Vibration Analysis and Analytical Calculation of Cantilever Model

Akhilesh N. Smart
M. Tech Student
Vishwakarma Institute of Technology, Pune, India

Abstract— The study of vibration analysis involves plate structure which is treated as a cantilever model for the prediction of its behavior under the action of external excitation. The part of analytical calculation gives degree of closeness between the value of amplitude by ANSYS WORKBENCH and value by manual calculations.

Key words: Cantilever Beam, Forced Vibration, Modal Analysis, Harmonic Analysis

I. Introduction

Vibration is the main concern as far as the every process is consider .Vibrations are fall into both the categories of free & forced. Free vibrations are considered without any consideration of external forces, In the case of forced vibration external agency repeatedly acts on the particular part or geometry. Vibration Analysis generally done with various vibration measurement devices if the practical situations are considered. This paper shows analysis of plate with the use of ANSYS WORKBENCH and justification of the result through manual calculations. The plate with certain thickness has gone through analysis and modifications in thickness of plate have done respectively. Plate thickness is very important as far as the material cost is considered.

Modal analysis has become a major technology in the quest of determining, improving and optimizing dynamic characteristics of engineering structures. The system will vibrate at one or more of its natural frequency which are properties of the system dynamics, established by its stiffness and mass distribution [1]. All the Vehicles, aircraft and home appliances structures are made up of fixed beam with one end free or combination of fixed beam so it is necessary to study fixed beam vibration [1].

II. Theory

The cantilever beam is an extremely useful model for electronic spring connectors .The equations that govern the behavior of straight cantilever beam with rectangular cross sections are extremely simple. There is also linear relationship between the force and deflection of a cantilever beam, as long as the deflection is small and the beam material does not yield .For a deflection at the end of beam perpendicular to the beam axis, the force can be expressed as [2]:

$$F = \frac{3xwxt^3}{4xL^3} x\, d$$

Numerical Analysis using ANSYS

Basic Steps of finite element analysis:

1) Pre Processor (Building the model)
2) Solution (Applying loads and solving)
3) Post Processor (Reviewing the results) [1].

Calculations [3]

The Vibration amplitude can be found out using the following equations,

$$\omega_n = \sqrt{\frac{k}{m}}$$

Where:

ω_n = circular natural frequency (radians per second)

k= stiffness of the beam

m= mass of model (kg)

$$X = \frac{\frac{f}{k}}{\sqrt{(1-r^2)^2+(2x\xi xr)^2}} \quad \ldots\ldots[r = \frac{w}{w_n}]$$

Where:

X = Amplitude of the vibration.

ξ = Damping Ratio.

r = Ratio of the harmonic force frequency over the undamped natural frequency of the mass.

f = External Force.

k = Stiffness of the beam.

