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Parametric based Vibration response Analysis of Stiffened Composite Material

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Abstract

This research paper presents the model based vibration response study and analysis on Stiffened plates which have been utilized effectively in construction of mechanical structures for many years. Pressure vessels, Storage tanks handling high temperature, train carriages, plate grinders, peripheral body structures of rockets, and a variety of other mechanical structures. Investigation of dynamic stability using vibration behaviour on stiffened composite plate. Studied effect of thickness ratio on the frequency of the stiffened plate. Also investigated the impact of Orientation angle on the frequency of stiffened plate. Orientation angle means it is the angle in which the material is given in the given plane. And also examined the impact of varying number of plates on stability of stiffened plate. Hypothesis for this investigation is stiffened composite plates have a better stiffness-to-weight ratio when compared with the unstiffened plates,

Keywords: Stiffened composite plates, Unstiffened composite plates, Marine Industry, Aerospace, thickness ratio, Orientation angle, varying number of plates

INTRODUCTION

The main aim of this research work is to study the impact of parameters such as thickness ratio, orientation angle and number of stiffeners on the vibration response of stiffened composite plates. Abaqus software is employed to construct the stiffened composite plates are. With the help of Abaqus the developed model stability is investigated by varying the parameters like orientation, thickness ratio and number of stiffeners. And a software program has been developed on MATLAB to study dynamic stability of the composite plate.

Stiffened plates which have been utilized effectively in construction of mechanical structures for many years. Pressure vessels, Storage tanks handling high temperature, train carriages, plate grinders, peripheral body structures of rockets, and a variety of other mechanical structures.

When compared to unstiffened plates, stiffened plates have a high stiffness-to-weight ratio.

The composite plate has been made up of multiple layers, each with its own metric and fibre. The metrics primary function is to hold the fibres together, and fibre is the composite plates primary load-bearing component. And the fibre angle varies from in each and every layer. The composite plate parameters will change depending on the fibre angle, with the fibre in the longitudinal direction has the highest strength and in the lateral direction, it has the least strength.

To have strength in both directions, positioned all the fibres in one laminar in X-direction, and then all the fibres in another laminar in the Y-direction. These will be stuck together later, and it will contain fibres in both the Y and X directions. Lamina refers to the separate pieces, whereas laminate refers to the combination of plates. In the same direction that the load is increasing, the is likewise increasing.

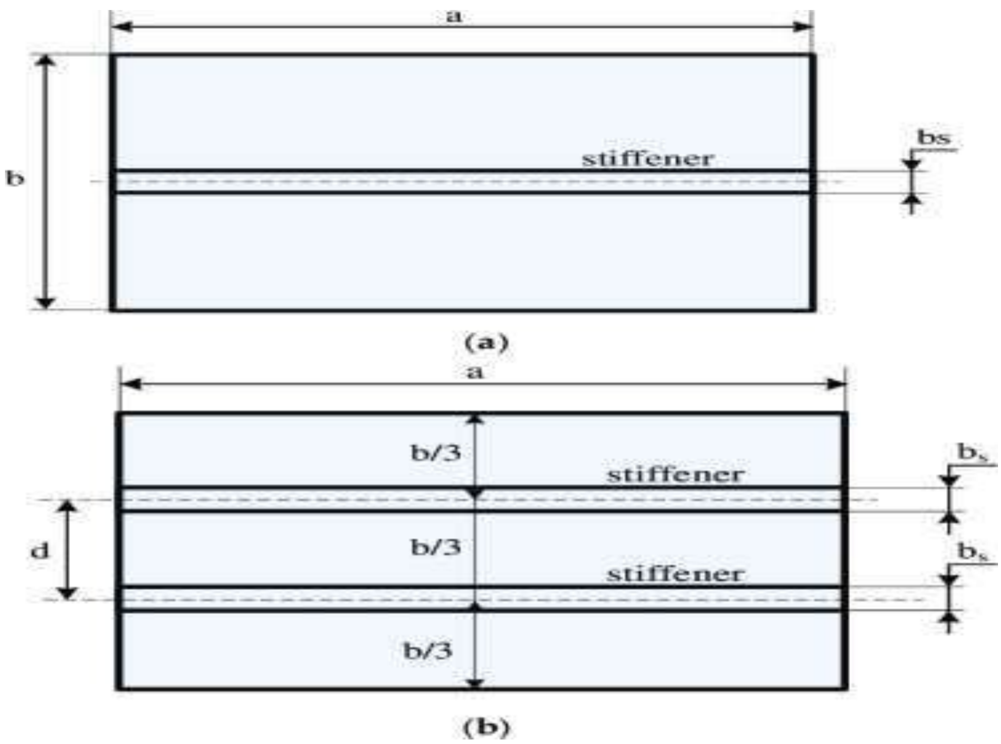


Fig 1

the industry is employing the traditional materials due to their low structural weight, high stiffness, and high static and dynamic strength. Anisotropic characteristic of composites is caused by differences in fibre and matrix properties in terms of mechanical and thermal terms. Which enhance the utilization of the materials a various fields. Also increased benefits to the metals for longer duration of life.

