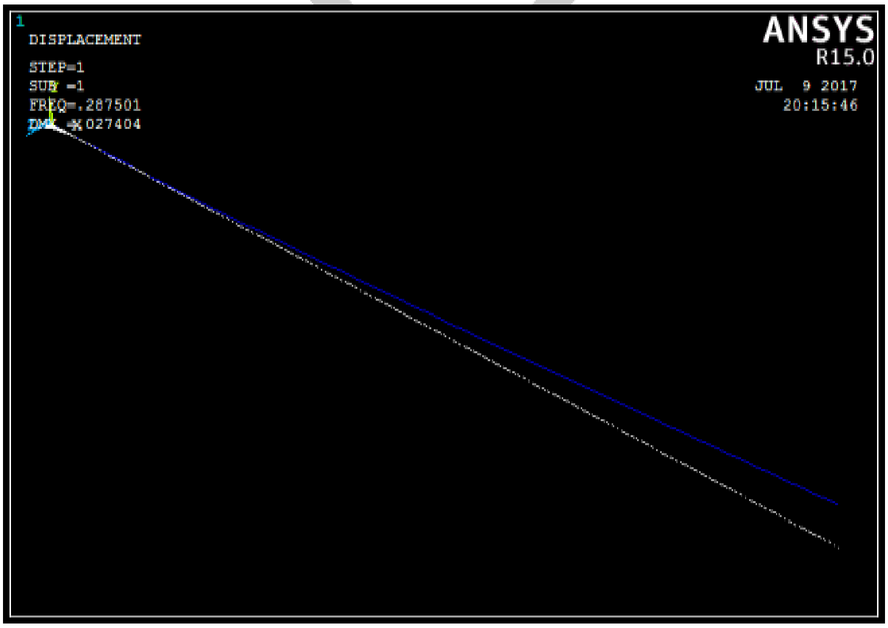
Harmonic Analysis :

The harmonic analysis is done on the cantileaverarrangement for 1N of point load at the end point and consider the Harmonic frequency as 0-50Hz.The amplitudes at different frequencies are represented by below graph.