III. Mathematical Solution

For an existing frame

A. *Dimensions – 893 x 774 x 36 mm*

1) *Input Frequency = 400 Hz*

400 x 2π = 2513.47 rad /sec

$$k = \frac{200x10^9 x\, 0.774\, x\, 0.036^3}{4\, x\, 0.893^3}$$

$$= 2.53\ x10^6\ N / m$$

$$\omega_n = \sqrt{\frac{2.53x10^6}{195.577}}$$

$$= 113.73\ rad /sec$$

2) *External Force = 5500 N*

$$d = \frac{5500}{2.53\ x\ 10^6}$$

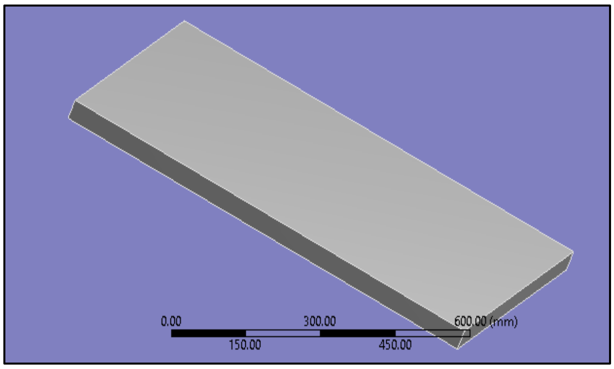
$$= 2.17\ x\ 10^{-3}\ mm$$

$$X = \frac{\frac{5500}{2.53x10^6}}{\sqrt{(1-(\frac{2513.27}{113.73})^2)^2}}$$

$$= 4.45\ x\ 10^{-3}\ mm$$

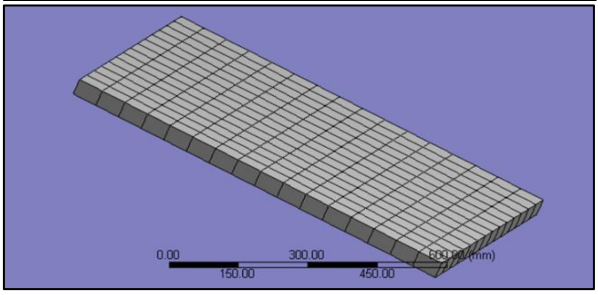
IV. Finite Element Analysis

A. *Model*



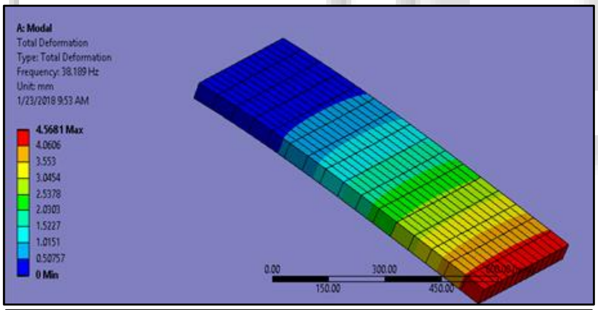
B. *Mesh Strategy*

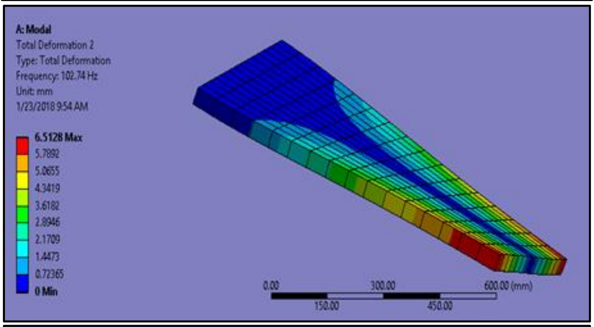
Sizing	
Use Advanced Si...	Off
Relevance Center	Coarse
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge L...	36.0 mm

