Comparative Analysis of Natural Frequencies of Simply Supported Beams

[1]Sathvik Sripad, [2]Siddharth Joshi, [3]Priya Gupta,[4]Simon Jayasingh

[1][2][3][4]VIT University, Vellore,

[1]sathviksripad@gmail.com, [2]siddharthjoshi8810@gmail.com,
[3]priya.gupta2013@vit.ac.in, [4]simon.jayasingh@vit.ac.in

Abstract: — In recent times, understanding the vibration patterns of structures has become very crucial :courtesy the various types of forces, both static and dynamic coming into play. Modal analysis helps to determine the vibrational characteristics of a structure explicitly during its design process. Behavioral tendencies of structures under time dependant loads can at times be tricky as the exact nature of dynamic loadings is difficult to comprehend. Modal analysis has proven to be helpful in our understanding towards many vibrational phenomena that were encountered in practice. In this work, focus has been laid on one structural entity- the beam. Finite elemental analysis was carried out for the beams using ANSYS WORKBENCH as a platform for the same. Simply supported beams made up of structural steel, Carbon Fiber Reinforced Polymer(CFRP) and Glass Fiber Reinforced Polymer(GFRP) with both fibers aligned at zero degree inclinations were fabricated under ANSYS Workbench platform simulated under modal analysis. Results were duly compared with respect to the natural frequencies and deflections produced in the three types of beams.

Keywords: -- Natural frequency, Modal Analysis, Finite Elemental Analysis, Deflection

I. INTRODUCTION

There are many dynamic forces that act on a structure at a given time. These dynamic forces bring about vibrations in the structure. Vibration analysis is very important as it helps to design a structure subject to dynamic loads. If the external frequency is equal to the natural frequency, then the structure resonates and very severe damages can be caused. The knowledge of natural frequency helps us to make changes in the material properties and hence evade the resonance condition[1],[2]. The design of the structure becomes safer as dynamic loading is also taken into account. Hence it is very important to analyze the vibration properties.

In this work, 6 meters long beams were duly analyzed. The materials chosen were structural steel, CFRP and GFRP. Finite elemental analysis was carried out and the natural frequencies of these beams were found using ANSYS as a platform for the same. Natural frequencies upto 6 mode shapes were found. To fabricate the beam properties of composite beams in the software, coding was used to vary properties.

II. OBJECTIVE

The main objective was to compare the natural frequencies of beams having different materials. Finite elemental analysis was carried out using ANSYS WORKBENCH as a platform. The vibrational patterns of these beams were studied and the results were compared. Trend in variation of natural frequencies with different materials was sought after.

III. MODELING OF BEAMS

Modal analysis of beams was carried out using ANSYS12.0 Workbench. Beam was dimensioned as follows- 6000mmx250mmx400mm. First a static structural is created and named, this includes analysis system, engineering data where the material to be used is chosen. In this case we have taken structural steel for analysis , the standard properties of the structural steel are mentioned and can be changed according to the design. The properties include density of steel which is 7850kg/m^3, poisons ratio as 0.3andYoung's modulus as 250GPa. Later, modeling and modal analysis was done for composite beams as well namely- CFRP and GFRP with the properties known beforehand.

Table 1 Summary of Types of Beams to be Analyzed in ANSYS

Dimensions &Properties	Structural Steel	CFRP	GFRP
Length	6000mm	6000mm	6000mm
Width	250mm	250mm	250mm
Depth	400mm	400mm	400mm
Young's Modulus	200GPa	1.50Gpa	26Gpa
Density	$7.8mg/m^3$	$1.5mg/m^3$	$1.8mg/m^3$

After the material and the properties were selected, geometrical modeling was the next step in the design modular. Accordingly the dimensions are assigned and the load only includes the self-weight of the beam.

