RESEARCH PAPER | Engineering | Volume : 5 | Issue : 6 | June 2015 | ISSN - 2249-555X

A STUDY OF FREE VIBRATION ANALYSIS OF FIXED-FREE CONFIGURATION BEAMS USING EMA TECHNIQUE

KEYWORDS: ANSYS, EMA, Fixed-free beam, FFT, Free vibration

Indrajeet J Shinde
Research scholar, Department of Mechanical Engineering, Bharati Vidyapeeth University College of Engineering, Satara Road, Pune, Maharashtra, India

D.B. Jadhav
Assistant Professor, Department of Mechanical Engineering, Bharati Vidyapeeth University College of Engineering, Satara Road, Pune, Maharashtra, India

Dr. S. S. Kadam
Associate Professor and Head, Department of Mechanical Engineering, Bharati Vidyapeeth University College of Engineering, Satara Road, Pune, Maharashtra, India

ABSTRACT *Experimental Modal Analysis (shortened as EMA) is a method to predict the behavior of a system by effectively using the modal or vibration data. It helps in understanding and evaluating the dynamic behavior of a system in actual scenario. In this paper, an attempt is made to study the free vibration analysis of the cantilevered beams of different materials and lengths using the EMA technique. EMA is implemented using the OROS FFT analyzer and NV Gate software to acquire the vibration data of the specimens. The results obtained by experimentation are cross checked using the ANSYS simulation package.*

INTRODUCTION

Phenomena of vibration is very crucial from design point of view. A major concern is given to vibration analysis of a system now a days before implementing it. The intention is to avoid the vibration intuitive malfunctioning or letdowns of the system. The main reasons that the vibration analysis is given a prime importance is due to the fact that the actual working environment and working conditions are changing day by day as the technological advancement is taking place. Also, the considerations of the mass, energy and efficiency of working is constraining the design to be more optimized and system to be light weight [1]. Due to this, it is not acceptable to solely rely on the theoretical approach but to predict the behavior using the experimental way. This is the reason why Experimental Modal Analysis (EMA) has gained popularity in the recent decade. It has become an effective way of recognizing, understanding and forecasting the dynamic behavior of the system [2]. Moreover, it is categorized as the non-destructive testing method that is based on the vibration response of the system or structure. EMA produces a modal model (i.e. a frequency response) that consists of vibration data (frequencies, mode shapes, modal damping etc.) [1]. The natural frequency of the cantilever beam specimen can be theoretically calculated by the equation mentioned below [3]:

$$\omega = \frac{1}{2\pi}(\beta l^2)\sqrt{\frac{EI}{\rho A L^4}} \qquad (1)$$

Where, A is the cross sec' ' area of specimen, L is the length of the specimen, $\beta l \beta l$ is the constant relative to the vibration bound condition, E is the young's modulus of the material, I is the moment of inertia.

In the present work, modal testing is performed on a newly developed multi-configuration beam vibration test setup [4]. Mild steel and aluminum specimens are considered for the study which are experimented using the FFT analyzer and an accelerometer. Figure 1 shows the schematic of testing arrangement [5].

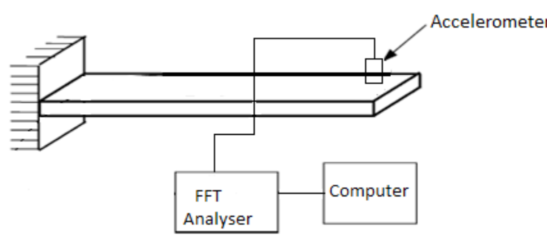

Fig. 1- Block diagram of test setup arrangement [4]

EXPERIMENTAL INVESTIGATION

The beam specimens by varying the materials (M.S and aluminum) and the lengths are used for experimentation. One end of the specimen is fixed in the beam fixture on the setup and other is kept free to get the cantilever (fixed-free) arrangement. The frequency responses are captured using the FFT analyzer and the accelerometer. FFT is of OROS made OR34 having 4 channel input with sigma delta 24 bit ADC. Accelerometer used is a single axis transducer of DYTRAN made (Model 3056B2) having the reference sensitivity of 103.7 mV/g. A wooden mallet is used to excite the natural frequencies of the specimens in order to capture the frequency response (FRFs). FFT hardware is connected to the computer using the NV Gate software provided with the FFT analyzer.

