FREE VIBRATION ANALYSIS OF PERFORATED PLATE

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Abstract

In generally perforated plates are mostly used in industrial application like screening materials, farmhouse acoustics proofing & also in agriculture application. It is also used in nuclear engineering field. The perforated structures usually supported equivalent or a component, and a reactor coolant flows through the perforated plates. In this project we will do free vibration analysis of perforated plate with different penetration pattern like circular, rectangular etc. & changing percentage of perforated region to get different natural frequency & mode shape. In free vibration analysis of perforated plate firstly we take FEA analysis of existing component after that we take FEA analysis of new component which has made by use in structural steel after taking both result compare, if any result are varying in existing and new plate modal then we continue our FEA process with changing the perforated region and thickness of that plate up to that frequency which has suitable for our result. Also carry out experimental analysis on test specimens using FFT analyzer.

Keywords: FFT Analyzer, Finite element analysis, Natural frequency, perforated plate.

1 INTRODUCTION

Basically we see in our surrounding & industrial area we used the perforated plate in large amount, like as pastry and pizza baking tins, building, m/c and system component, also use in modern architecture and design, these are basically used for stairs which has present in platform, industry, house, agriculture sector, cars. The perforated structures are also support to equipment and prevent the machine component from whatever heat has produce by heating equipment.

There are many potential applications where perforated plates should be used. However, the strength and stiffness properties of perforated plate are important. Because perforated structures mostly use in many applications in reactor internals involving different geometries, loading conditions & material, in this paper we increasing the natural frequency of perforated plate by varying the hole diameter as thickness remain same as well as the material also same. We use the structural steel as our material.

II. LITERATURE REVIEW

2.1 Free vibration analysis of perforated plate with square penetration pattern using equivalent material property

By MYUNG JO JHUNG and KYEONG HOON JEONG, the natural frequencies of the perforated square plate with a square penetration pattern are generally obtained as a function of ligament efficiency using the commercial FEA code ANSYS. In addition, they are used to extracting the effective modulus of elasticity under an assumption of a constant Poisson's ratio. The effective modulus of elasticity of total completely perforated square plate is applied to modal analysis of a partially perforated square plate by using a homogeneous finite-element analysis model. The natural frequencies and the corresponding mode shapes are of the homogeneous model are compared with the results of the detailed finite-element analysis model of partially perforated square plate to check the validity of the effective modulus of elasticity. In addition, the theoretical method is to calculate the natural frequencies of a partially perforated square plate with fixed all edges is suggested according to Rayleighe-Ritz method.

2.2 Dynamic response analysis of rectangular perforated plates with varying sizes of circular perforation holes

In this work vibration characteristics of the rectangular perforated plates with varying the sizes of circular perforation holes arranged in the diagonal array are investigated. Natural frequencies of the free vibration of the perforated plates and the corresponding mode shapes are obtained experimentally and numerically. Numerical analysis of dynamic characteristics of perforated plates are carried out using ANSYS, the FEM analysis software package and the experimental analysis is carried out using FFT analyzer, accelerometer and the impact hammer. Parameters defining of the geometry of holes in a perforation array are presented, as well as the ratio of modal resonance frequencies of a perforate to those of a corresponding solid panel, the effective resonance frequency is introduced. The curve fitting technique is utilized to find relationship of the mass remnant ratio with the effective resonance frequency. The functions obtained from curve fitting can be used predict to accurately the effective resonance frequencies of wide range of perforation geometries.

2.3 Finite element analysis of perforated steel plate during compression

Compression of the perforated plate is complicated due to the bending of that plate. Other complexity is of the slip of the plate on the UTM machine. It is very difficult to conduct experimental investigations to get the results. Hence Finite element method is the best tool to analyze such problems as long as it has been validated. In present research work, results have been obtained for the perforated plate with different perforation area, different length of the plate, different shape of perforation area and with various loading ratio. In the present research work the data has been used throughout, has been validated by the prior researcher, who have worked on same type of the plate of different loading ratio, different length and the different shape of perforation area.

III OBJECTIVES

- To compare resonance frequency, damping ratio & material properties of perforated plate.
- To design of perforated plate with different penetration pattern like circular, rectangular, etc. for reducing vibration of perforated plate.
- To get different natural frequency & mode shape by changing percentage of perforated region.
- Obtain highly efficient perforated plate having good environmental and structural properties.
- To design of perforated plate have more higher shear loads and also sustain the characteristics of higher vibration

IV FUTURE SCOPE

The present work having the following scope:

- Performance of perforated plate can be improved.
- Improve the efficiency of perforated plate and also increase natural frequency of perforated plate
- Improve properties of perforated plate such as shear strength and resist high damping ratios such that the perforated plate can be used in industry, farm, and aircrafts.