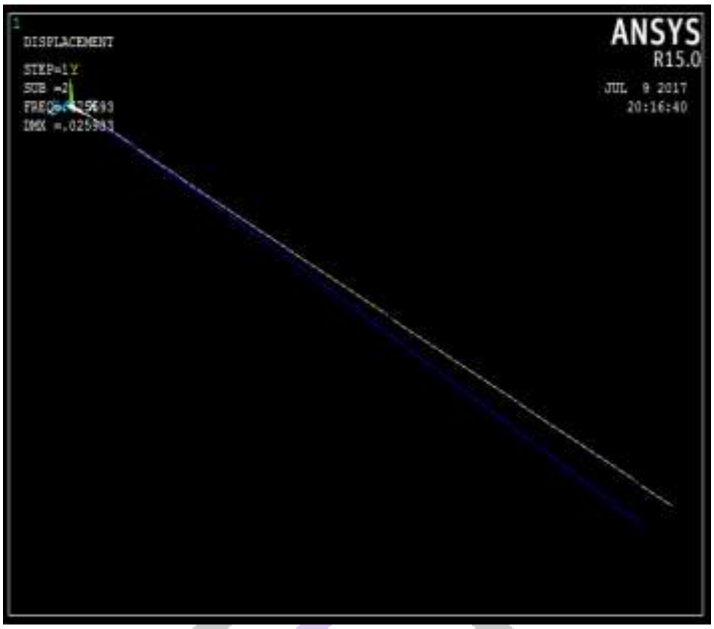


MODES OF C- SECTION FOR STAINLESS STEEL

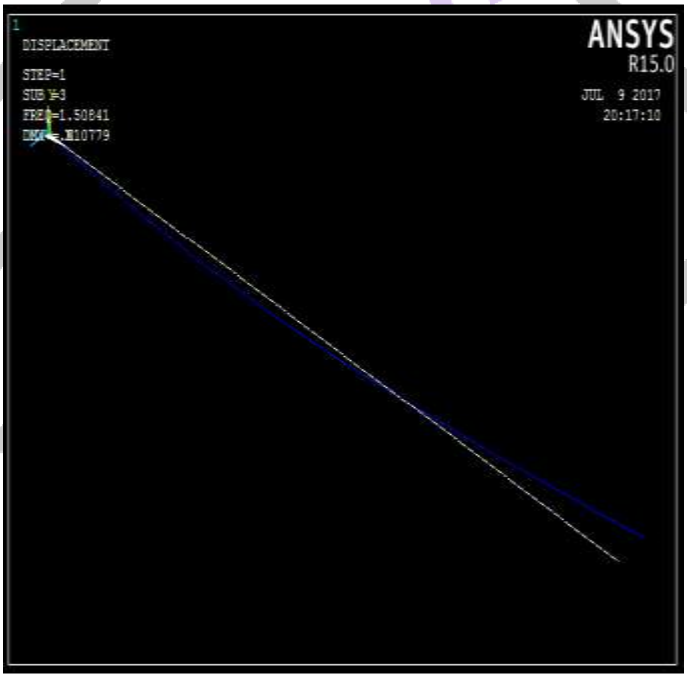
MODE – 1



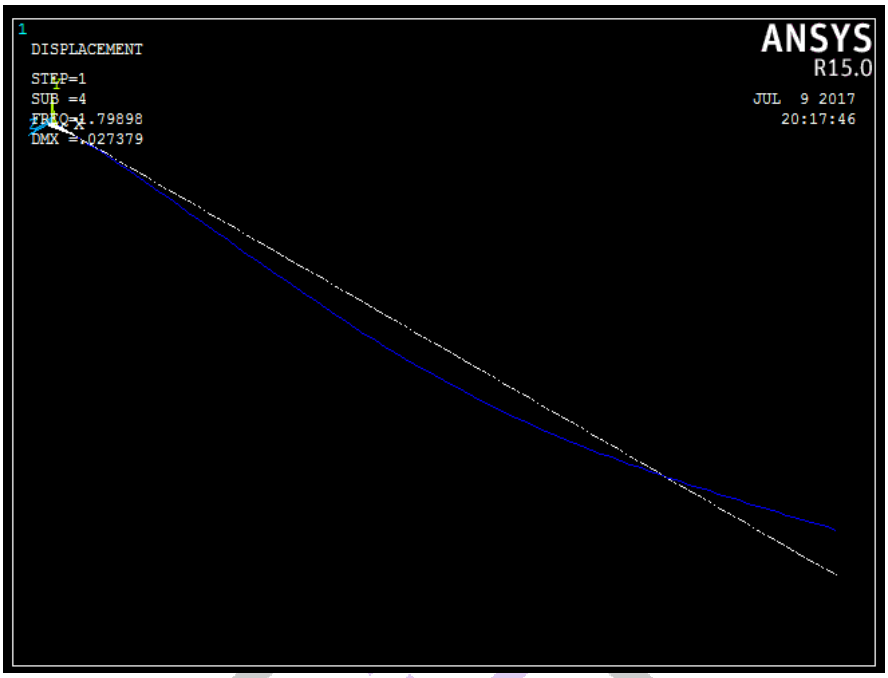
MODE – 2


DISPLACEMENT
STEP=1
SUB =2
DMX =.025983
ANSYS
R15.0
JUL 9 2017
20:16:40

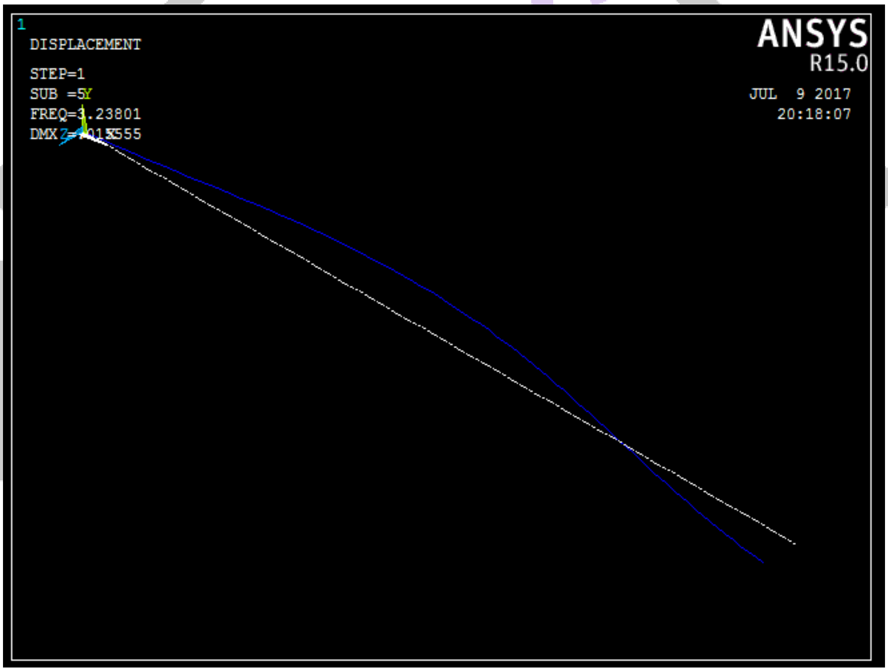
MODE – 3


DISPLACEMENT
STEP=1
SUB =3
FREQ=1.50841
ANSYS
R15.0
JUL 9 2017
20:17:10

MODE – 4



MODE – 5

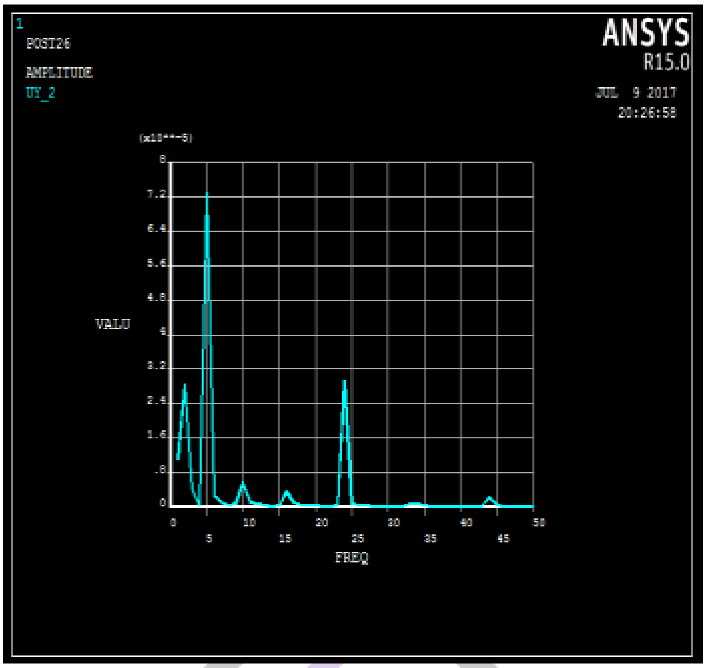


