International Journal of Research in Engineering, Science and Management
Volume 4, Issue 7, July 2021
https://www.ijresm.com | ISSN (Online): 2581-5792

Numerical Investigation for Mass Loading Effects on Natural Frequencies of Thin Plate

Ayush Kumar[1], Anuj Yadav[2*], Hirendra Singh[3]
[1]*M.Tech. Student, Department of Mechanical Engineering, Naraina College of Engineering and Technology, Kanpur, India*
[2]*Department of Mechanical Engineering, National Institute of Technology, Patna, India*
[3]*Assistant Professor, Department of Mechanical Engineering, Naraina College of Engineering and Technology, Kanpur, India*

***Abstract*: In most experimental investigations, the accelerometer mass effect is neglected since the accelerometer mass is small in comparison to the mass of the test construction. When a lightweight construction is examined, however, this impact is noticeable. The goal of this research is to see how mass affects thin plate vibration. The characteristics of interest were the natural frequency and its associated mode shape. Using finite element analysis, the thin plate simply supported boundary condition was studied. The mass was added to the plate and distinct sites were chosen for mounting. The mass has a considerable influence on certain of the structure's modes, while it has no effect on others, according to the findings. The mass, which was placed at the plate's highest deflection point, revealed significant variations in natural frequencies and their associated mode shapes. For the mass mounted at the nodal line of the specific mode, there are no notable changes in natural frequency or mode shapes. The influence of mass is found to be dependent on the position of the mass, the vibration mode, and the magnitude of the mass.**

***Keywords*: ANSYS, mode shape, natural frequency, finite element method.**

1. Introduction

Machineries nowadays are considerably larger and better than in the past, allowing for quicker and broader performances, which emphasizes the necessity of analyzing vibrations generated by these machines. A machine on a large floor functions in the same way as a concentrated point mass on a plate does. Furthermore, the machinery must be mounted on a plate for a variety of practical reasons. Because of the quantity of single concentrated point mass, its location, or numerous concentrated point masses and their positions, these natural frequencies of a plate might alter depending on the boundary circumstances. These frequency changes in different modes are now crucial to know for engineering design in order to avoid plate resonance. Lighter structures are ones that use significant deflection to increase the load bearing capacity of the components, allowing the load to be carried largely in tension. The form of the structure is dictated by the applied load, which is calculated by an optimization procedure. Cable, membrane, shell, thin plate, and folded structures are examples of lightweight structures. Because the extra mass puts an additional load to the structure, transducer effects on a structure are also known as "mass loading." Several authors [1]-[4] Addressed and examined several approaches for analyzing linear and nonlinear vibrations of plates with various geometry and boundary conditions. The free vibrations of a plate with a single lumped mass attachment were studied by Cha et al. [5]. They assumed that the structure was linear elastic and that the boundary conditions were simply supported. The frequencies of a plate stiffened by any number of arbitrarily dimensioned and directed rectangular beams were studied by Xu et al. in [6]. Using various approaches such as the precise solution [7-8], some studies investigated the free vibration of rectangular plates with an elastic or rigid single concentrated mass connected to the plate. The aim of this paper is to find out the effects on natural frequencies of a mass attachment at an arbitrary location in a thin aluminum alloy simply supported plate. For the investigation of dynamic characteristics, a numerical approach is considered and ANSYS Workbench software is used.

2. Finite Element Analysis Using ANSYS

Finite element techniques are currently widely utilized in engineering analysis, and their use is expected to grow considerably in the next years. Finite element methods are used widely in the study of solids and structures, as well as heat transport and fluids, and are helpful in nearly every aspect of engineering analysis. A three-dimensional model of a thin aluminum alloy plate (Fig. 1) having dimensions 2000×1000×10 mm is developed in a design modular ANSYS workbench.

The plate is made up of aluminum alloy having density of 2770 Kg/m^3 and Young's modulus 71GPa. The mass of the plate is 55.4 Kg and an additional point mass of 5 Kg is attached to the plate at arbitrary locations to find out the effects on natural frequencies. Now the model is meshed with Hex20 type element and meshed model is shown in (Fig. 2). The total

*Corresponding author: anujyadav0693@gmail.com

number of nodes and elements are 23003 and 3200 respectively. The simply supported boundary conditions are applied to the plate and 5 Kg of additional point mass attached at desired locations. Finally, the natural frequencies of plates are obtained in Hz.