Material Specifications are as mentioned below:

Length- 450mm, 350mm for M.S and aluminum
Width- 50mm
Thickness- 05mm
Material density- 7850 kg/m^3 (M.S), 2700 kg/m^3 (Aluminum)
Young' modulus- 210 GPa (M.S), 75 GPa (Aluminum)

The actual experimenting arrangement is as shown in the figure 2 and a typical FFT response obtained is as shown

Volume : 5 | Issue : 6 | June 2015 | ISSN - 2249-555X

in figure 3. The results are presented in results and discussion point.

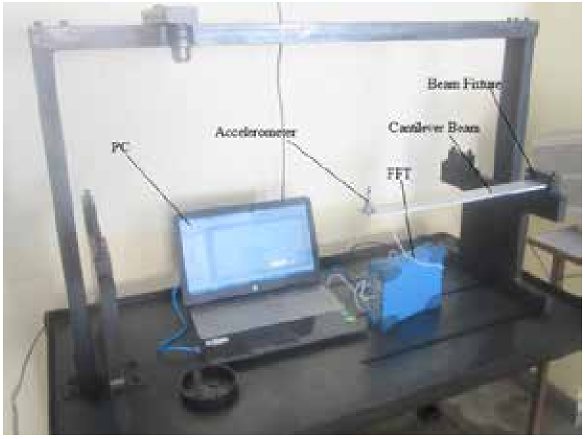

Figure 2- Actual testing arrangement on the setup

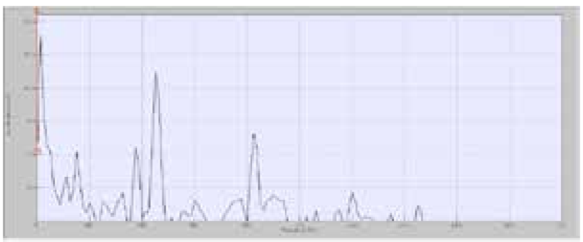

Figure 3- Typical FFT response for mild steel specimen

MODAL ANALYSIS USING ANSYS

Modal analysis is carried in order to validate the results obtained from Experimental modal analysis. For this, ANSYS 14.5 workbench module is used. The beam geometry is modelled using SolidWorks 2012 version and the IGES file is imported in the ANSYS 14.5 workbench module. The necessary material properties like Young's modulus, material density and poissons ratio are inputted in the run. One end of the beam is constrained and other is kept free to achieve the cantilever arrangement. Solid185 element type is implemented to the geometry imported. The geometry is meshed fine with minimum edge length of 0.005m having 4252 nodes and 552 elements. The symmetric block lanczos mode extraction method is implemented and first ten modes are extracted and expanded in the workbench. This is carried out for all the specimens by applying appropriate material properties, boundary condition and by importing the appropriate IGES file to workbench. Figure 4 shows the typical output window obtained from the ANSYS runs.

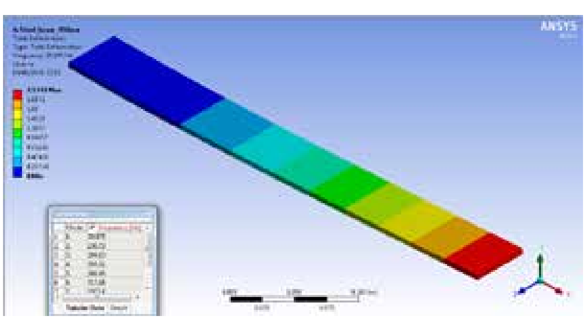

Figure 4- Typical ANSYS response for 450mm M.S beam

RESULTS AND DISCUSSION

Table 1 enumerates the FEA and Experimental Modal Analysis (EMA) values for the first three modes of vibration for 450mm length specimens of M.S and aluminum while table 2 shows the FEA and EMA values for first three modes values for 350mm specimens.

