Modal Analysis of a Square Plate with Different Shape Cut Out

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ABSTRACT

This Modal analysis is a major technique to determine the vibration characteristics of engineering structures and its component's. It is a process by which the natural frequencies, mode shapes of the structure can be determined with a relative ease. It should be a major alternative to provide a helpful contribution in understanding control of many vibration phenomena which encompasses in practice. In this work comparison of the natural frequency of the square plate with different cross sectional cut out is found by using FEA .The main objective of this paper is to determine the natural frequency and mode shape of a square plate with different shape cut outs. The area of cut out of different shapes is maintained same.

Keywords: *Natural frequency, mode shapes, FEA*

A. INTRODUCTION

The paper aims to calculate the natural frequencies and accompanying mode shapes of the plate which are the key parameters when considering noise and acoustic parameters. To determine these parameters modal analysis will be used.

Vibration problems are often occurred in mechanical structure. It is important to prevent such problems because it can cause structures damage by fatigue. The structure itself has a certain properties so it is necessary to understand its characteristics. In this work a modal analysis by finite element method is used.

The main purpose of modal analysis is to study the dynamic properties of structures like natural frequency and mode shapes. This can also be used for some purposes such as, troubleshooting i.e. direct insight into the root cause of vibration problems, find structural flexibility properties quickly to monitor incremental structural changes, design optimization-design according to noise and vibration targets, enhance performance and reduce component and overall vibration & fast, test based evaluation of redesign for dynamics etc. So it is important to determine dynamic properties of a square plate of mild steel material. First the modal analysis of a square plate is done by finite element analysis software method.

Modal analysis is a method of determining the natural acoustic characteristics or dynamic response of materials.

The analysis involves imposing an excitation into the structure and finding the frequencies at which the structure resonates (when the excitation and vibration response match). A typical modal analysis will return multiple frequencies each with an accompanying displacement field which the structure experiencing at that frequency. Each frequency is known as mode and displacement field is known as mode shape. In this work the free vibration responses of a square mild steel plate with different circular cut outs at the centre and subjected to different boundary conditions is tabulated and analyzed.

B. PROBLEM DEFINITION:

A square plate of (50X50)mm planar area is considered for analysis. Thickness of the plate considered is 2mm. The plate is then subjected to different cut outs i.e circular, rectangular, square. All the cut out areas are maintained same so that the weight of the square plate remains same for all the cases The boundary conditions for the plate with different cut outs is kept same i.e all the four corners of the plate are constrained in all DOF Four different square plates of above mentioned dimensions is considered with all four corners completely fixed in all DOF. A cut out of 400mm2 on the square plate is considered.