LITERATURE REVIEW:

Finite element model has been constructed considering higher-order plate theory, in order to estimate and analyze parametric instability on composite plates. To adapt this theory assumed stress-free boundary conditions and cubic thickness fluctuations in the plane displacements. With two distinct boundary conditions and plate thicknesses, numerical results are reported for isotropic and [(0/90)2]s graphite (or) epoxy composite plates.

Using the finite element method the effect of stiffeners is examined. Free vibration characteristics are considered like fundamental frequency and mode shapes of the stiffened plate. Further, more design charts are suggested which are used by designers to proceed with nom dimensional parameters.

The study on fundamental frequency uses the effect of aspect ratio which attends to assume that the fundamental frequency which is increased is maximal for the square plate(a/b=1) check out by the rectangular, narrow, long plates. which the value is considered using clamped boundary conditions and simply supported together. And free vibrational behavior on the stiffened planes in the clamped boundary conditions shows its dominance over the simply supported one.

GAPS IN LITERATURE:

The following research papers studied has failed to explain the effect on modes of natural frequency by varying the different parameters.

The gaps focused on effect of dynamic stability by the various parameters

- Stiffened panels have been utilized in heavy industrial vessels, ships and bodies of space vehicles construction for many years, while stiffened plates are widely applied in railway carriages, meter gauge rails, plate grinders, and aircraft wings.
- When compared to unstiffened plates, these stiffened plates have a moderately high stiffness to weight ratio.
- The stiffened plates have greater advantage over ordinary materials are a result of their low design weight, high solidness, high static and dynamic strength. The anisotropic idea of the composites in their mechanical and warm attributes which

happens because of various properties of fiber and framework makes them of more noteworthy significance in different fields. The ideal direction and stacking arrangement of fibre layers likewise adds to their potential benefits over ordinary metals.

The objectives of this research were listed below.

- Effect of number of stiffened plates on the cumulative frequency of the stiffened plate. Adding number of stiffened plates is being studies during the investigation.
- Effect of changing Orientation angle on the frequency of stiffened plate. Orientation angle means it is the angle in which the material is given in the given plane.
- Effect of thickness ratio on the frequency of stiffened plate. Thickness ratio is the proportion of the thickness of the plate to the length of the plate

METHODOLOGY:

A Model of composite plane built on Abacus. In order to study a composite plane is selected to be (4x4)mm which consists of a plate and a stiffener. The dimensions are thickness of the plate 0. 2mm, height of the stiffener is 0.4mm,thickness of the stiffener is 0.1mm. properties: e1= 1.344*10^5MPa, e2=e3=1.03*10^4MPa, and the values of G12,G13 are equal to 4.999*10^33MPa , G23=1.9999e3MPa,nu=12=nu13=nu23=0.33.
Employed cross ply arrangement and studied the key parameters such as aspect ratio, orthographic ratio.

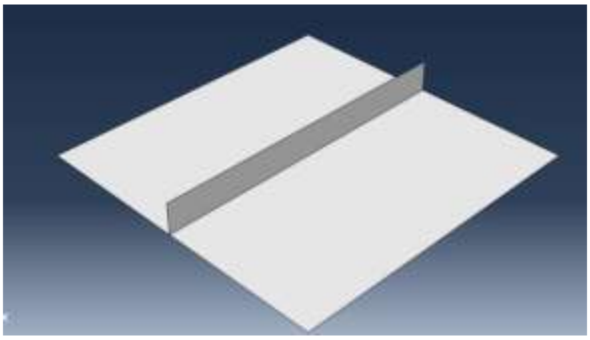


Fig. 2

A Matlab program has been written to analyze the parameters. The input file is generated in Abaqus and used the file to run the code in Matlab program. Created graphs with frequency values.

Angle ply laminate contains of 8 layers with the orientation which are generalized as (θ/-θ/θ/θ/-θ/θ) which changes from -60 to 90 are used to study the orientation on the natural frequency.

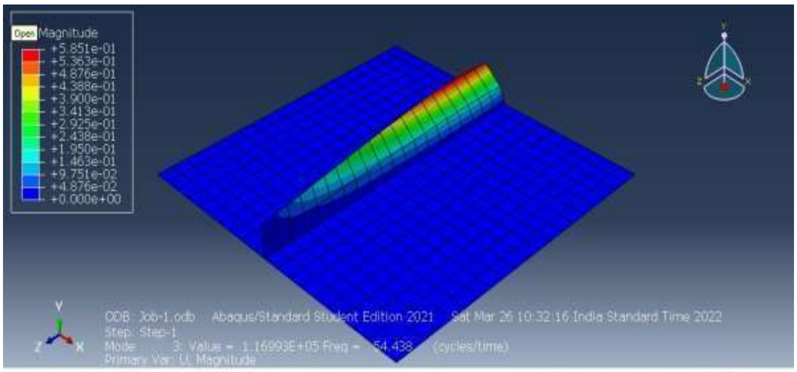


Fig. 3

S.NO	Rotational angles
1	(0/90)2s
2	(0/45/-45/90)s
3	(0/30/60/90)s
4	(0/30/-30/90)s
5	(0/60/-60/90)s

Table 1

Angle of symmetric cross play the e1 remains constant and E2, E3 values have beenchanged and used the study of orthographic ratio on natural frequency.