V. METHODOLOGY

5.1 Modeling

The modeling of the perforated plate was done using CATIA V5R20. The below fig. shows that imported model of perforated plate in ANSYS.

5.2 Finite Element Analysis

Finite Element Method is a numerical method which is used for obtaining the approximate solution of engineering critical problems. In this method, the complex region or body defining a continuum is discretized into simple geometric shapes. When the boundary conditions are applied, a set of linear or nonlinear equations is usually obtained. The solution of these equations gives an approximate solution of the problem. In this work, modal analysis of that plate is performed with an FEA methodology to find out natural modes of vibration. Dynamic frequency response analysis is also performed to find out the localized stresses induced in plate.

5.3 Modal analysis of plain sheet

Modal analysis is a method to describe a structure in terms of its dynamic characteristics, which are frequency, damping and mode shapes. The natural modes of vibration are inherent to a dynamic system and are determined completely by its physical properties and their spatial distributions. in the ANSYS after importing the model from CATIAV5. Then mesh the given model.

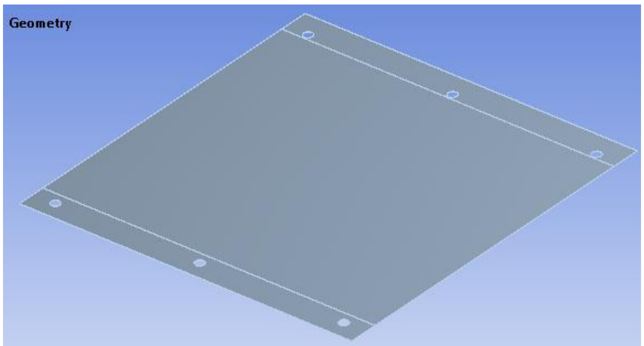


Fig.9 Plain sheet model

	Property	Value
1	Modulus of elasticity	200GPa
2	Poisson's ratio	0.3
3	Density	7.85e-6 kg/mm*3
4	Perforated area	305 x 305
5	Circular hole diameter	8mm
6	Pitch	11.5mm
7	No. of hole	765
8	Thickness	0.6mm
9	Material	Structural Steel

Table 1 material & model property

5.4 Meshing

After assigning the material then meshing is carried out of the model in this model the nodes are 27083 and 3774 are meshing elements in which tetrahedral, hexahedral and wedge type elements. The meshed model is as shown in figure.

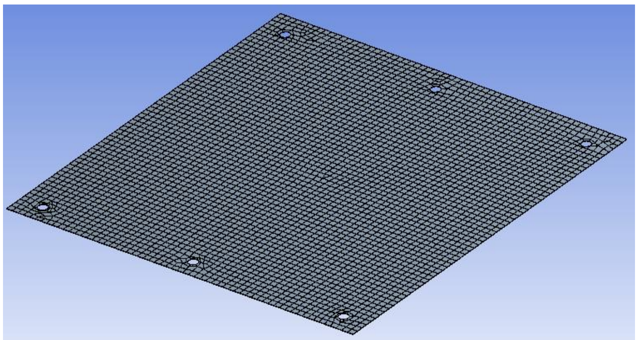


Fig.10 Meshed Model of plain sheet

5.5 Boundary Condition for plain plate

In Plain sheet the boundary conditions are this model is fixed at all end and as shown in given figure.

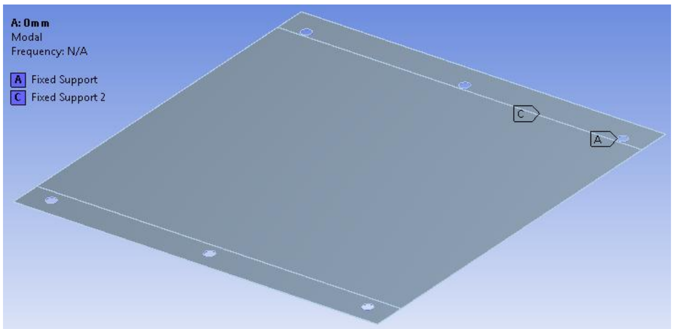
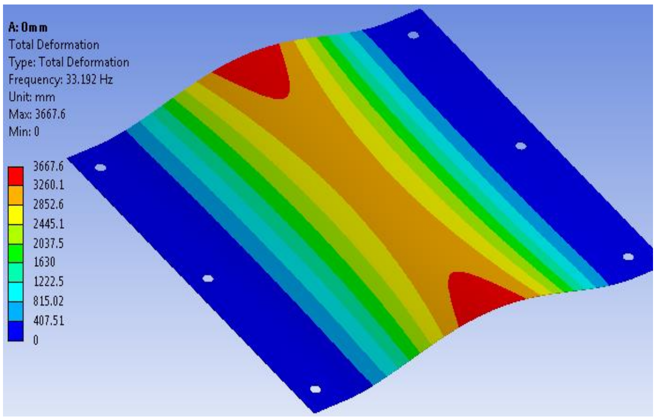