TABLE 1: Results for 450m length specimens

	FOR L=450 mm					
	FEA			Experimental		
	1st Mode	2nd Mode	3rd Mode	1st Mode	2nd Mode	3rd Mode
M.S	21	131	205	22.5	125	212.5
ALU	21.27	133.21	208.72	18.5	112.5	185.5

TABLE 2: Results for 350mm length specimens

	FOR L=350 mm					
	FEA			Experimental		
	1st Mode	2nd Mode	3rd Mode	1st Mode	2nd Mode	3rd Mode
M.S	34.566	216.35	336.71	37.5	175	337.5
ALU	34.737	217.54	340.84	27.5	185.5	325

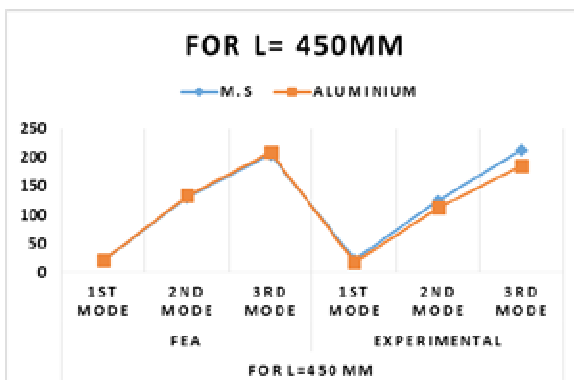

Figure 5- Comparative Graph for 450 mm length specimens

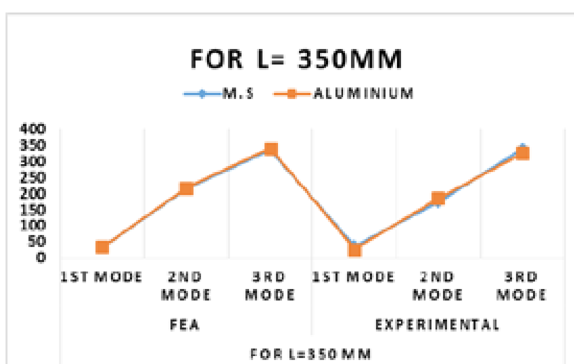

Figure 6- Comparative Graph for 350 mm length specimens

CONCLUSION

Thus, the EMA results are quite in good agreement with the FEA results. Structures can be designed using the data

Volume : 5 | Issue : 6 | June 2015 | ISSN - 2249-555X

in order to avoid the resonance condition. Here the effect of damping is not considered. Also, in this work the non-destructive modal testing method is successfully implemented and there is good agreement in the results. Discrepancies in the result may be due to the approximations, loading effects, material non-homogeneity etc. It is closely observed that the natural frequency of aluminum is slightly higher than the mild steel material in both the cases of lengths considered in the work.

REFERENCE

[1] Nigam V. Oza, Ravi D Patel, 'Predicting Dynamic Behavior of Cantilever Beams using FEA and validating through EMA', International Journal of Engineering Research and Technology (IJERT), Vol. 3 Issue 6, June 2014, pg. 1739-1742. | [2] D. Ravi Prasad and D. R. Seshu, 'A study on dynamic characteristics of structural materials using modal analysis', Asian journal of civil Engineering (Building and housing) Vol. 9, No. 2 (2008), pg. 141-152. | [3] J. P. Chopade, R.B. Barjibhe, 'Free vibration analysis of fixed free beam with theoretical and numerical approach method', International Journal of Innovations in Engineering and Technology, Vol. II/Issue I/February 2013, pg. 352-356. | [4] Indrajeet Shinde, D. B. Jadhav, Dr. S. S. Kadam, Prasad Ranbhare, 'Design and Development of a Multi-Configuration Beam Vibration Test Setup', International Journal of Mechanical Engineering and Technology, Vol. 6 Issue 5, May 2015, pg. 25-33. | [5] Ertugrul Cam, Sadettin Orhan, Murat Luy, 'An analysis of cracked beam structure using impact echo method', NDT&E International 38 (2005), pg. 368-373. |