The geometry of square plate without hole, with circular cut out, square cut out, rectangular cut out is shown in figures from fig1 to fig4.
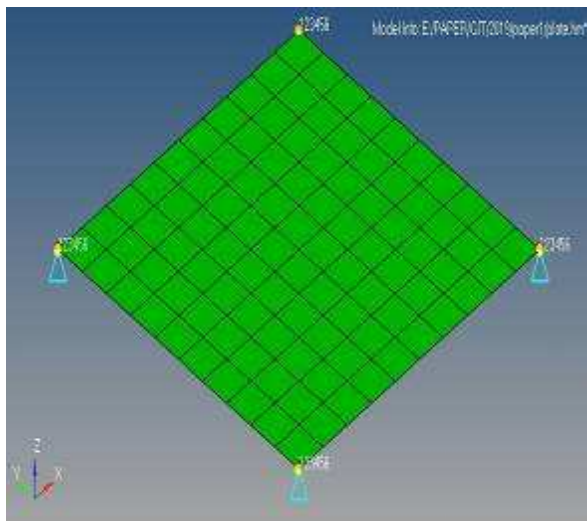
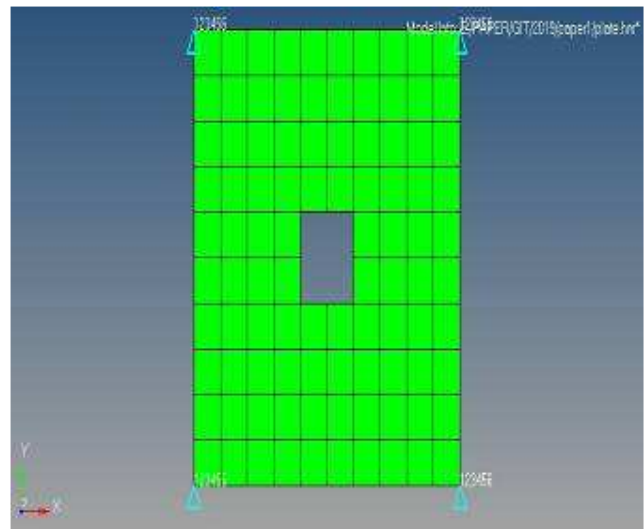Fig.1 Square plate without cut out
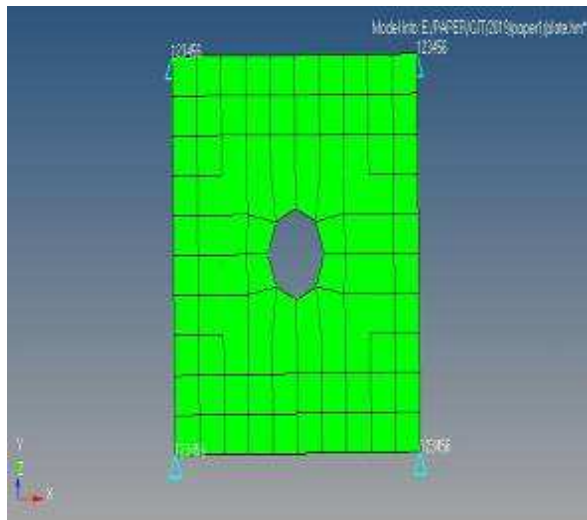

Fig.3 Square plate with square cut out

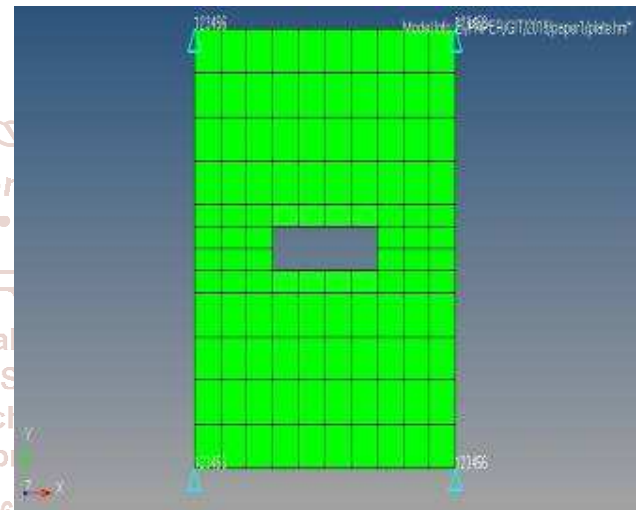Fig.2 Square plate with circular cut out

Fig.4 Square plate with rectangular cut out

C. RESULT ANALYSIS:

The modal analysis of all the plates with different cut outs is carried out and the results are tabulated as shown in below table.

Mode Shape .No	Without hole	With circular hole	With square hole	With rectangular hole
1	1229	1218	1215	1181
2	2389	2386	2383	2346
3	2389	2386	2383	2382
4	2856	2760	2750	2697
5	5499	5356	5343	5154
6	5507	5412	5412	5404

Table1: Natural frequencies of plate with different cutouts for 6 mode shapes.