Fig.11 Boundary condition applies for plain sheet

5.6 Natural frequency of plain plate

The natural frequency of plain sheet plate at different modes is shown in figure.



Fig/12 Frequency at Mode1(51.297Hz)

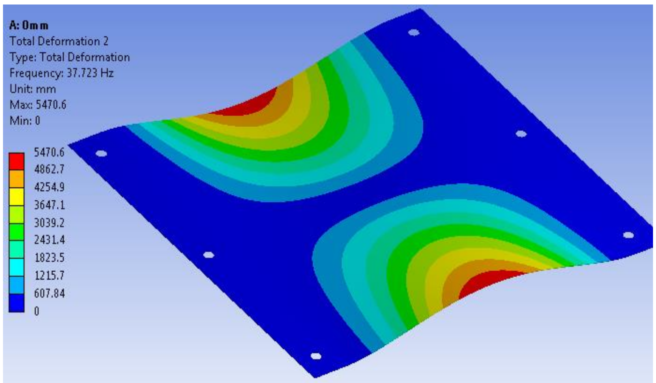


Fig.13 Frequency at Mode 2(104.35Hz)

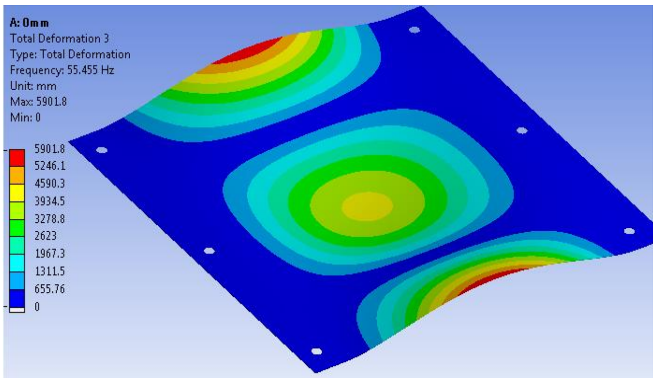


Fig.14 Frequency at Mode 3(104.81Hz)

5.7 Harmonic Response for plain plate

For this the boundary conditions are having acceleration 9.81 mm/s2 and components are 0.,0.,9.81 mm/s2 are shown in given diagram.

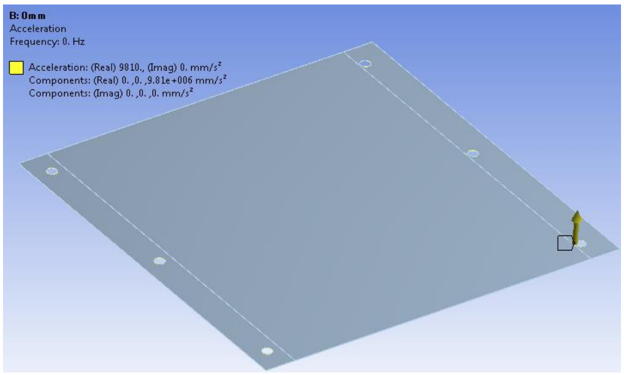


Fig.15 Boundary Condition for Harmonic Response of plain sheet

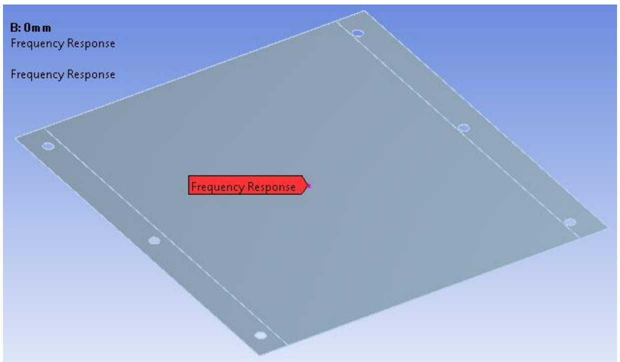
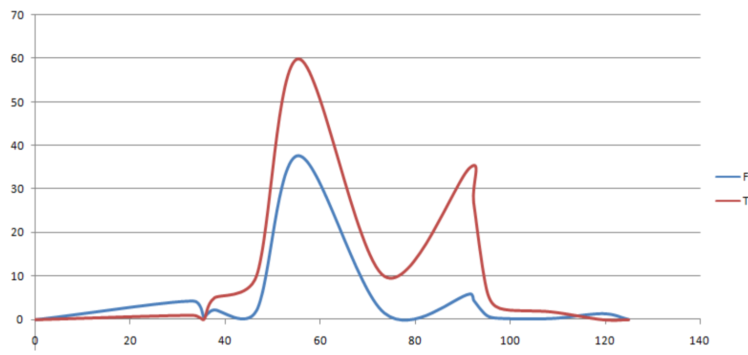