Frequency values for different modes

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	0.2875	1	1	1
2	0.6756	1	2	2
3	1.5084	1	3	3
4	1.7989	1	4	4
5	3.2380	1	5	5

Harmonic Analysis :

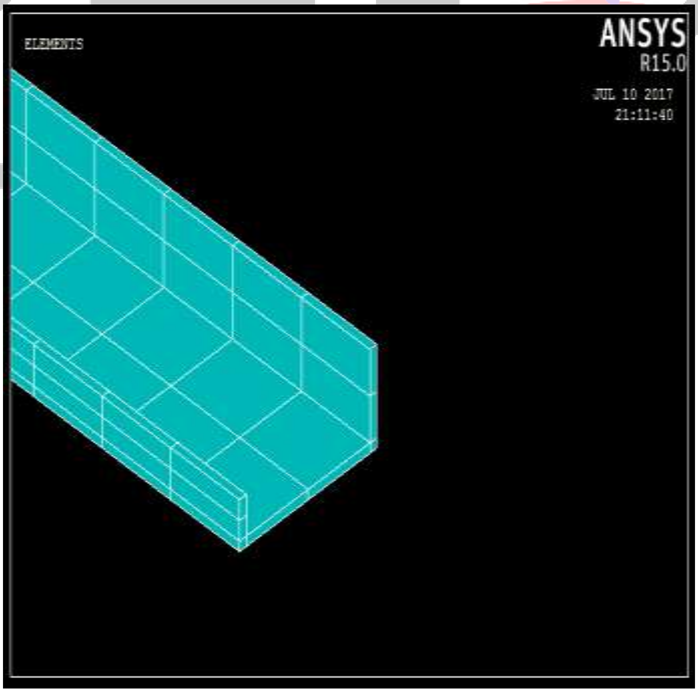
The harmonic analysis is done on the cantileaver arrangement for 1N of point load at the end point and consider the Harmonic frequency as 0-50Hz.The amplitudes at different frequencies are represented by below graph.