Mode shapes of Square plate without cut out
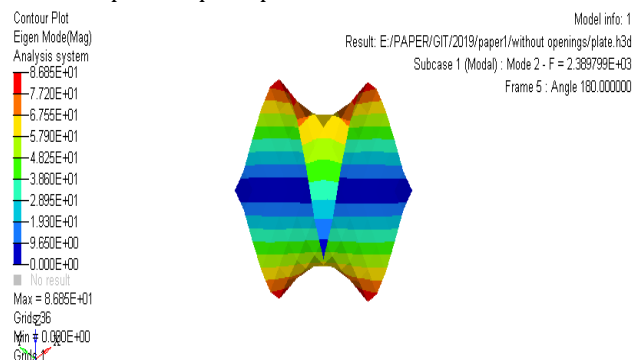
Fig 5 Mode shape 1with Natural frequency 1229
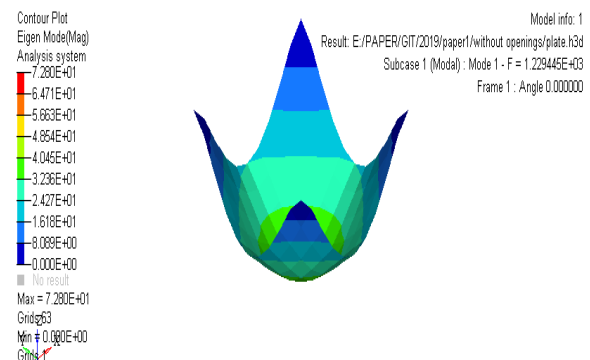
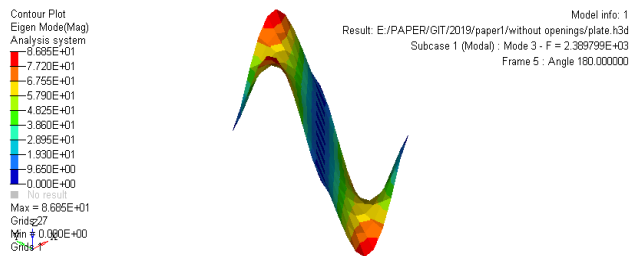Fig 6 Mode shape 2 with Natural frequency 2389

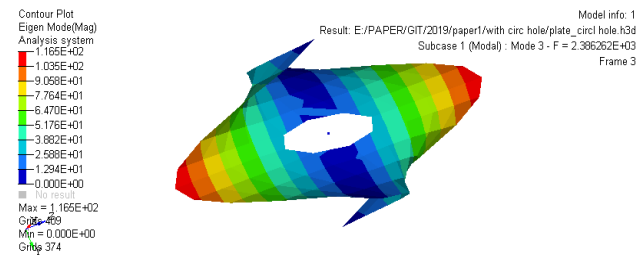Fig.7 Mode shape 3 with Natural frequency 2389

Fig.13 Mode shape3 with Natural frequency 2386
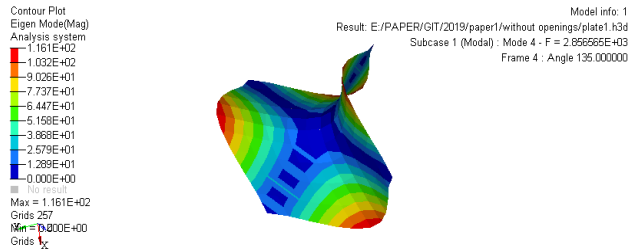

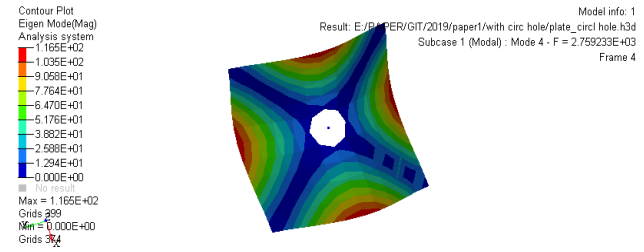Fig.8 Mode shape 4 with Natural frequency 2856

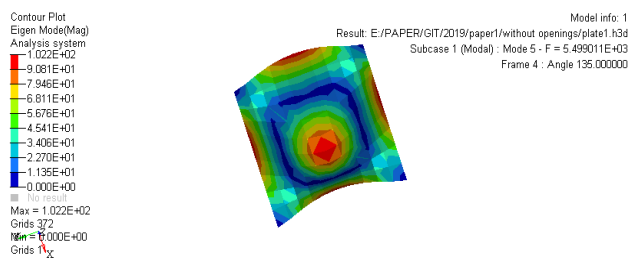Fig.14 Mode shape4 with Natural frequency 2760