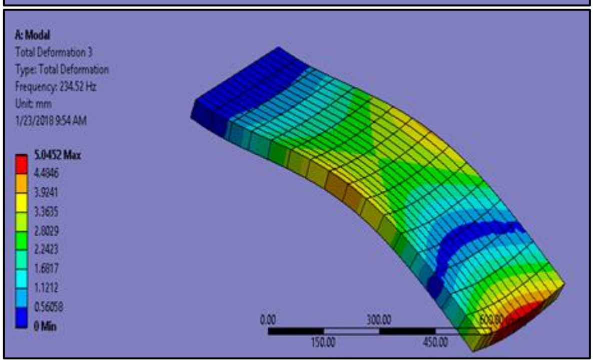


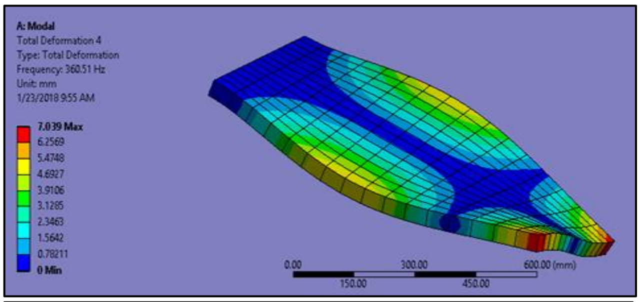
C. *Modal Analysis*

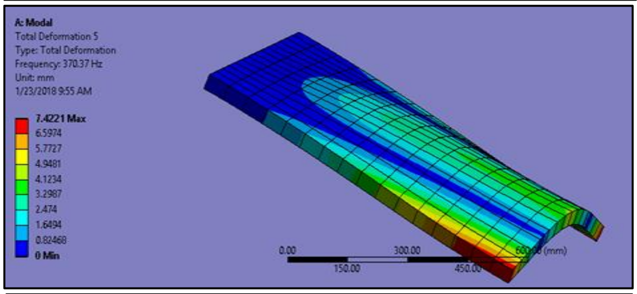
Options	
Max Modes to Find	6
Limit Search to Range	No
Solver Controls	
Damped	No
Solver Type	Program Controlled

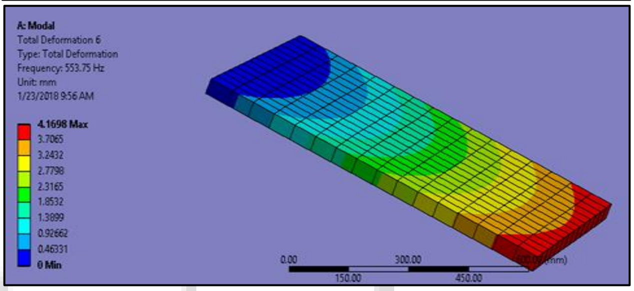








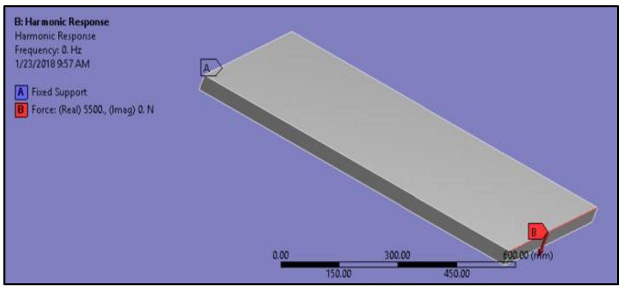




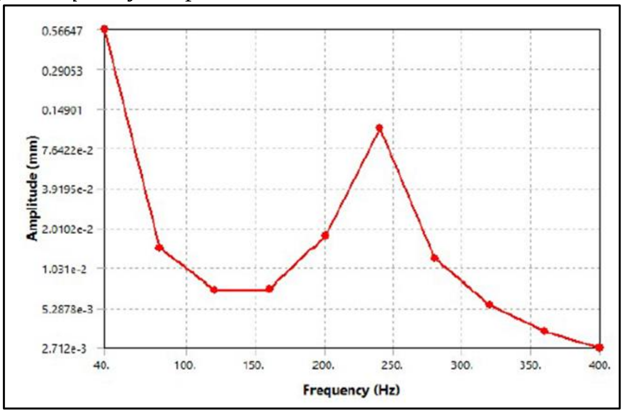
D. *Harmonic Analysis*

Options	
Frequency Spacing	Linear
Range Minimum	0. Hz
Range Maximum	400. Hz
Solution Intervals	10
Solution Method	Mode Superposition
Cluster Results	No
Modal Frequency Range	Program Controlled
Store Results At All Frequencies	Yes

Definition	
Type	Force
Define By	Components
Coordinate System	Global Coordinate System
X Component	0. N
Y Component	0. N
Z Component	5500. N
X Phase Angle	0. °
Y Phase Angle	0. °
Z Phase Angle	0. °



1) *Frequency Response Curve:*



V. RESULTS

1) Amplitude by manual calculation = 0.004 mm
2) Ansys Workbench Output = 0.002 mm

VI. CONCLUSION

The vibration calculations gives nearmost value with that of use of ANSYS WORKBENCH ,From modal analysis we can predict the accurate frequency for the work ,Harmonic response for the frequency 0-400 Hz has been studied . Variation of displacement amplitude (frequency response) with respect to frequency has been graphically plotted. Manual calculations are possible for specific geometries rather than complicated one.

Manual Calculations are totally depends on mass, stiffness, damping conditions. Vibration measurement or analysis at a particular location can be done through software help because everytime doing calculations is not preferable.

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