The values for Orthographic ratio is

E1	**1.334e11**	**1.344e11**	**1.344e11**	**1.344e11**	**1.344e11**	**1.344e11**
E2	1.033e10	1033000000	2066000000	3099000000	4132000000	5165000000
E3	1.033e10	1033000000	2066000000	3099000000	4132000000	5165000000

Table 2: List of Youngs Modulus

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 51, Issue 3, March 2022

The Aspect ratio values are

S.NO	**Aspect ratio**
1	0.8
2	0.9
3	1

Table 3: List of aspect ratios

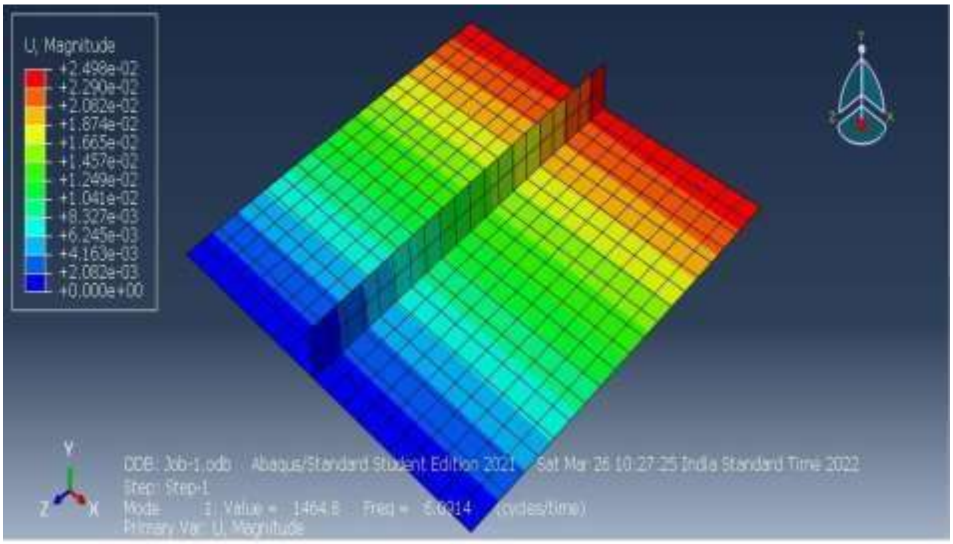


Fig 4

The Values for thickness ratio were

S.NO	**Thickness ratio**
1	0.6
2	0.7
3	0.8
4	0.9
5	1

Table 4

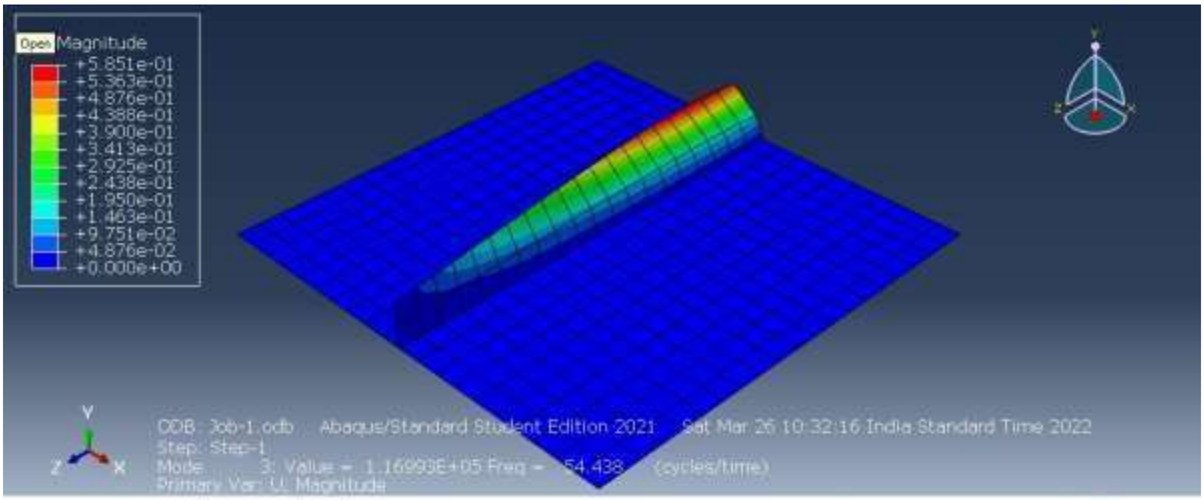


Fig 5

RESULTS AND ANALYSIS:

During this investigation the input parameters of the Abacus model were run on the Matlab program which was developed and the parameters and their behavior discussed below. The following values tabulated which represent the variation of natural frequency with orthographic ratio.