Fig.9 Mode shape 5 with Natural frequency 5499
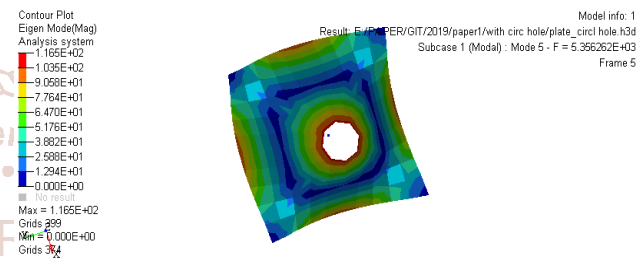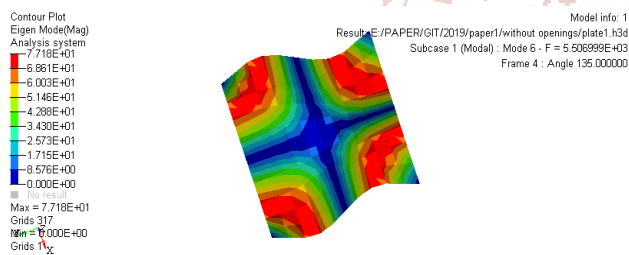

Fig.15 Mode shape5 with Natural frequency 5356

Fig.10 Mode shape 6 with Natural frequency 5507

Fig.16 Mode shape6 with Natural frequency 5412

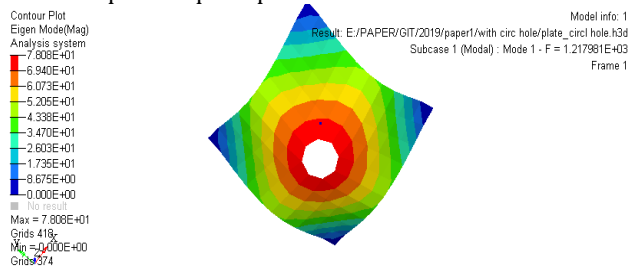Mode shapes of Square plate with circular cut out

Mode shapes of Square plate with square cut out

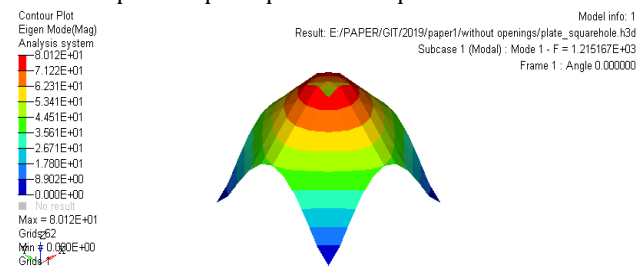Fig.11 Mode shape1 with Natural frequency 1218

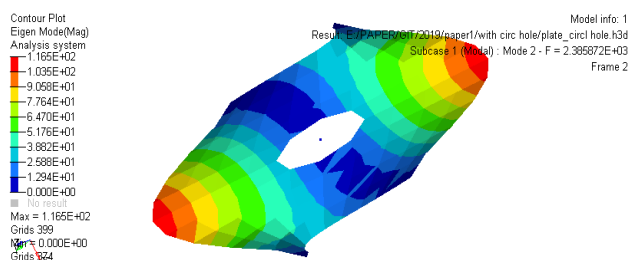Fig.17 Mode shape1 with Natural frequency 1215

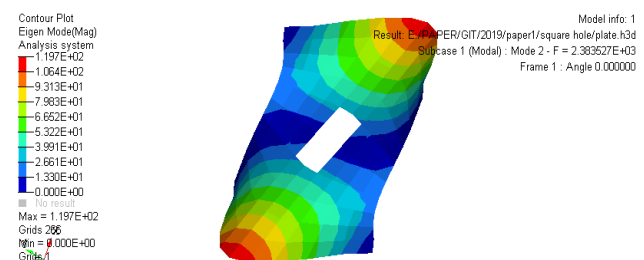Fig.12 Mode shape2 with Natural frequency 2386

