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Free Vibration Analysis of Cantilever Beam of Different Materials

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Abstract: ***All materials possess sure amount of internal damping which manifested as dissipation of energy from the system. This energy in a vibratory system is either dissipated into radiated away from the system. To study and find the damping in structures made of different materials aluminum, brass, mild steel are still remains as a big task. The main objective of this study is to estimate the natural frequency of aluminum, brass and steel by free vibration analysis experimentally & verify theoretically. Cantilever beam (450mm x 30mm), (400mm x 25mm) and Tapered cantilever beam (450mm x 23mm), (400mm x 20mm) of size are prepared for experimental purpose of free vibration analysis of beams made with different materials such as aluminum, brass and mild steel. The natural frequency of the beams obtained from experimental & theoretical methods will be compared with harmonic analysis using ANSYS software.***

Keywords: Damping, Natural Frequency, Cantilever Beam, Tapered Cantilever Beam, Harmonic Analysis

1. Introduction

It is well known that beams are very common types of structural components and can be classified according to their geometric configuration as uniform or tapered, and slender or thick. It has been used in many engineering applications and a large number of studies can be found in literature about transverse vibration of uniform and non-uniform beams. Free vibration analysis that has been done in here is a process of describing a structure in terms of its natural characteristics which are the frequency and mode shapes. The change of modal characteristics directly provides an indication of structural condition based on changes in mode shapes and frequencies of vibration.

1.1. Vibration

Vibration is the motion of a particle or a body or system of connected bodies displaced from a position of equilibrium. Most vibrations are undesirable in machines and structures because they produce increased stresses, energy losses, cause added wear, increase bearing loads, induce fatigue, create passenger discomfort in vehicles, and absorb energy from the system. Rotating machine parts need careful balancing in order to prevent damage from vibrations. There have been many methods developed yet now for calculating the frequencies and mode shapes of beam. Due to advancement in computational techniques and availability of software.

1.2. Free Vibration

Free vibration is a vibration in which energy is neither added to nor removed from the vibrating system. It will just keep vibrating forever at the same amplitude. Except from some superconducting electronic oscillators, or possibly the motion of an electron in its orbit about an atomic nucleus, there are no free vibrations in nature. They are all damped to some extent.

1.3. Forced Vibration

Forced vibrations occur when the object is forced to vibrate at a particular frequency by a periodic input of force. The tendency of one object to force another adjoining or interconnected object into vibrational motion is referred to as a forced vibration.

1.4. Damping

Damping is the resistance offered by a body to the motion of a vibratory system. The resistance may be applied by a liquid or solid internally or externally. The main advantage of providing damping in mechanical systems is just to control the amplitude of vibration so that the failure occurring because of resonance may be avoided.

1.5. Natural Frequency

The natural frequency is the rate at which an object vibrates when it is not disturbed by an outside force.

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

where f-natural frequency, k-stiffness, m-mass.

1.6. Mode Shapes

A mode shape is a specific pattern of vibration executed by a mechanical system at a specific frequency. Different mode shapes will be associated with different frequencies. The experimental technique of modal analysis discovers these mode shapes and the frequencies.

1.7 Cantilever Beam

A cantilever is a beam supported on only one end. The beam transfers the load to the support where it has managed the moment of force and shear stress.

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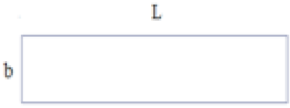

Figure 1: Cantilever Beam

1.8 Tapered Cantilever Beam

A system is said to be a tapered cantilever beam system if one end of the system is rigidly fixed to a support and the other end is free to move.

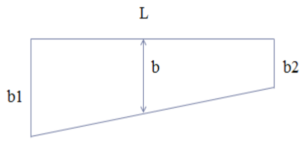

Figure 2: Tapered Cantilever Beam

2. Theoretical Natural Frequency of Cantilever Beam

Title	1st N.F (Hz)	2nd N.F (Hz)	3rd N.F (Hz)
AL1	60.5	379	1061
AL2	45	283	795
BR1	45	284	797
BR2	30.5	190	534
MS1	60	375	1051
MS2	40	252	706

3. Theoretical Natural Frequency of Tapered Cantilever Beam

Title	1st N.F (Hz)	2nd N.F (Hz)	3rd N.F (Hz)
AL1	60	374	1049
AL2	39.78	249	697
BR1	45	283	793
BR2	30	187	524
MS1	59	374	1049
MS2	39.31	246	691

4. Analytical Work (ANSYS)

4.1. Harmonic Analysis

A harmonic analysis is used to determine the response of the structure under a steady-state sinusoidal loading at a given frequency. The harmonic analysis procedure is very similar to performing a linear static analysis.