Modal analysis on UnSymmetrical C- section Beam

Dimensions of the Beam section:

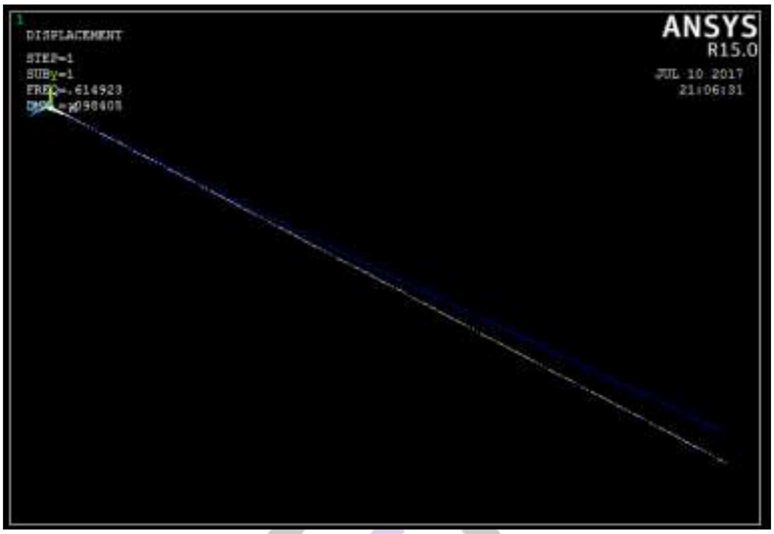
Length of the Beam l = 8m,
Width of top flange b_1 = 0.05m,
Width of bottom flange b_2 = 0.1m,
Width of web b_3 = 0.20m,
Thickness of top flange t_1 = 0.01m,
Thickness of top flange t_2 = 0.01m,
Thickness of web t_3 = 0.01m,
Cross section Area A = 0.0023 m^2.