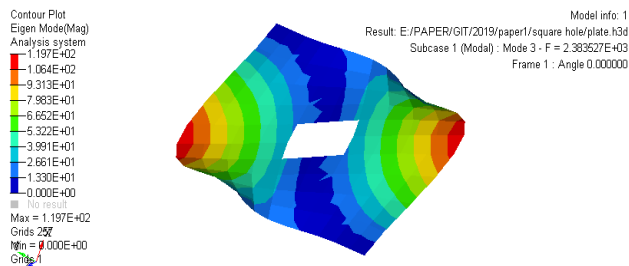Fig.18 Mode shape2 with Natural frequency 2383

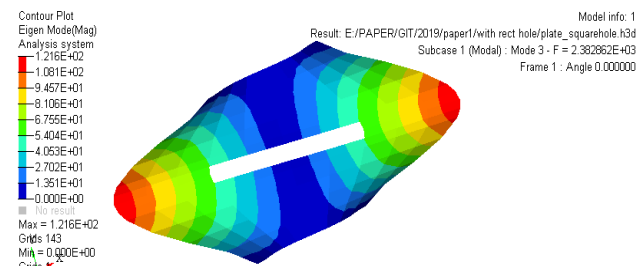Fig.19 Mode shape3 with Natural frequency 2383

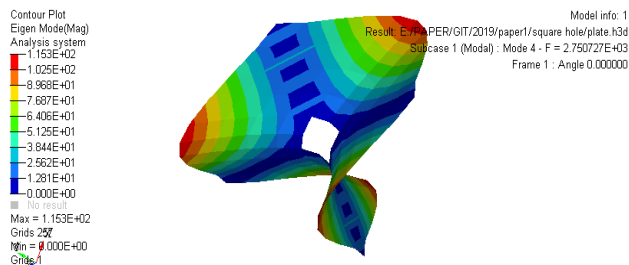Fig.25 Mode shape3 with Natural frequency 2382

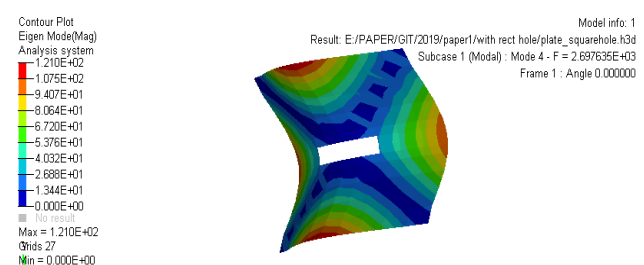Fig.20 Mode shape 4with Natural frequency 2750

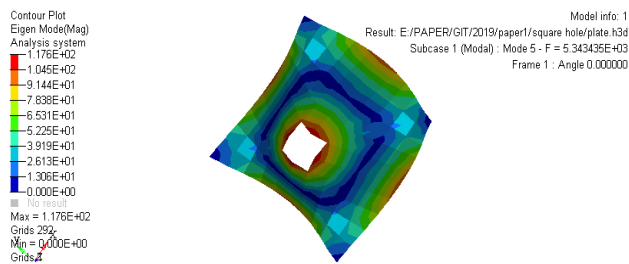Fig.26 Mode shape4 with Natural frequency 2697

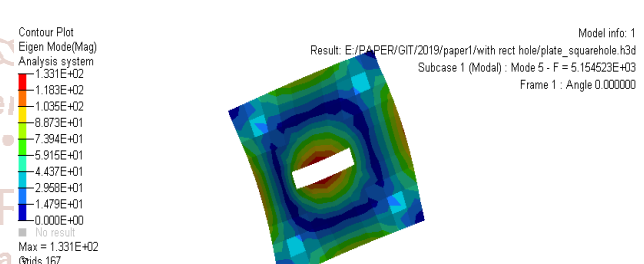Fig.21 Mode shape5 with Natural frequency 5343