Fig.16 Point at Which Harmonic Response Derived.



Amplitude vs frequency

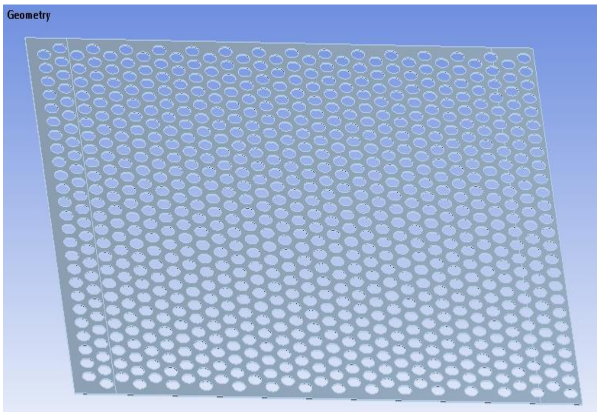
Graph 1 Frequency Response for plain sheet. model.

In given graph of FEA & Experimental frequency response of existing plain plate is shown where the amplitude is maximum at frequency range between 55-60Hz approximately.

Sr. No	FEA Freq.	Amplitude	Test Freq.	Amplitude.
1	33.192	1.067	47.45	4.16
2	37.723	0	54.339	2.03
3	55.452	37	79.634	53

Table 2 Reading For 6mm hole Dia. Plate

5.8 Modal analysis of 8mm perforated plate



Cad part for 8mm hole dia perforated sheet

5.9 Meshing.

After assigning the material then meshing is carried out of the model in this model the nodes are 52125 and 20081are meshing elements in which tetrahedral, hexahedral and wedge type elements. The meshed model is as shown in figure

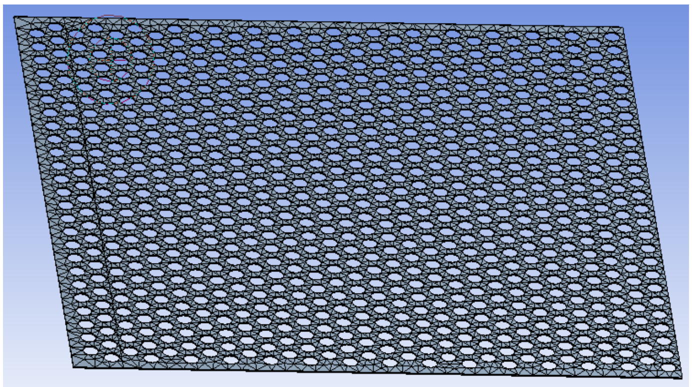


Fig.2 Meshed Model of 8mm plate

5.10 Boundary Condition

Boundary condition for given plate which is 8mm dia. as shown in given figure, which shows that it is fixed at two side at 6 hole end.

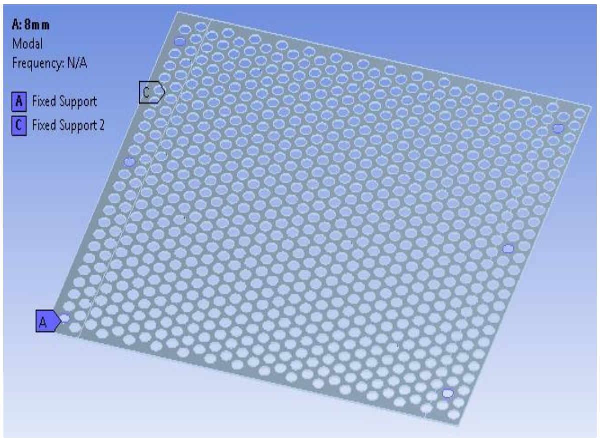


Fig.3 Boundary Condition Apply For 8mm dia. of plate

After meshing and applying boundary condition the results of total deformation are obtained and we can get the frequency in HZ of perforated plate at different mode shapes. These frequencies at different mode shapes are given bellow.