The beam is modeled in the desired plane and the mesh is created. Simply supported condition is adhered to.
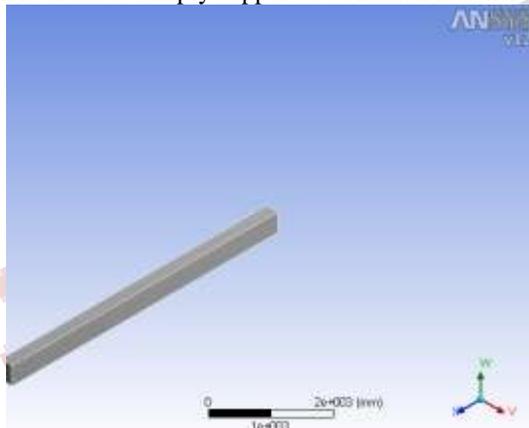

Fig1 Geometrical Model of the Beam assigned to all three types under study- structural steel, CFRP and GFRP beams

IV. CALCULATION OF NATURAL FREQUENCY

After the modeling and analyzing of beams, the natural frequency is calculated for the three beams. We have taken six modes for calculating the natural frequency[6],[7]. These six modes depend on the degree of freedoms. The command for the calculation of natural frequency is given and the natural frequency is calculated.

V. MODAL ANALYSIS

Modal analysis is a tool which is used to basically determine the vibration characteristics of the structure or machine. Explicitly used in the design process, modal analysis can enhance the accuracy of the predictions of the vibrations in all its different modes[8]. It correctly shows variations for different elements with different cross sections and materials with a specific pattern from which we can draw apt conclusions[9]. Modal analysis is very useful when it comes to ensuring safety of structures as it is very essential for the structures natural frequency to not match the frequency of external vibrations. Modal analysis relies its results on the stiffness and mass of the structure through which comparative results are drawn. Bridge design heavily relies on modal analysis . It has been extensively used to calculate the natural frequencies of different beams and duly compare them. Modal analysis carried out by gave the frequencies for six different modes and through ANSYS.
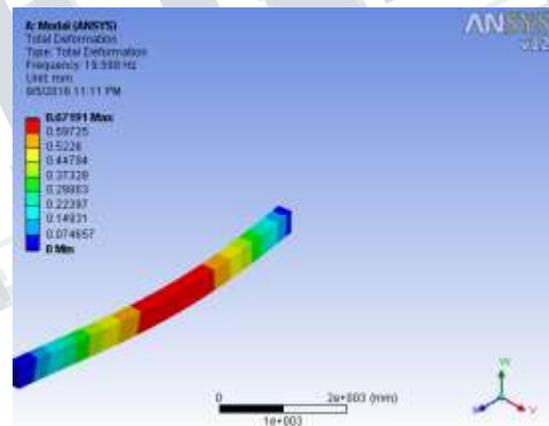
VI. RESULTS AND ANALYSIS

Fig.2 Modal Analysis and deflection pattern of Structural Steel Beam in the First Mode of Resonance

As mentioned, modal analysis was carried out for 6 modes. Fig. 2 represents the simulation for mode 1. The corresponding deflection column is the deflection produced in various parts of the beam during the first mode of resonance.

Table 2 Summary of modal analysis carried out for structural steel beam

Mode	Maximum Deflection(mm)	Natural Frequency(Hz)
1	0.671	19.5
2	0.646	24.8

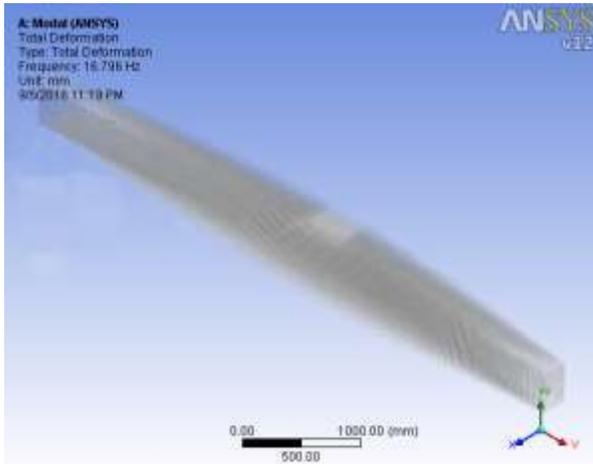| 3 | 0.701 | 67.1 |
4	0.631	91.4
5	0.989	128
6	0.609	149.4

Fig.3 Modal Analysis of CFRP in the First Mode of Resonance

Similar procedure was followed to get the set of natural frequencies and deflections for a beam made up of CFRP.