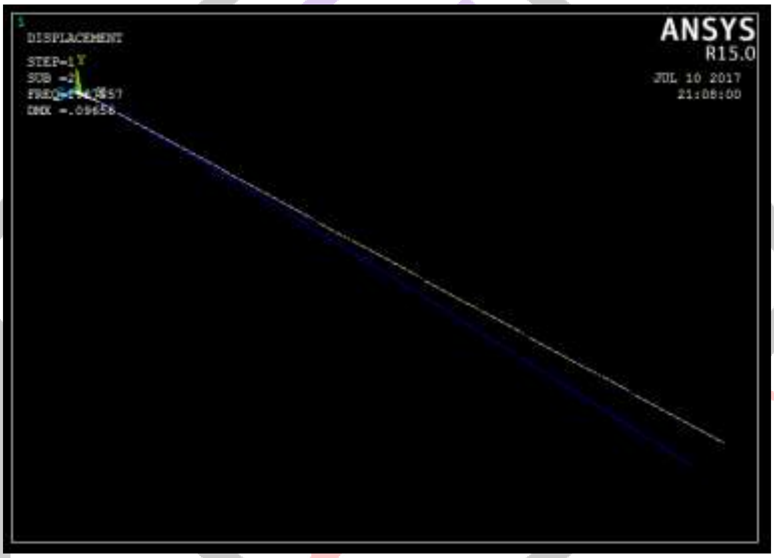
Cross section of beam with elements

MODES OF C-SECTION FOR GRAPHITE EPOXY

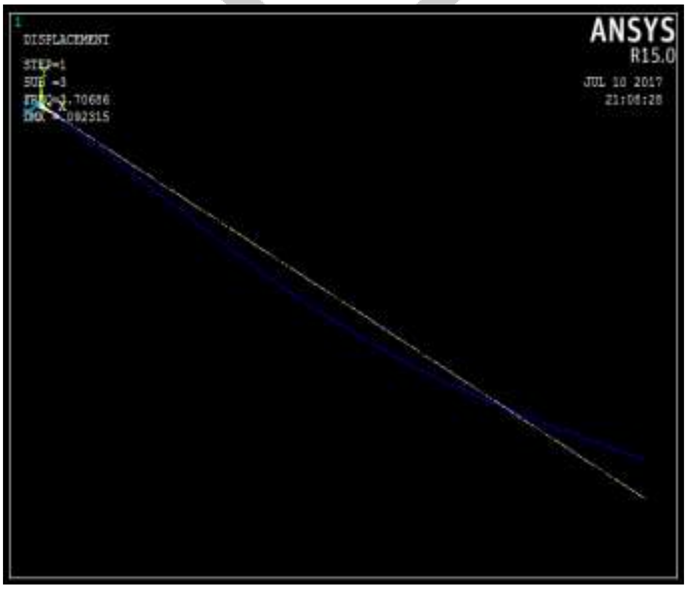
MODE – 1



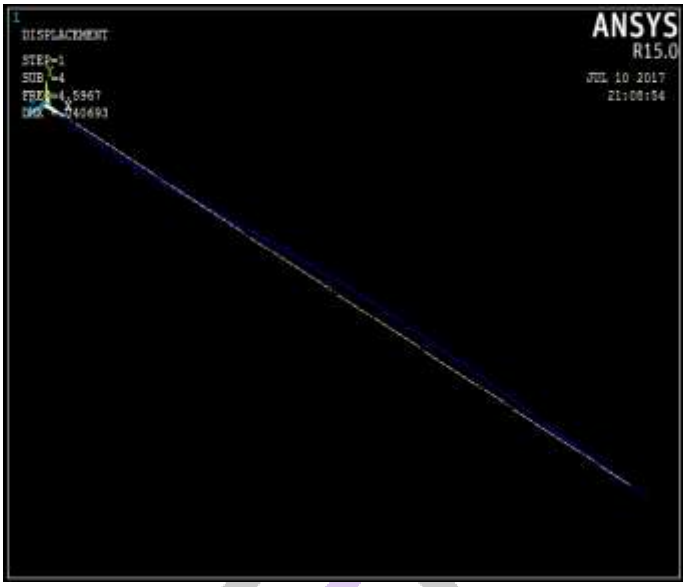
MODE – 2



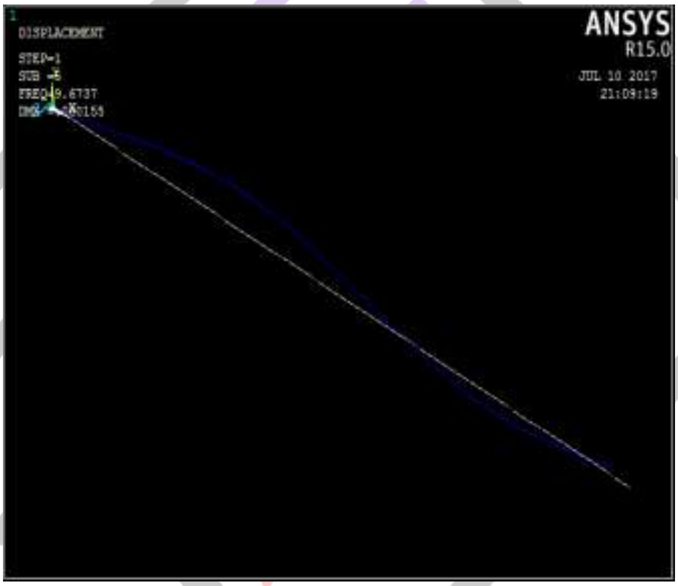
MODE – 3



MODE – 4



MODE – 5

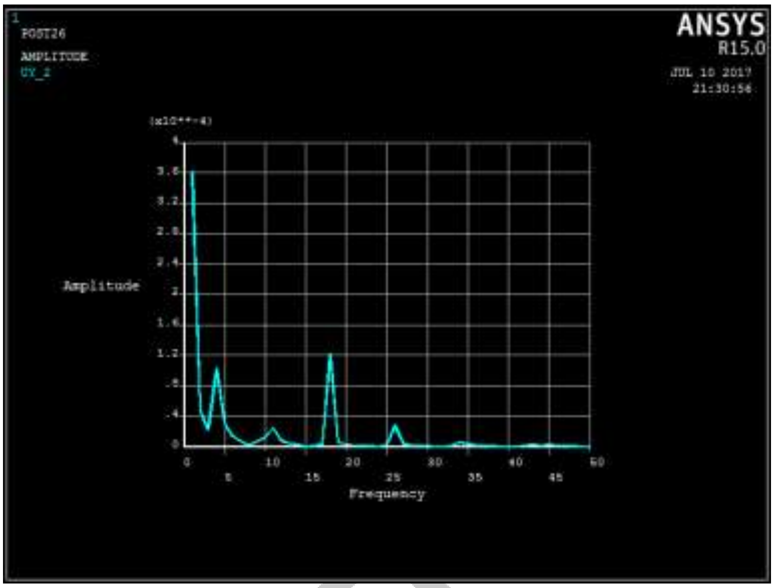


Frequency values for different modes