Fig.27 Mode shape 5with Natural frequency 5154
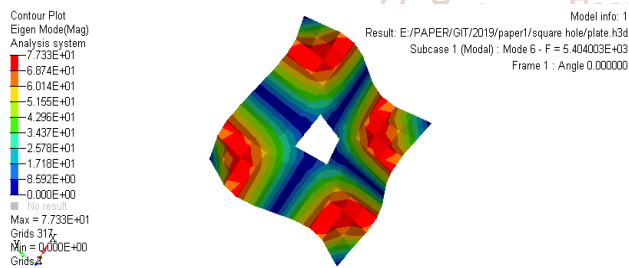
Fig.22 Mode shape6 with Natural frequency 5404
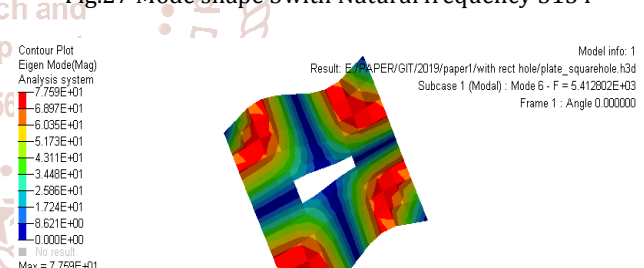
Fig.28 Mode shape6 with Natural frequency 5412

The bar chart showing the variation of natural frequency in each mode for different cut out shapes is shown in the below figures.
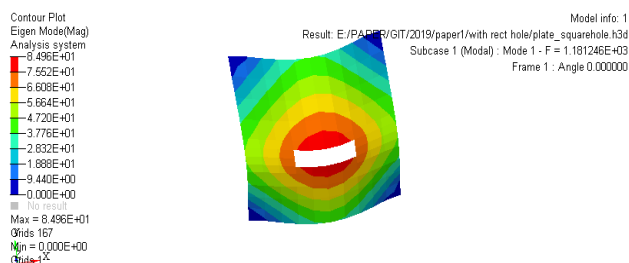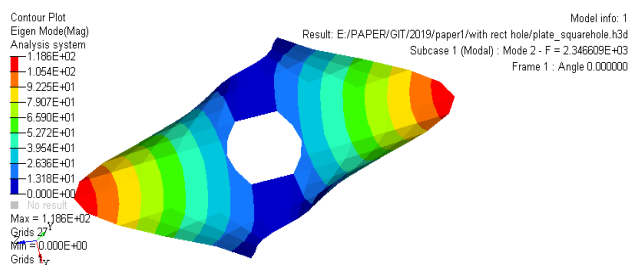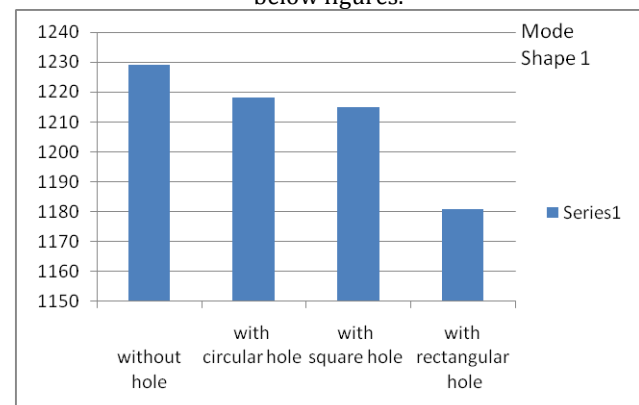

Fig.23 Mode shape1 with Natural frequency 1181

Fig.24 Mode shape2 with Natural frequency 2346

Fig.29 Variation of natural frequency for Mode shape 1
It has been observed that for mode shape 1 the natural frequency is decreasing.

Fig.30 Variation of natural frequency for Mode shape 2
It has been observed that for mode shape 2 the natural frequency is decreasing.

Fig.31 Variation of natural frequency for Mode shape 3
It has been observed that for mode shape 3 the natural frequency is decreasing.