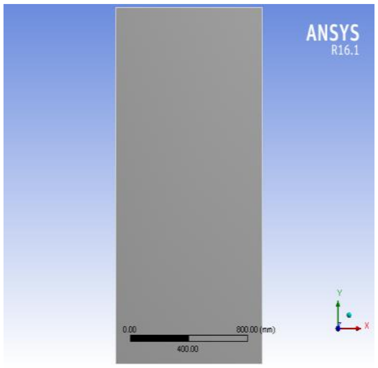

Fig. 1. 3D plate model

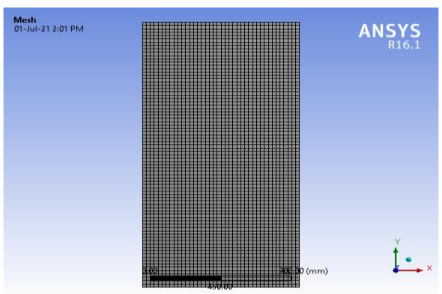

Fig. 2. Mesh model

3. Results and Discussion

Case I: The natural frequencies of plate without adding mass for five different modes are shown in Table 1. Mode shapes of plate are shown in (Fig. 3, 4, 5).

Table 1
Natural frequencies of plate without adding mass

MODE SHAPE	FREQUENCY (Hz)
1	30.337
2	48.481
3	78.799
4	103.220
5	121.270

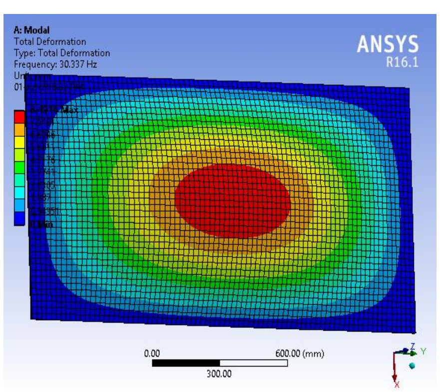

Fig. 3. Mode 1

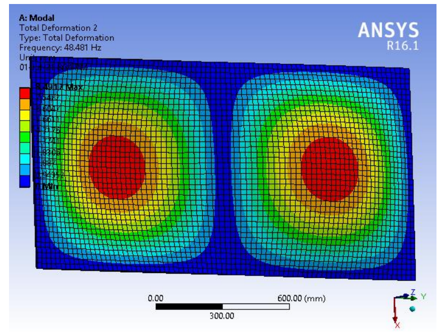

Fig. 4. Mode 2

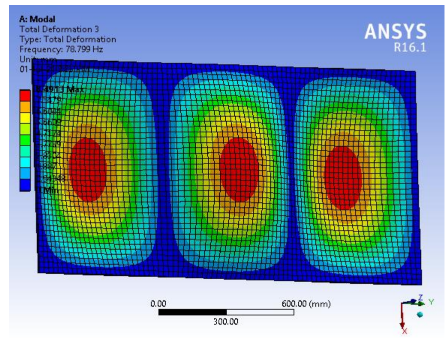

Fig. 5. Mode 3

Case II: The natural frequencies of plate after adding 5 Kg mass at plate midpoint (500, 1000) mm for five different modes are shown in Table 2. Mode shapes of plate after adding mass are shown in (Fig. 6, 7, 8).

Table 2
Natural frequencies of plate after adding mass at midpoint.