Thickness Ratio Vs Natural Frequency:

Mode	0.05	0.06	0.07	0.08	0.09
1	6.0169	6.5583	7.049	7.5016	7.9208
2	11.713	11.712	11.712	11.712	11.712
3	27.442	32.915	36.378	43.829	49.265
4	29.458	35.33	41.192	47.039	52.863
5	35.031	42.01	48.97	55.517	56.096

Table 5: Variation of natural frequency with thickness ratio.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 51, Issue 3, March 2022

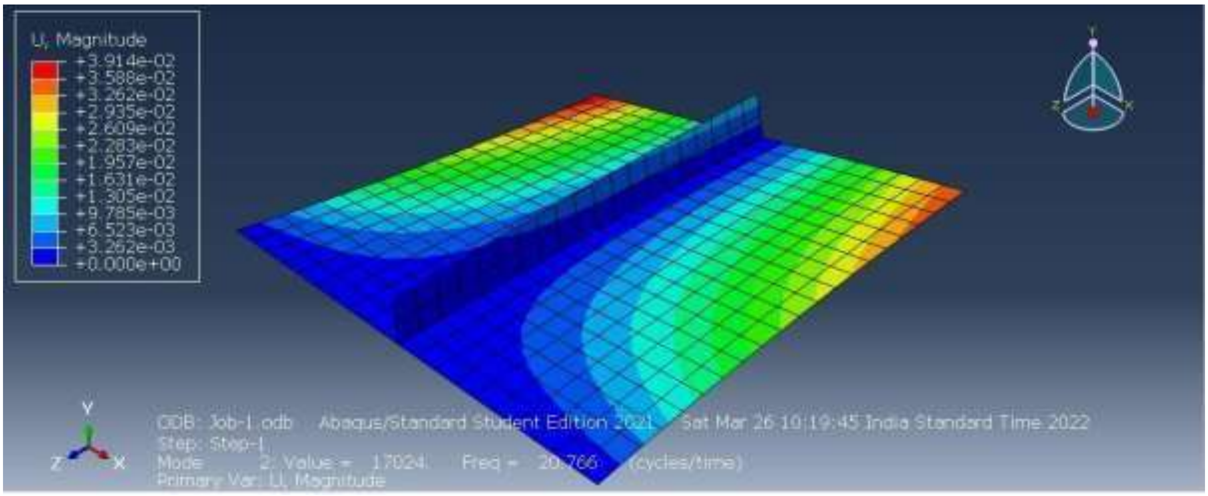
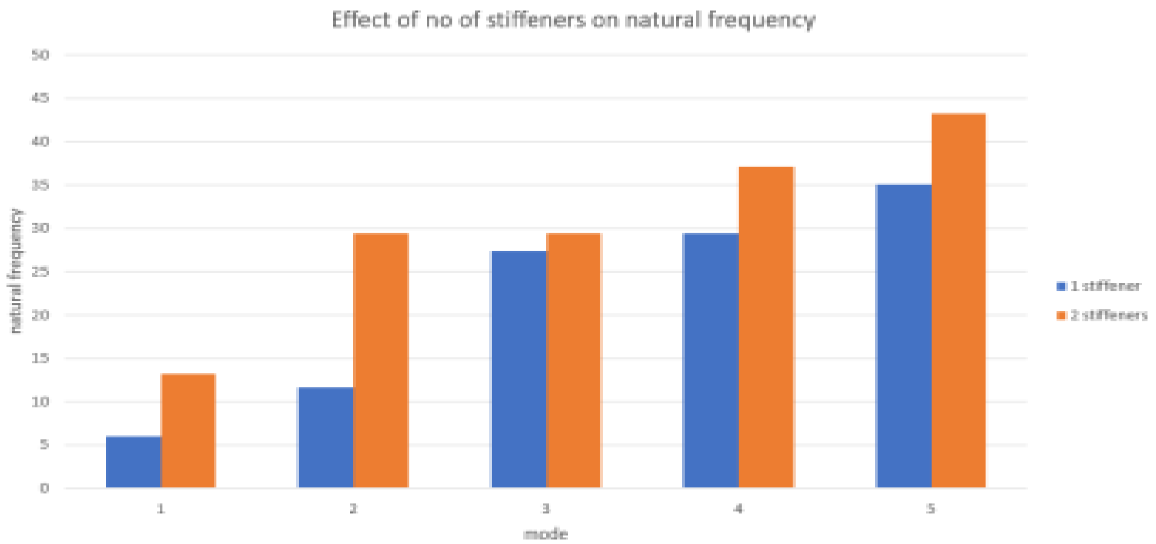


Fig 6: Thickness ratio Vs natural frequency

It is observed that the thickness ratio plays vital role in the stiffness. Also it is observed that as the orthographic ratio increases the natural frequency also increases. And the increase in natural frequency is proportional to increase in stiffness.