SET	TIME/FREQ	LOAD STEP	SUB STEP	CUMULATIVE
1	0.61492	1	1	1
2	1.8726	1	2	2
3	3.7069	1	3	3
4	4.5967	1	4	4
5	9.6737	1	5	5

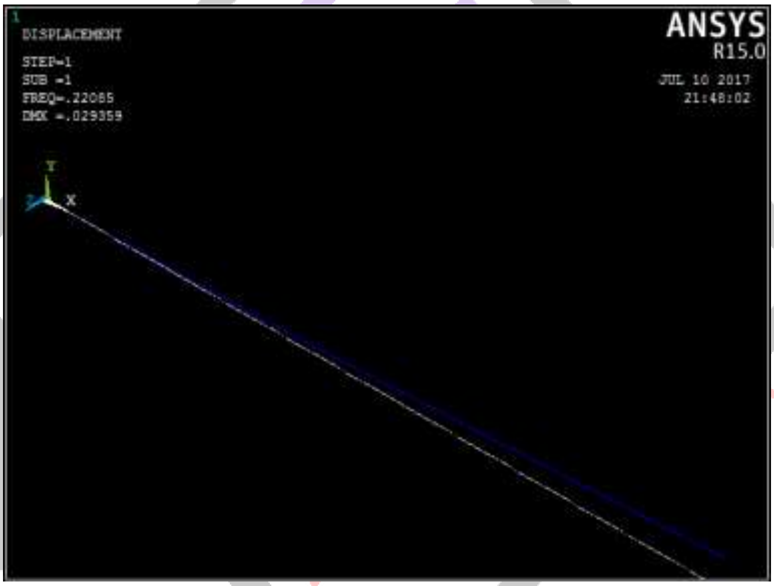
Harmonic Analysis :

The harmonic analysis is done on the cantileaver arrangement for 1N of point load at the end point and consider the Harmonic frequency as 0-50Hz.The amplitudes at different frequencies are represented by below graph.