MODE SHAPE	FREQUENCY (Hz)
1	25.746
2	48.479
3	69.249
4	103.210
5	121.250

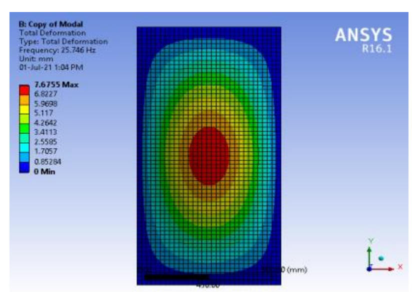

Fig. 6. Mode 1

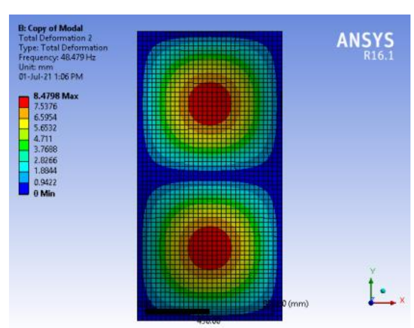

Fig. 7. Mode 2

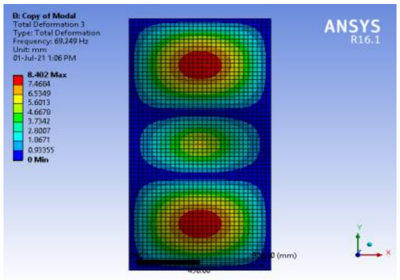

Fig. 8. Mode 3

Case III: The natural frequencies of plate after adding 5 Kg mass at point (250, 500) mm on the plate for five different modes are shown in Table 3. Mode shapes of plate after adding mass are shown in (Fig. 9, 10, 11).

Table 3
Natural frequencies of plate after adding mass at point (250, 500)

MODE SHAPE	FREQUENCY (Hz)
1	28.784
2	44.720
3	74.442
4	92.547
5	111.690

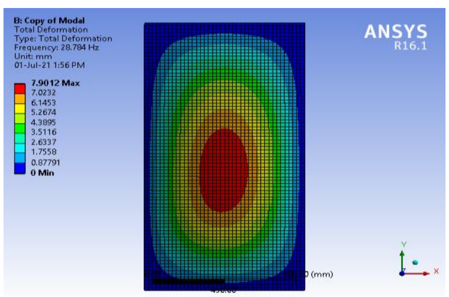

Fig. 9. Mode 1

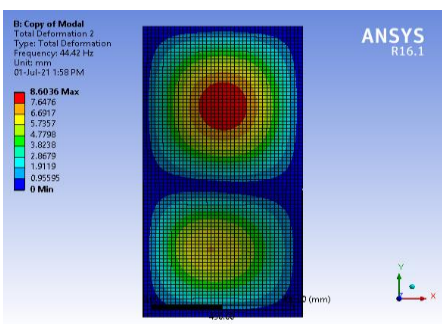

Fig. 10. Mode 2

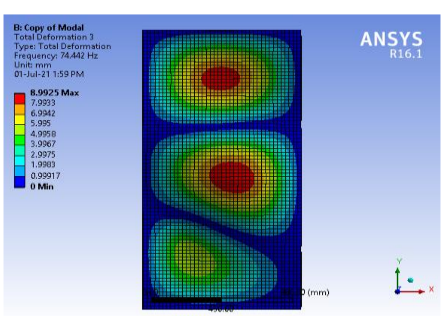

Fig. 11. Mode 3

Case IV: The natural frequencies of plate after adding 5 Kg mass at point (750, 1500) mm on the plate for five different modes are shown in Table 4. Mode shapes of plate after adding mass are shown in (Fig. 12, 13, 14).

Table 4
Natural frequencies of plate after adding mass at point (750, 1500)

MODE SHAPE	FREQUENCY (Hz)
1	28.784
2	44.720
3	74.442
4	92.547
5	111.690

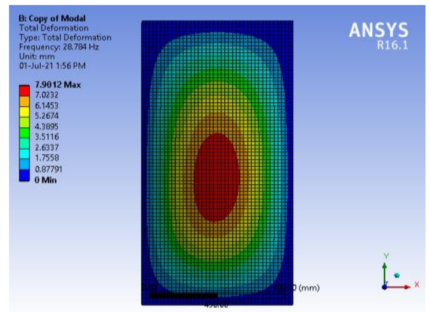

Fig. 12. Mode 1

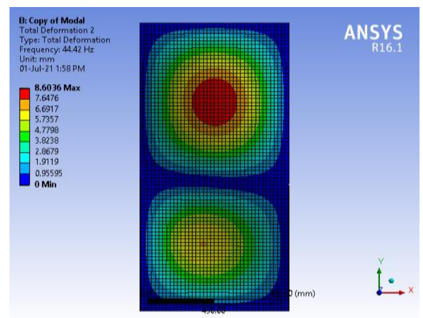

Fig. 13. Mode 2

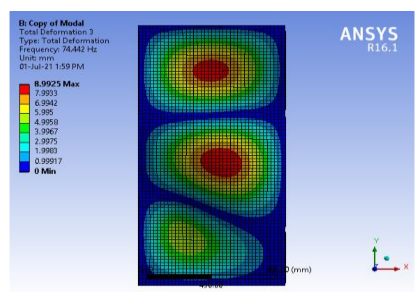

Fig. 14. Mode 3

Case V: The natural frequencies of plate after adding 5 Kg mass at point (1000, 2000) mm on the plate for five different modes are shown in Table 5. Mode shapes of plate after adding mass are shown in (Fig. 15, 16, 17).