Effect of number of stiffeners on natural frequency: The effect of number of stiffeners on natural frequency has been analyzed during this research. The fig 7 illustrates how the number of stiffeners affects the natural frequency. And it is observed that by varying number of stiffeners increases the natural frequency.



Industrial Engineering Journal
ISSN: 0970-2555
Volume : 51, Issue 3, March 2022

Fig 7: Number of stiffeners Vs natural frequency

And it is also observed from the fig 7 that the increase in number of stiffeners proportionately increases the natural frequency. And natural frequency enhances the stability of the plates.

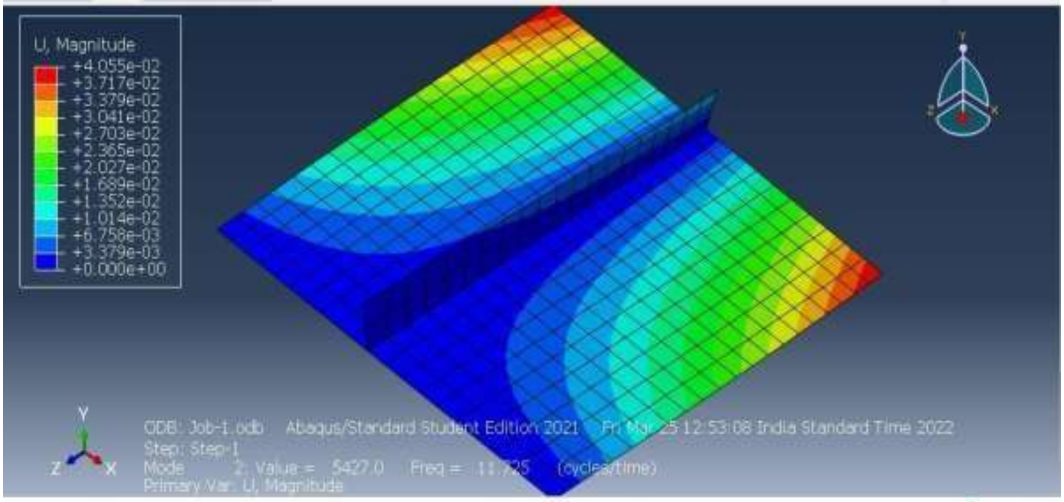


Fig 8: Number of stiffeners on natural frequency

In the fig 8, it is clearly observed that the there is increase in natural frequency with the increase in number of stiffeners.

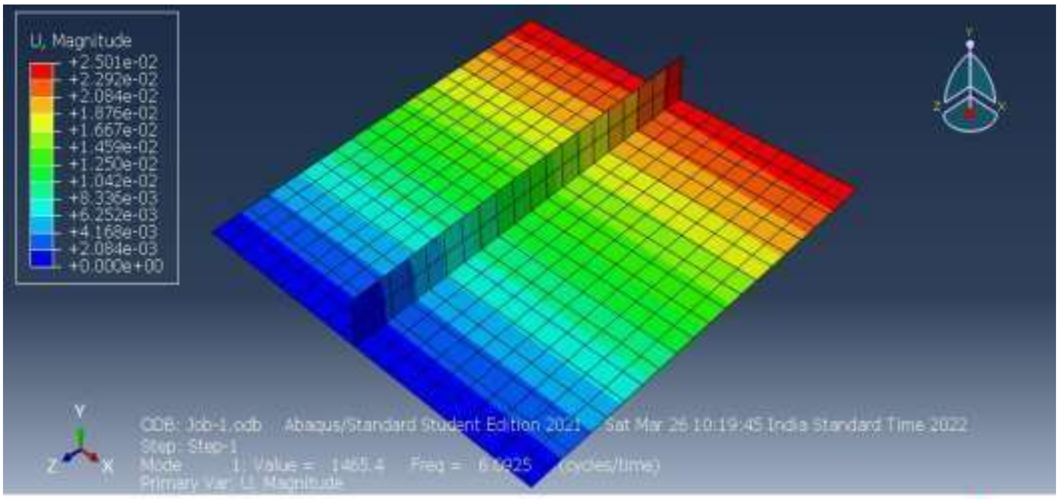


Fig 9 : Effect of number of stiffeners on natural frequency

It is observed that in fig 9 the increase in number of stiffeners causes increase in natural frequency and the dynamic frequency also being increased. And the more increased stability is possible.