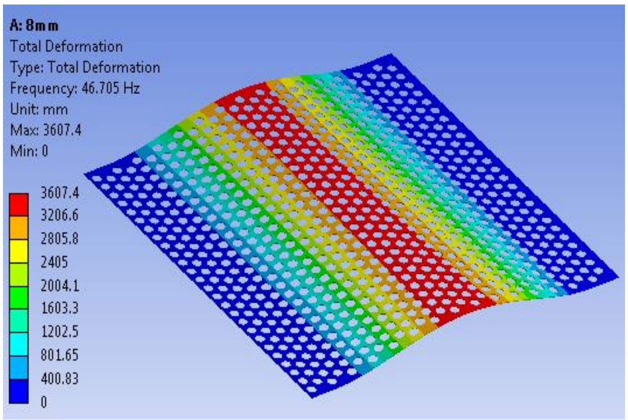


Fig.4 Frequency at Mode 1(46.705Hz)

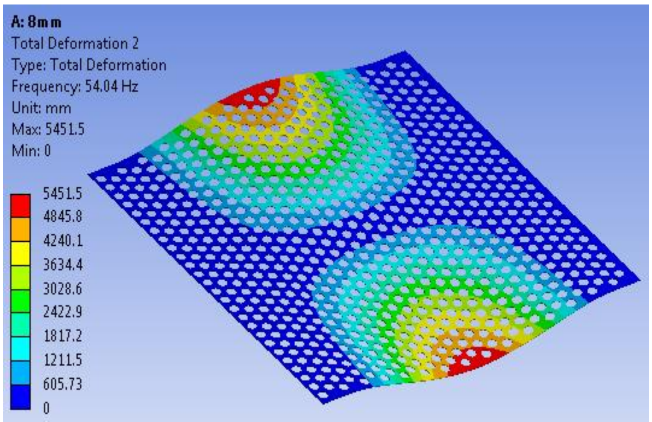


Fig.5 Frequency at Mode 2(54.04Hz)

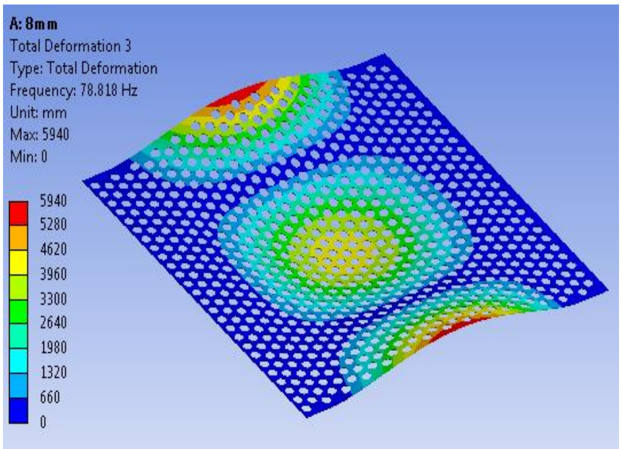


Fig.6 Frequency at Mode 3(78.818Hz)

5.11 Harmonic response of 8mm dia. of perforated plate

For this the boundary conditions are having acceleration 9810 mm/s2 and components are 0.,0.,9.81e+006 mm/s2 are shown in given diagram.