Table 3 Summary of Modal Analysis carried out for CFRP beam

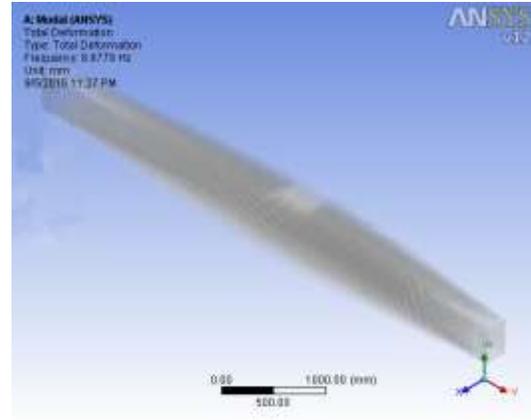| Mode	Maximum Deflection(mm)	Natural Frequency(Hz)
1	0.665	16.7
2	0.645	21.5
3	0.604	57.8
4	0.630	79.3
5	0.956	108.3
6	0.607	128.4

Fig4 Modal Analysis of GFRP in the First Mode of Resonance

Similar procedure was followed to get the set of natural frequencies and deflections for a beam made up of GFRP.

Table 2 Summary of Modal Analysis Carried out for GFRP Beam

Mode	Maximum Deflection(mm)	Natural Frequency(Hz)
1	0.667	8.67
2	0.646	11.13
3	0.691	29.84
4	0.631	40.93
5	0.979	55.05
6	0.607	65.48

VII. CONCLUSIONS

1. Structural Steel showed the maximum deflection of 0.989mm, whereas minimum deflection was shown by CFRP : 0.604mm
2. Maximum natural frequency was recorded by structural steel. It was measured to be 149.4 Hz in the sixth mode of resonance.
3. Minimum natural frequency was recorded by GFRP:8.67 Hz in its first mode of resonance.

REFERENCES

1. G.R GILLICH and I. NEGRU**.** (2012), ''The relationship between changes of deflection and natural frequencies of damaged beams'' Advances

in Remote Sensing Finite Differences and Information Security"

2. O. S. Salawu.(1995)," Detection of Structural Damage through changes in Frequency: a Review" Engineering Structures, Vol. 19, No. 9, pp. 718-723, 1997 © 1997 Elsevier Science Ltd.

3. Norazman Mohamad Nor, Mohd Hanif Ahmad Boestamam, Mohammed Alias Yusof(2013)," Carbon Fiber Reinforced Polymer (CFRP) as Reinforcement for Concrete Beam" International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 2, February 2013)

4. Saeed Ghaffarpour Jahromi ,Parinaz Arashnia(2015)" AN EXPERIMENTAL AND NUMERICAL STUDY ON THE PULTRUDED GFRP I-SECTIONS BEAMS" Proceedings of International Conference on Structural Architectural and Civil Engineering Held on 21-22, Nov, 2015, in Dubai, ISBN:9788193137321

5. M.Hajianmaleki and M. S. Qatu(2013)," Vibrations of straight and curved composite beams: A review" Composite Structures 100 (2013) 218–232.

6. Vipin Kumar[1], Kapil Kumar Singh[2] and Shwetanshu Gaurav[3].(2015), "Analysis of Natural Frequencies for Cantilever Beam with I- and T-Section Using Ansys" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 02 Issue: 06.

7. K. Nguyen and T.V Lien.(2001) "A simplified method for natural frequency analysis of a multiple cracked beam" Journal of Sound and Vibration.

8. Brian J. Schwarz & Mark H. Richardson(1999)," EXPERIMENTAL MODAL ANALYSIS" Vibrant Technology, Inc. Jamestown, California 95327 , CSI Reliability Week, Orlando, FL

9. Aniket Patil, Dr.R.J.Patil(2015)," STATIC AND MODAL ANALYSIS OF IMPELLER" Patil et al, International Journal of Advanced Engineering Research and Studies   E-ISSN2249–8974