Industrial Engineering Journal
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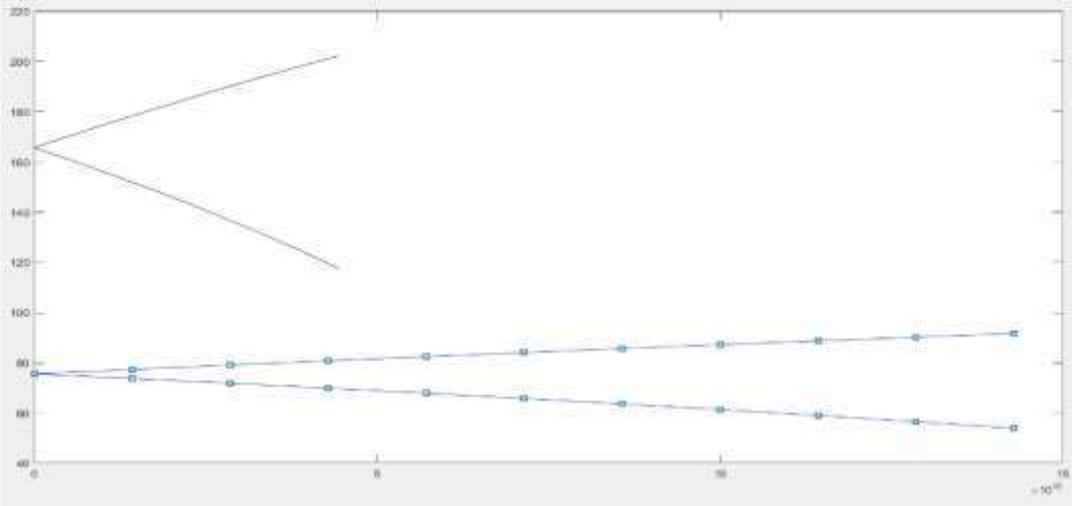


Fig 10: Dynamic stability of stiffened panel by varying number of stiffeners

As per the demonstration in above fig 10 the stability of the stiffened panel found increased with the increase in number of stiffeners. Also it is observed that both in stability during static and dynamic conditions.

Effect of thickness ratio on natural frequency:

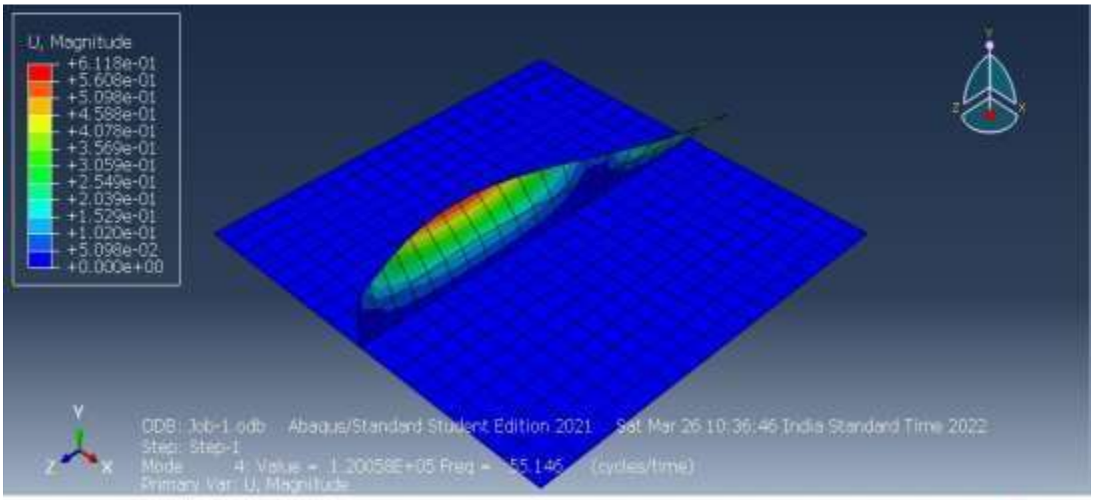


Fig 11: Thickness ratio impact on natural frequency

As per the demonstration of Fig 11 it is very clear that with the increase in thickness ratio there increase in dynamic stability.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 51, Issue 3, March 2022