The steps are specific to harmonic analyses,
1) Attach Geometry,
2) Assign Material Properties,
3) Define Contact Regions,
4) Define Mesh Controls,
5) Include Loads and Supports,
6) Request Harmonic Tool Results,
7) Set Harmonic Analysis Options,
8) Solve the Model,
9) Review Results.

4.2. Harmonic Analysis of Cantilever Beam

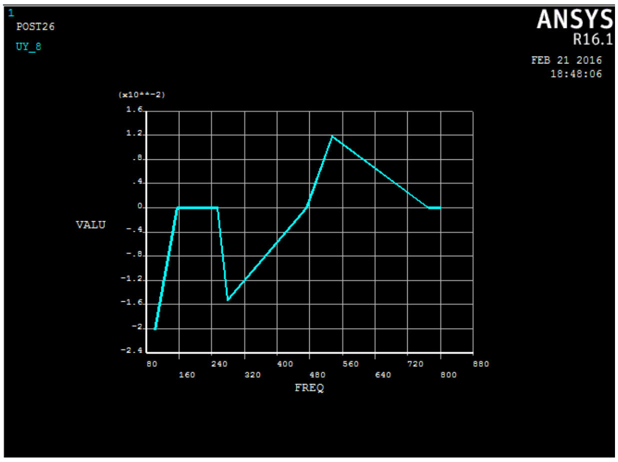

Figure 3: Aluminum 1 (Graph)

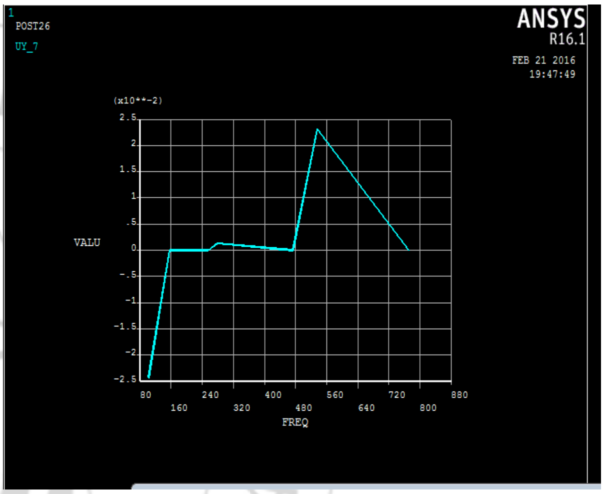

Figure 4: Aluminum 2 (Graph)

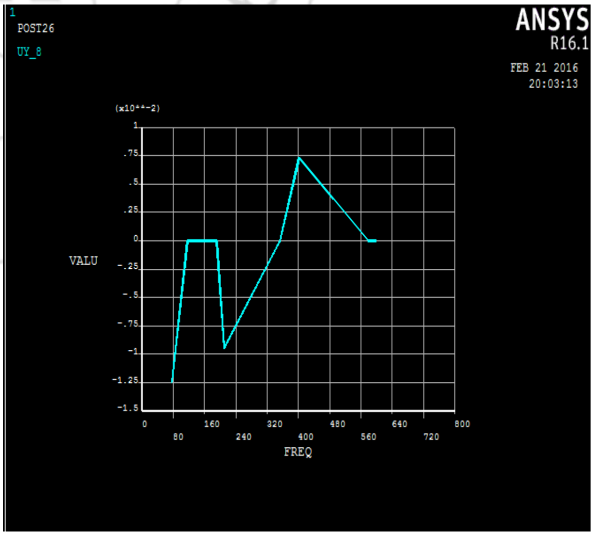

Figure 5: Brass 1 (Graph)

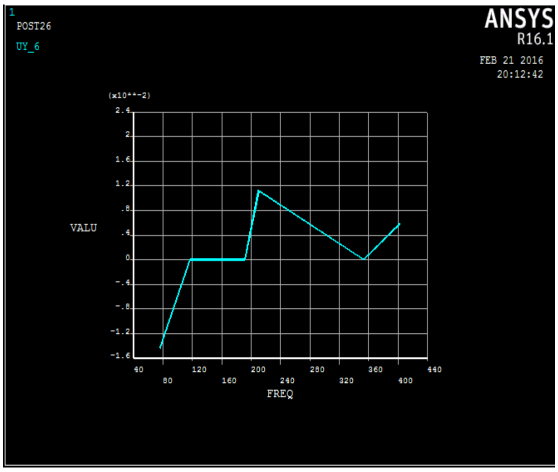

Figure 6: Brass 2 (Graph)