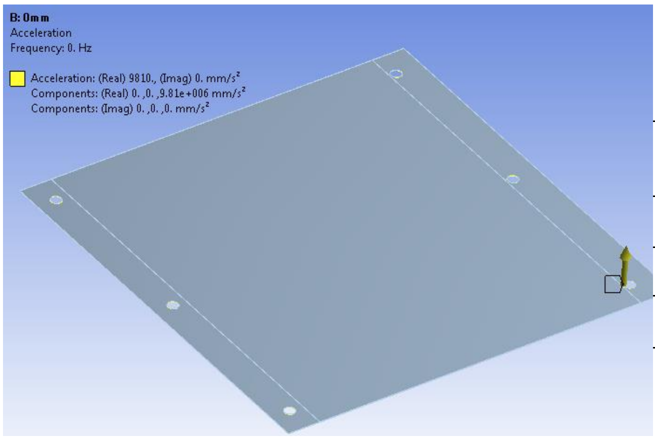


Fig.7 Boundary Condition for Harmonic Response

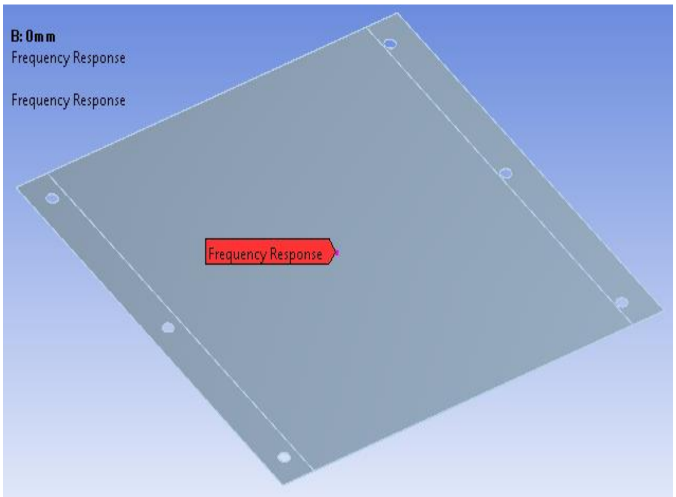
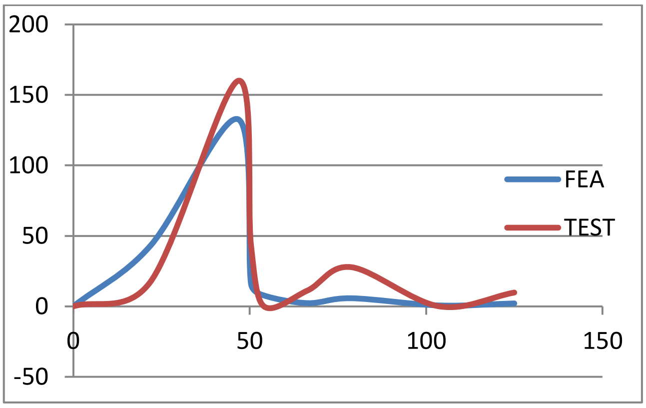


Fig.8 Point at Which Harmonic Response Derived.



Amplitude vs frequency

Graph 2 Frequency Response of 8mm dia. Plate model.

In given graph of frequency response of FEA & Experimental of 8mm dia. Hole of perforated plate is shown where the amplitude of perforated plate is maximum at frequency range between 42.5-44 approximately.

Sr. No	FEA Freq.	Amplitude	Test Freq.	Amplitude.
1	46.705	126.45	46.705	138.67
2	54.04	11.04	54.04	19.75
3	78.818	6.104	78.818	30.03

Table 3 Reading For 6mm hole Dia. Plate

5.12 Modal analysis of 6mm perforated sheet

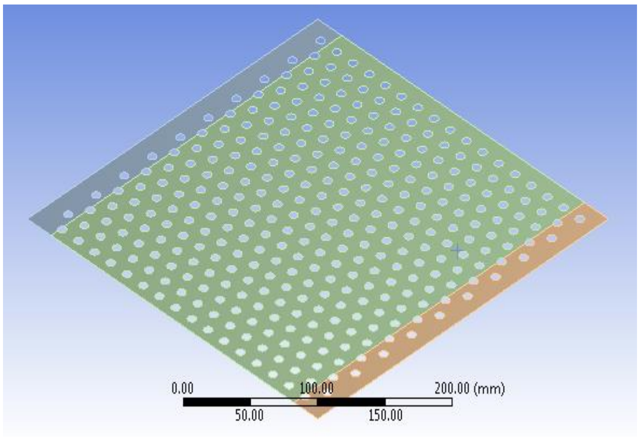


Fig.9 6mm hole dia perforated sheet

5.13 Meshing

After assigning the material then meshing is carried out of the model in this model the nodes are 4770 and 4076 are meshing elements in which tetrahedral, hexahedral and wedge type elements. The meshed model is as shown in figure

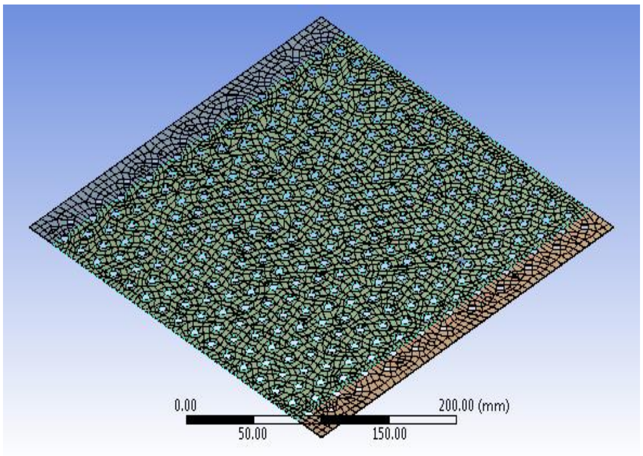


Fig. 10 6mm hole dia perforated sheet meshing

5.14 Boundary Condition

Boundary condition for given plate which is 6mm dia. as shown in given figure, which shows that it is fixed at two side at 6 hole end.