Table 5
Natural frequencies of plate after adding mass at point (1000, 2000)

MODE SHAPE	FREQUENCY (Hz)
1	30.337
2	48.481
3	78.799
4	103.220
5	121.270

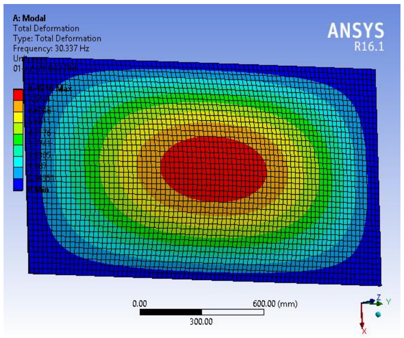

Fig. 15. Mode 1

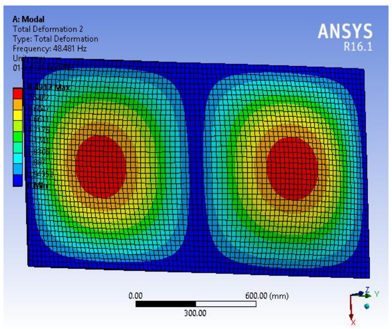

Fig. 16. Mode 2

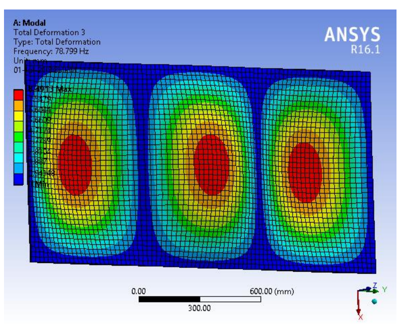

Fig. 17. Mode 3

4. Conclusion

The goal of this research was to look at the influence of mass on thin plate vibration, using natural frequencies and their corresponding mode shapes as the main variables. The findings showed that the mass affects certain of a structure's modes while leaving others unaffected. The natural frequency varies more when a mass is connected near the antinode. As a result, the mode forms for that mode have changed significantly. However, numerical findings indicated that when a mass is mounted near a nodal line of a particular mode of the structure, the natural frequencies of the mode stay constant. As a result, there are no major changes in mode form at this mode.

References

[1] S.S Rao, "Mechanical Vibration," Pearson Education, Inc., Prentice Hall, 2011.
[2] L. S. Srinath, Y. C. Das, "Vibration of beams carrying mass," Journal of Applied Mechanics, Transactions of the ASME, Series E, vol. 34, no. 3, pp. 784-785, 1967
[3] E. Özkaya, M. Pakdemirli, H. R. Öz, "Non-linear vibrations of a beam mass system under different boundary conditions," Journal of Sound and Vibration, vol. 199, no. 4, pp. 679-696, 1977.
[4] K. H. Low, "On the eigen frequencies for mass loaded beams under classical boundary conditions," Journal of Sound and Vibration, vol. 215, pp. 381-409, 1998.
[5] P. D. Cha, "Free Vibration of a Rectangular Plate Carrying a Concentrated Mass," in *Journal of Sound and Vibration*, vol. 207, no. 4, pp. 593–596, Nov. 1997.
[6] H. Xu, "Vibrations of rectangular plates reinforced by any number of beams of arbitrary lengths and placement angles," in *Journal of Sound and Vibration*, vol. 329, no. 18, pp. 3759–3779, Aug. 2010.
[7] A. J. McMillan, A. J. Keane, "Vibration isolation in a thin rectangular plate using a large number of optimally positioned point masses". Journal of Sound and Vibration, vol. 202, pp. 219-234, 1997.
[8] Soedel Werner, "Vibration of Shells and Plate," Marcel Dekker, Inc., New York, 1981.