Fig.32 Variation of natural frequency for Mode shape 4
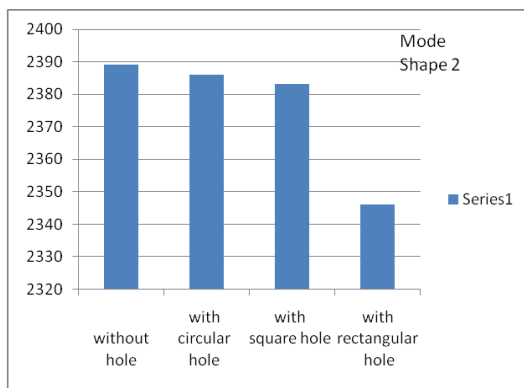It has been observed that for mode shape 4 the natural frequency is decreasing.

Fig.33 Variation of natural frequency for Mode shape 5
It has been observed that for mode shape 5 the natural frequency is decreasing.

Fig.34 Variation of natural frequency for Mode shape 6
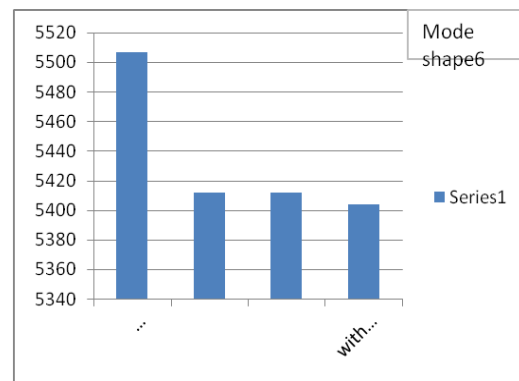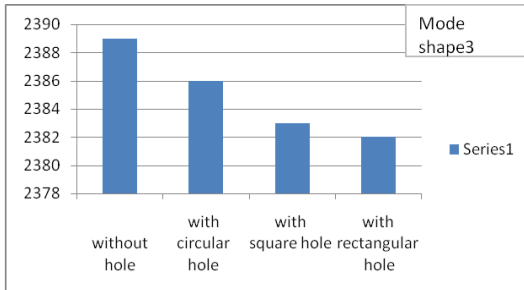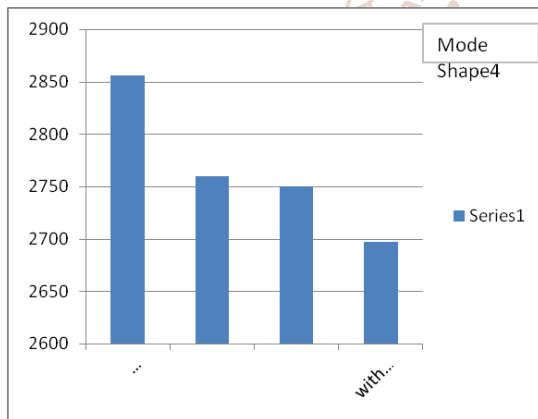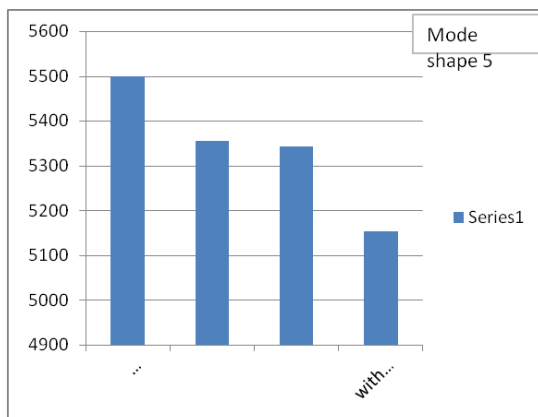It has been observed that for mode shape 6 the natural frequency is decreasing.

CONCLUSION

The finite element formulation is used to study effect of different shape cut out on the free vibration of Mild steel plate. The results obtained from finite element software are presented and discussed above. The conclusions that can be made from the present study are summarized as follows:
It has been observed that the natural frequency is decreasing for the mode shapes. The lowest frequency is observed for plate with rectangular cut out for all the mode shapes. The frequency is maximum for plate without hole. Hence depending on the requirement of the frequency the shape of the cut out can be selected.

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