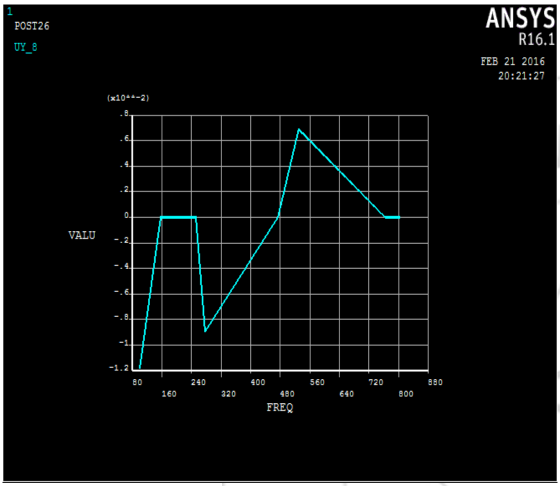

Figure 7: Mild Steel 1 (Graph)

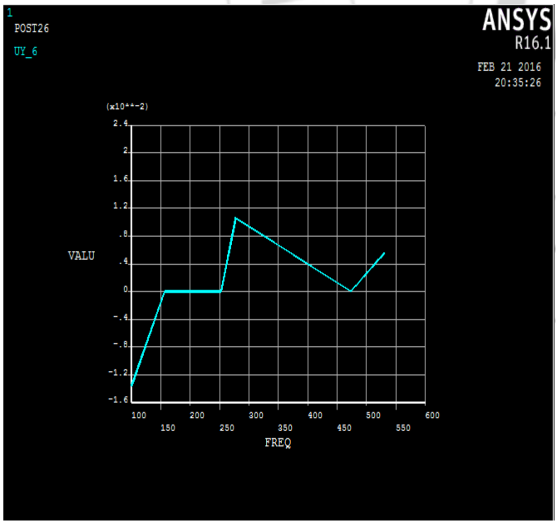

Figure 8: Mild Steel 2 (Graph)

4.3. Harmonic Analysis of Tapered Cantilever Beam

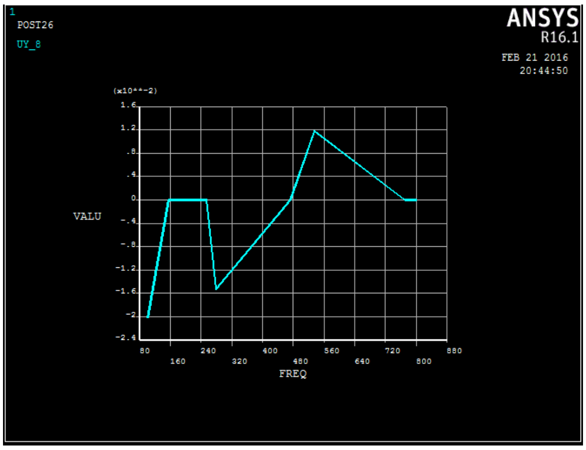

Figure 9: Aluminum 1 (Graph)

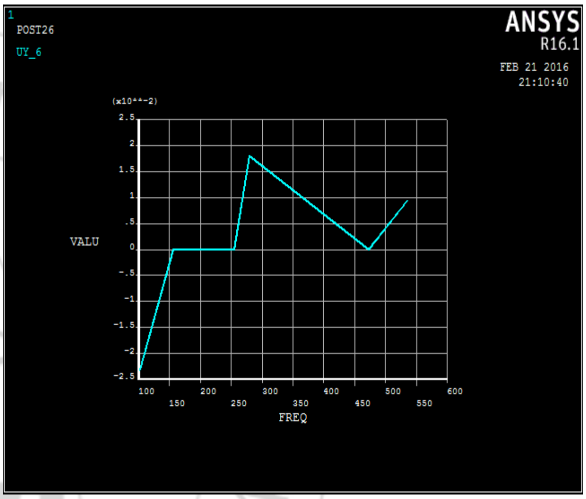

Figure 10: Aluminum 2 (Graph)