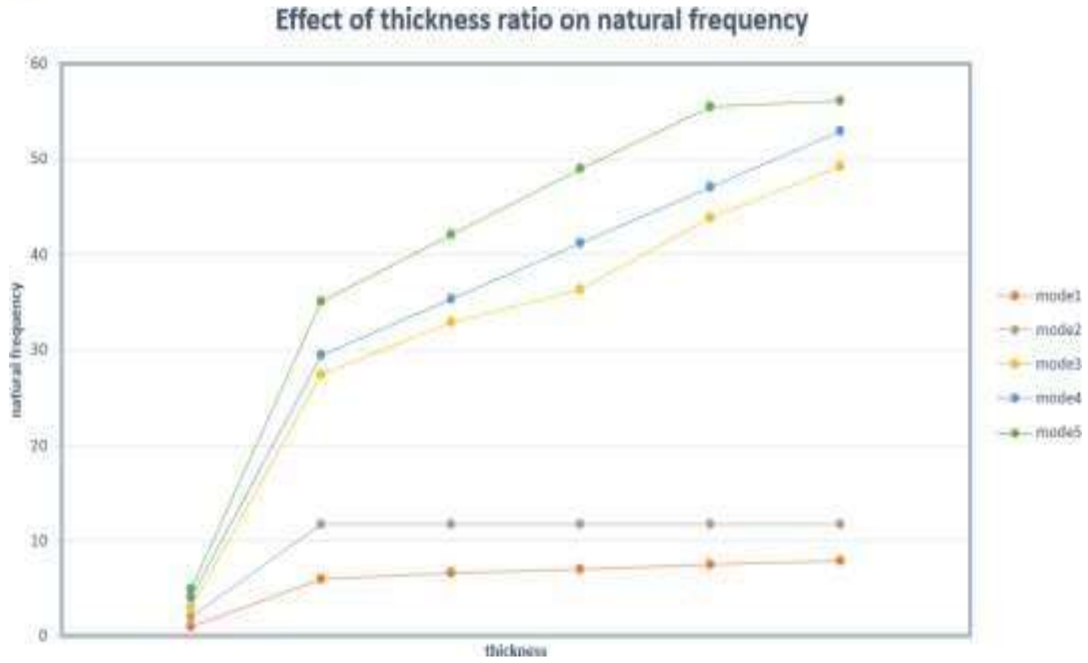


Fig 12: Effect of increase in thickness ratio on natural frequency

The fig 12 illustrates that the thickness ratio has significant impact on natural frequency. The stability observed will be increased with increase in thickness ratio.

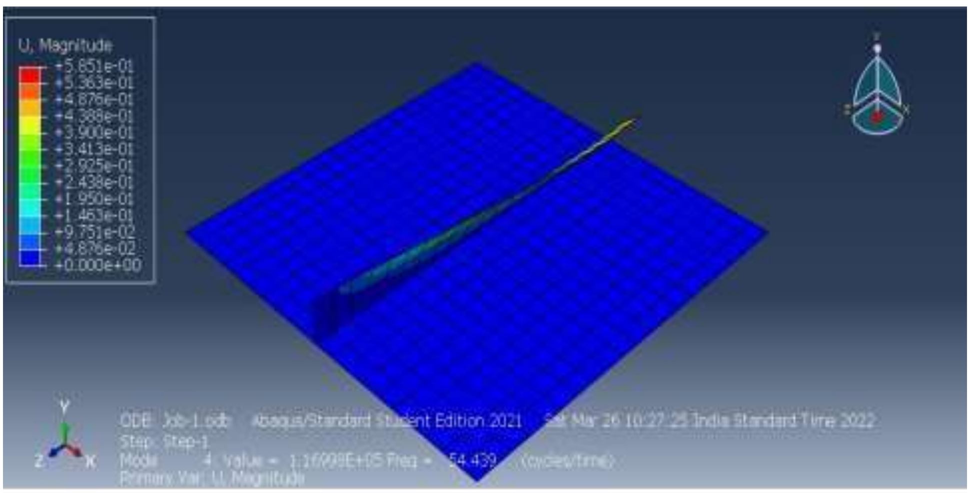


Fig 13: Effect of thickness ratio on dynamic stability

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 51, Issue 3, March 2022

The figure 13 illustrates that the increase in thickness ratio causes the increase in dynamic stability. As the stiffness is directly proportional with the increase in natural frequency.