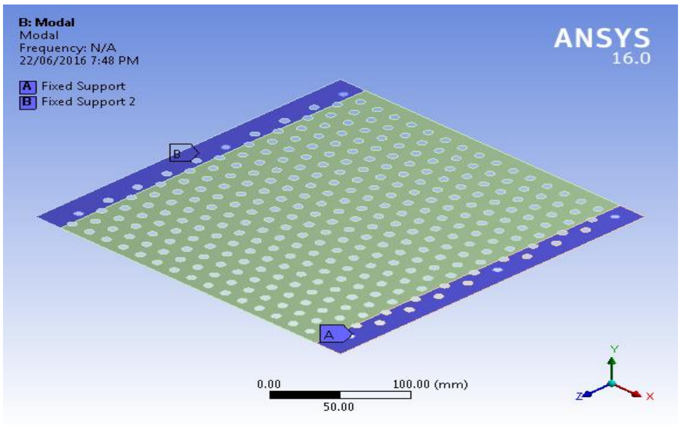


Fig.11 Boundary condition of 6mm hole dia perforated sheet

After meshing and applying boundary condition the results of total deformation are obtained and we can get the frequency in HZ of perforated plate at different mode shapes. These frequencies at different mode shapes are given bellow

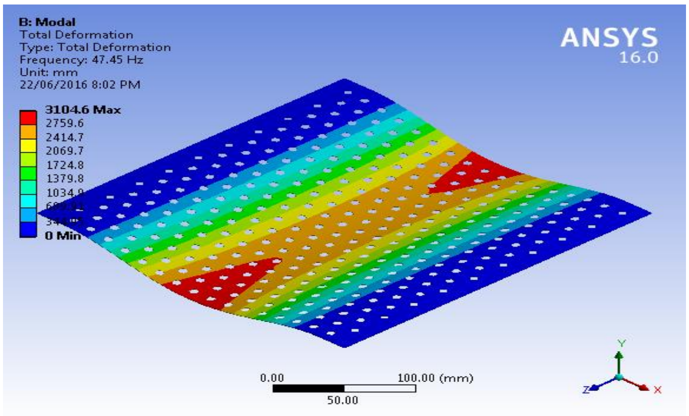


Fig.12 Frequency at Mode 1(47.45Hz)

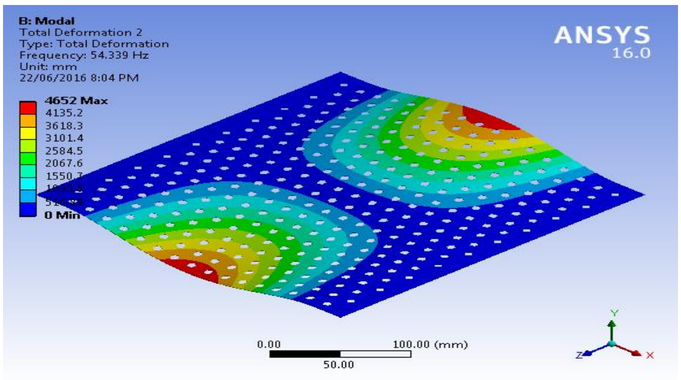


Fig.13 Frequency at Mode 2(54.339Hz)

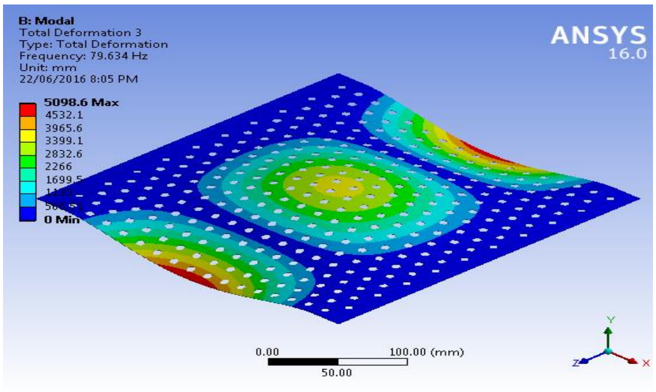


Fig.14 Frequency at Mode 3(78.818Hz)

5.15 Harmonic response of 6mm dia. of perforated plate

For this the boundary conditions are having acceleration 9810 mm/s2 and components are 0.,0.,9.81e+006 mm/s2 are shown in given diagram.