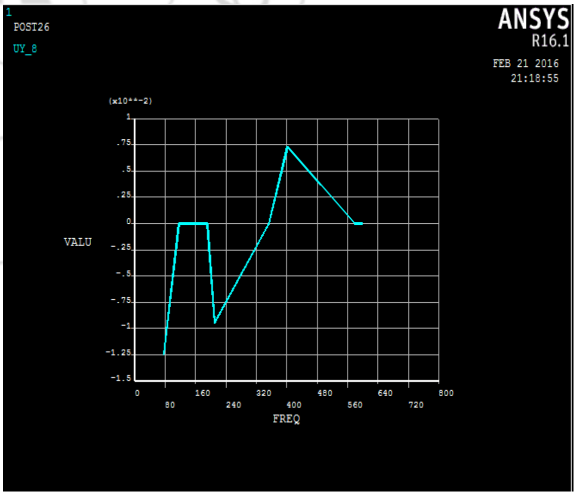

Figure 11: Brass 1 (Graph)

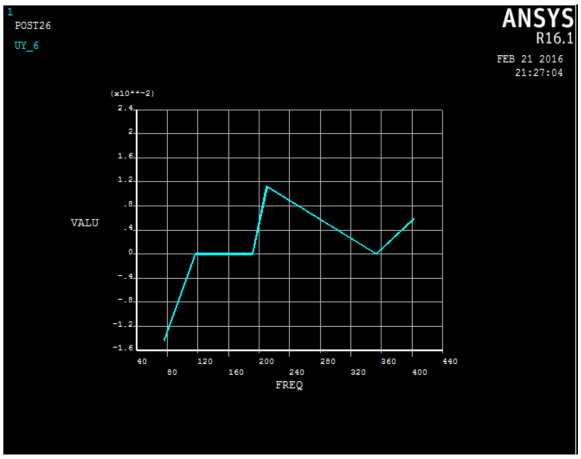

Figure 12: Brass 2 (Graph)

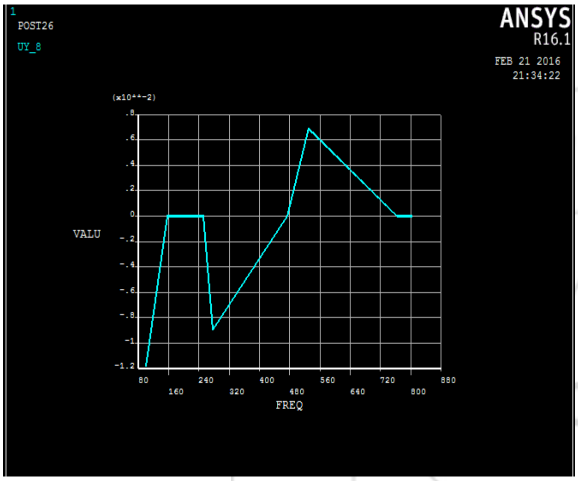

Figure 13: Mild Steel 1 (Graph)

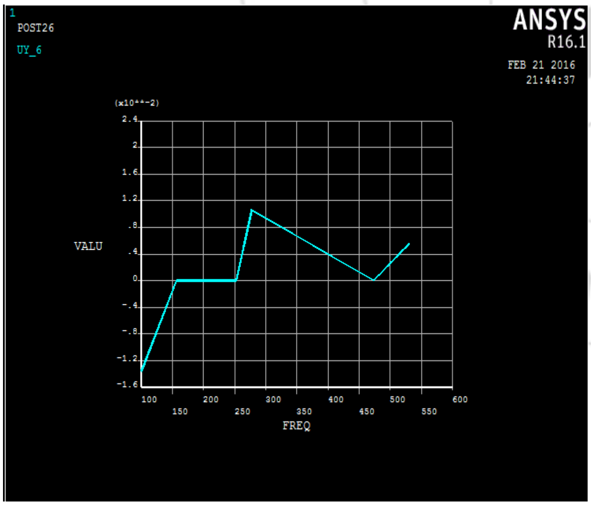

Figure 14: Mild Steel 2 (Graph)

3. Conclusion

The Vibration damping characteristics of beams made up of three different materials i.e. aluminum, brass, mild steel with respect to different parameters like thickness, length, width of the cantilever beam and tapered cantilever beam are studied by theoretical and analytical method by using ansys software. On the basis of present study following conclusion is drawn,

a) The natural frequency increases with decreases in thickness for each material.
b) The Natural frequency of cantilever beam and tapered cantilever beam will be studied by experimental method. Natural frequencies of beams obtained from theoretical and experimental methods will be compared with analytical results.

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