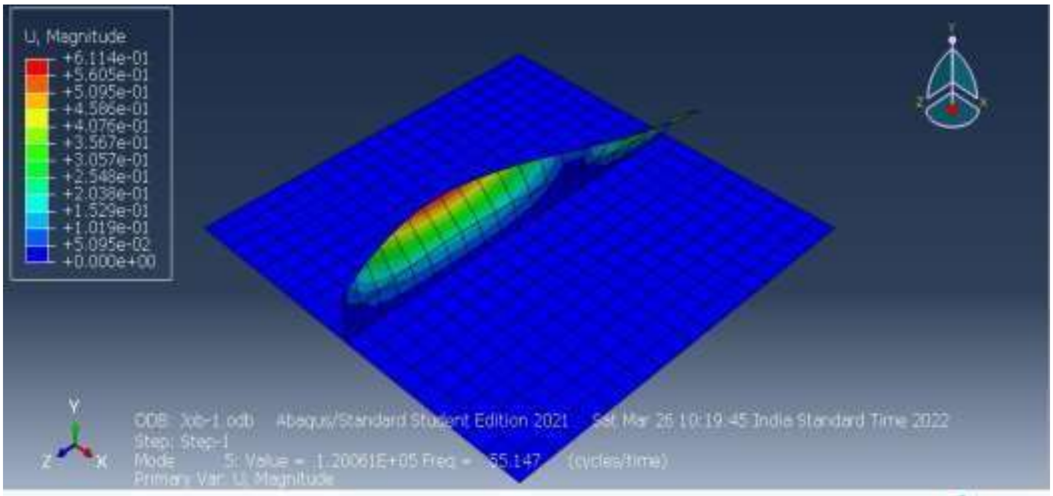
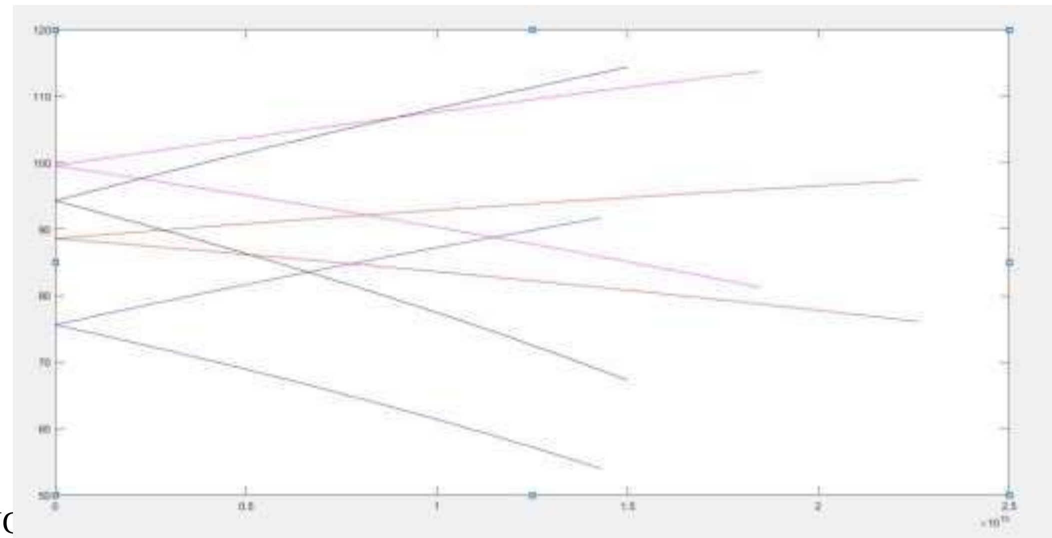


Fig 14: Effect of thickness ratio on dynamic stability

The illustrated graph fig 14 indicates how the thickness ratio impacts the dynamic stability of the composite plates with the stiffeners. And the dynamic stability found increased with the increase in thickness ratio.



Industrial Engineering Journal
ISSN: 0970-2555
Volume : 51, Issue 3, March 2022

Fig 15: Dynamic stability with increase in thickness ratio

The fig 15 indicates how the dynamic stability gets increased with the increase in thickness ratio.

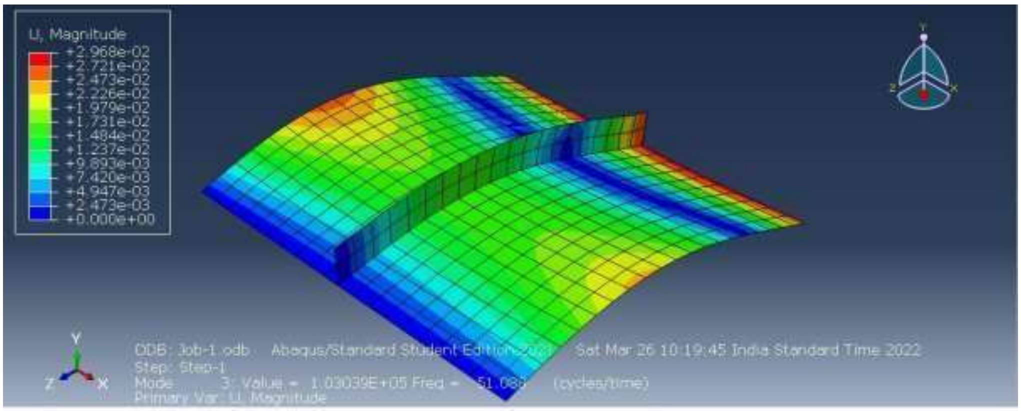


Fig 16: Dynamic stability with change in orientation

The fig 16 shows how the change in orientation impacts the dynamic stability in a composite plates with stiffeners. At certain orientation angle the dynamic stability observed is maximum.

CONCLUSION

This research paper analyzed by investigating the effects of varying in number of stiffeners, variation in thickness ratio and orientation on stiffness. And it is observed that the frequency values have increased by increasing the parametric values of number of stiffeners, thickness ratio and orientation. The variation in thickness ratio leads to decrease in natural frequency by increasing the stiffness. The variation in orientation increases in natural frequency there by increase in stiffness. The dynamic stability of stiffness observed varied by varying thickness ratio, orientation and number of stiffeners.

The dynamic stability of a Stiffened plate have be inspected thoroughly in a particular load and the rest of the considerations still exists. And the dynamic stability found increased with the increase in thickness ratio, orientation and varying the number of stiffeners.

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