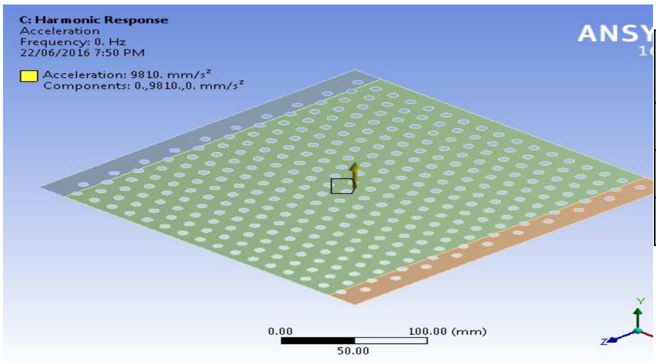


Fig.15 Harmonic response acceleration of 6mm hole dia. perforated plate

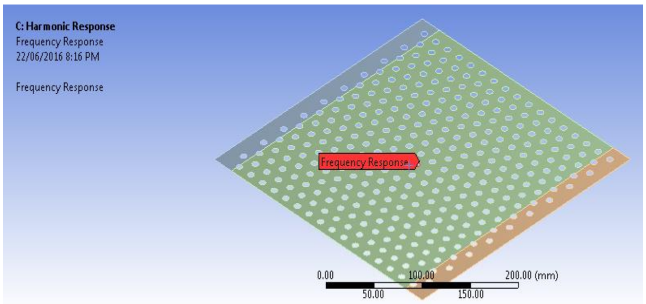
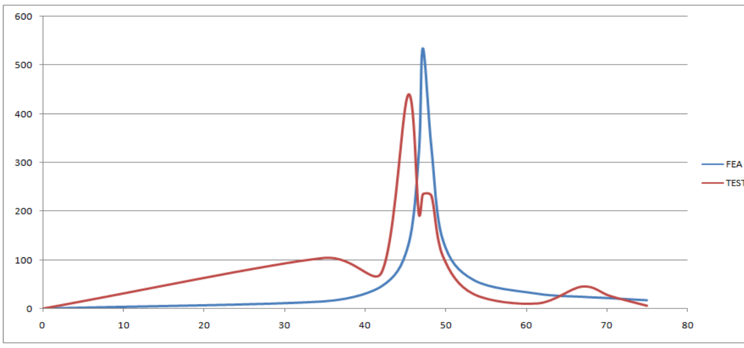


Fig.16 Point at Which Harmonic Response Derived.



Amplitude vs frequency

Graph 3 Frequency Response of 6mm dia. Plate model.

In given graph of frequency response of FEA & Experimental of 6mm dia. Hole of perforated plate is shown where the amplitude of perforated plate is maximum at frequency range between 45-48 approximately.

Sr. No.	FEA Freq.	Amplitude	Test Freq.	Amplitude.
1	47.45	315.59	47.45	320.45
2	54.339	70.58	54.339	50.72
3	79.634	0	79.634	0

Table 4 Reading For 6mm hole Dia. Plate

VI. RESULTS AND DISCUSSION

From the given results of model analysis of plain sheet model, 8mm hole dia. model & 6mm hole. Dia. model of perforated plate it is clear that the value of natural frequency are differ from plain sheet, 8mm hole dia. & 6mm hole dia. sheet, it is clear that by creating hole on perforation model, the natural frequency is varying and it is efficient and good for reducing the vibration in perforated plate. The comparison of natural frequency in plain & 8mm hole dia. of plate model is shown in given table.

Sr. No	FEA Freq.	Amplitude	Test Freq.	Amplitude.
1	33.192	1.067	47.45	4.16
2	37.723	0	54.339	2.03
3	55.452	37	79.634	53

Table 2 Reading for Plain Plate

Sr. No	FEA Freq.	Amplitude	Test Freq.	Amplitude.
1	46.705	126.45	46.705	138.67
2	54.04	11.04	54.04	19.75
3	78.818	6.104	78.818	30.03

Table 3 Reading For 8mm hole Dia. Plate

Sr. No.	FEA Freq.	Amplitude	Test Freq.	Amplitude.
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2	54.339	70.58	54.339	50.72
3	79.634	0	79.634	0

Table 4 Reading For 6mm hole Dia. Plate

Table 3Comparison of frequency of plain, 8mm & 6mm sheet

VII CONCLUSION

In this way we conclude that in modal analysis of perforated plate, by varying the hole diameter of the perforated plate and taking material (Structural steel) we increasing the natural frequency of that plate. By above result we reduce the vibration and noise as well as it is beneficial for heating purpose

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