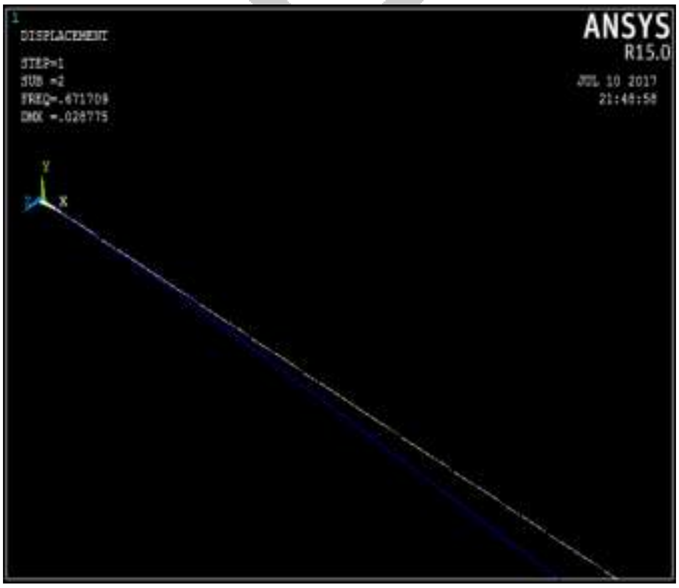


MODES OF C- SECTION FOR STAINLESS STEEL

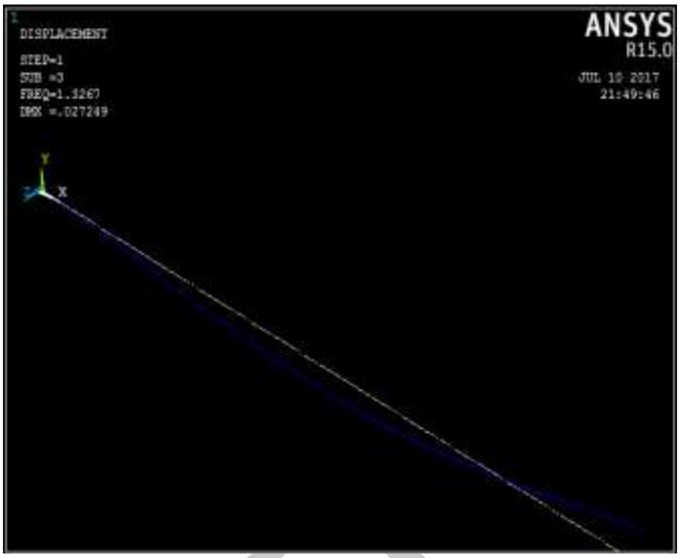
MODE – 1



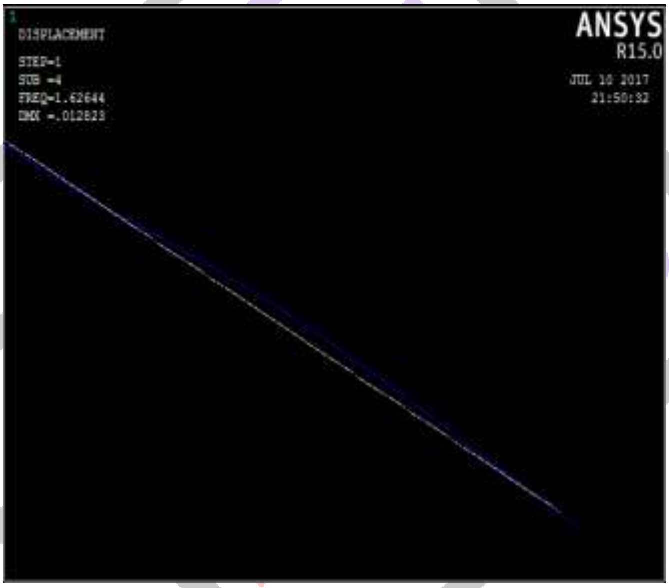
MODE – 2



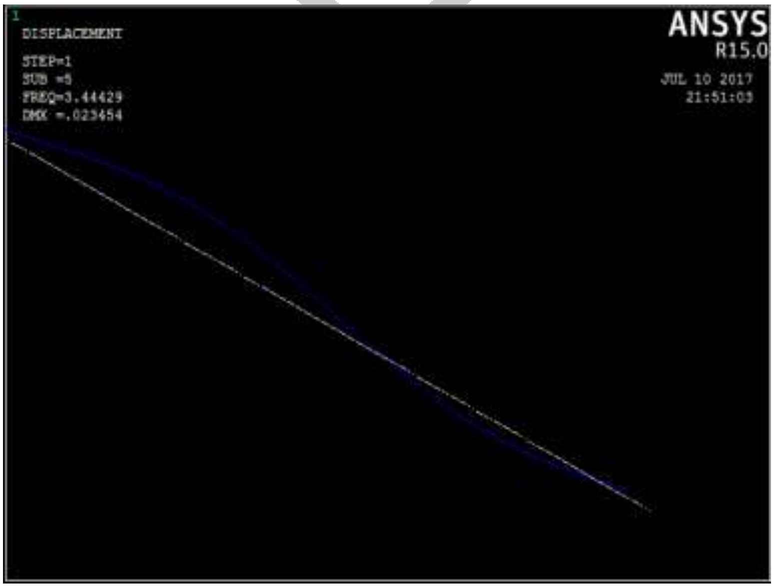
MODE – 3



MODE – 4



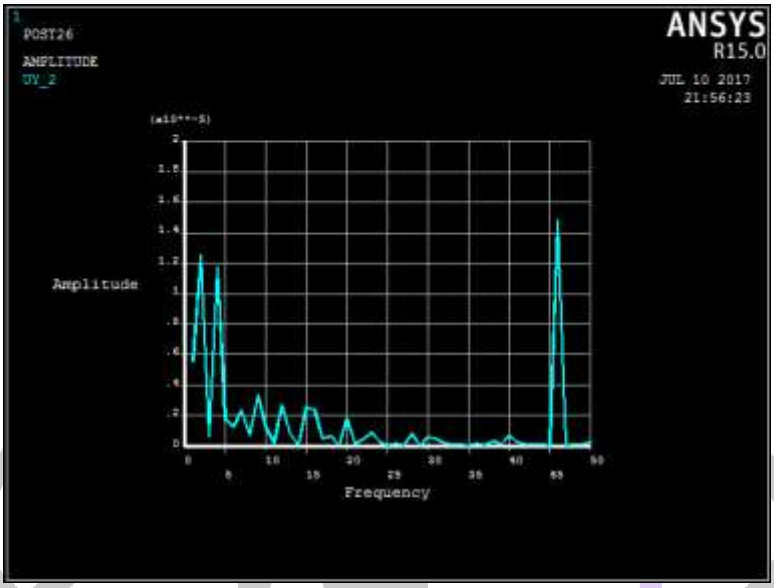
MODE – 5



SET	TIME/FREQ	LOAD STEP	SUB STEP	CUMULATIVE
1	0.22085	1	1	1
2	0.671709	1	2	2
3	1.3267	1	3	3
4	1.6244	1	4	4
5	3.44429	1	5	5

Harmonic Analysis :

The harmonic analysis is done on the cantileaver arrangement for 1N of point load at the end point and consider the Harmonic frequency as 0-50Hz.The amplitudes at different frequencies are represented by below graph.



COMPARISON OF RESULTS FOR SYMMETRICAL AND UNSYMMETRICAL BEAMS WITH DIFFERENT MATERIALS

The frequency values of modes for symmetrical & un- symmetrical sections for different materials are tabulated in the above table.

Section	SYMMETRICAL		UN SYMMETRICAL	
Material	Graphite epoxy	Stainless steel	Graphite epoxy	Stainless steel
SET	TIME/FREQ	TIME/FREQ	TIME/FREQ	TIME/FREQ
1	0.080041	0.2875	0.61492	0.22085
2	1.8871	0.6756	1.8726	0.671709
3	4.2691	1.5084	3.7069	1.3267
4	5.0087	1.7989	4.5967	1.6244
5	9.1421	3.238	9.6737	3.44429

Section	SYMMETRICAL		UN SYMETRICAL	
Material	Graphite epoxy	Stainless steel	Graphite epoxy	Stainless steel
	Amplitude	Amplitude	Amplitude	Amplitude
Max	2.44E-04	7.30E-05	3.60E-04	1.48E-05
Min	2.55E-08	8.93E-09	6.77E-08	1.40E-08

The frequency values of modes for symmetrical & un- symmetrical sections for different materials are tabulated in the above table.

CONCLUSION

In this work an analytical model was developed to study the flexural-torsional vibration of abeam with an C-section. The model is capable of predicting accurate natural frequencies as well as vibration mode shapes for various configurations including boundary conditions, laminate orientation, ratio of elastic moduli and height-to-thickness ratio of the composite beams. To formulate the problem, a one-dimensional displacement-based finite element method is employed. All of the possible vibration modes including flexural and torsional modes, and coupled flexural -torsional modes are included in the analysis. The model presented is found to be appropriate and efficient in analyzing free vibration problem of a beam.

FUTURE SCOPE OF WORK

In future, the analysis can be carried out for all types of beams with different materials. The analysis should carried out for symmetrical and un symmetrical sections for different frequencies and different load conditions. It can also be extended to study the effect of offset of shear center and centroid in beams of open sections.

REFERENCES

[1] Jones R M (1975), "Mechanics of Composite Materials", Hemisphere, Washington DC.
[2] Lee J and Kim S E (2001), "Flexural-Torsional Buckling of Thin-Walled I-section Composites", Comput Struct., Vol. 79, No. 10, pp. 987-995.
[3] McGee O G, Owings M I and Harris J W (1993), "Torsional Vibration of Pretwisted Thin-Walled Cantilevered I-Beams", Comput. Struct, Vol. 47, No. l, pp. 47-56.
[4] Ohga M, Takao H and Kara T (1995), "Natural Frequencies and Mode Shapes of ThinWalled Members", Comput Struct, Vol. 55, No. 6, pp. 971-978.
[5] Roberts T M (1987), "Natural Frequencies of Thin-Walled Bars of Open CrossSection", J. Struct Eng., Vol. 113, No. 10, pp. 1584-1593.