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A Review on Effect of Geometric Parameter on Free Vibration Analysis of Glass Fiber Epoxy Composite Laminated Plate With and Without Cutouts

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Abstract—*This paper present a review on combined experimental and numerical study of free vibration of composite plates .In this a different orientation of fiber is analyzed with and without cut-outs. ANSYS software is used for analyzing the plate under different boundary condition and different orientation. In this study basically we focus a modal characteristic of the unidirectional fiber compositeplate with and without cutouts. Cutouts be used in mechanical and electrical system such as passage of electric wires, hydraulic system also this composites have various application in aerospace, military aircraft, automotive. Cutouts of various shape and size are used to reduce weight or control the quality of structure. Plate with a cutout shows a dynamic characteristic due to this cutouts in a structure is to expose vibration sometimes due to cutout resonance condition is occur leads to fail in a structure. So it is necessary to predict the resonant frequency of this structure. For a plate with and with cutouts a boundary condition is used .Distance of cutouts is vary in a plate and also size of cutouts. The geometric parameter we consider in this paper is supporting condition, ply orientation, geometry of cutouts. For modal analysis, a FFT analyzer is used to find out natural frequencies of the mode shapes of composite plate. The purpose of this paper is to study the result obtained from FFT analyzer and ANSYS software.*

Keywords: *Composite, Natural Frequency, Cutouts, FFT analyzer,free vibration analysis, boundary condition.*

1. INTRODUCTION

A composite is a material that consists of two or more material combined together to form a new material at a macroscopic level which are insoluble in each other and differ in form or chemical compositions[1]. There are two phases of composite namely, reinforcing phase and matrix phase. The reinforcement is responsible for carry load and the matrix phase is distribute the force and stresses uniformly among the reinforcement and bind reinforcements together. The properties of the composite material depend on the properties of the type of constituents used, types of geometry and the distribution of phases. The strength and stiffness of fiber reinforced composite materials depend upon fiber due to the continuity nature of fiber [2]. Some more natural available composites is nature say wood, where the lignin matrix is reinforced with cellulose fibers. Composite systems include carbon fiber epoxy composite and glass fiber epoxy composite etc. Similarly, various properties and behavior of composite materials are discussed by many authors [3] and [4].

1.1 Importance of Present Study

Composite laminates are formed by stacking layers of different composite materials one above the other in different orientation of fibers.By construction requirements, composite laminates have the planar dimension one to two orders of magnitude of larger than their thickness. Therefore, composite laminates are treated sometime as plate elements .In many plates is used for various applications which having a cutouts. Cutouts are necessary for assembling the components in industry, damage inspection, access ports, electrical lines and fuel lines, automotive industry opening in a structure to serve as doors and windows, provide ventilation, to reduce weight. Cutouts are sometimes needed at the bottom plate for passage of liquid in liquid retaining structures. In some of these applications the composites are subjected to dynamic loads. These structures are exposed to the undesirable vibration, extra amount of deflection leads to the failure in the structure and many more during their service life and again these plate structures having cutout may change the responses considerably. This paper is study the free vibration and dynamic analysis of composite plate with and without cutouts.

2. LITERATURE SURVEY

The concept of composite material which is used is very old. The use of reinforcing mud walls in houses with bamboo shoots glued is laminated wood by Egyptians in 1500 B.C and

laminated metals in forging is used in (A.D. 1800). The modern composites were used in 20th century and also in 1930s glass fibers reinforced resins are mostly used. Boats, automotive parts and aircraft were built out of these glass composites [1]. The pace of composite material is development was accelerated during World War II. Not only even more aircraft being developed and therefore, composites were more widely used in tooling ,in industry but the use of composites for structural and semi-structural parts. Since the 1970s, application of composites has widely increased due to development of new fibers such as carbon, Kevlar, graphite, silicon boron and aramids and new composite systems with matrices made of metals and ceramics. Concrete is also a composite material mostly used in civil and used more than any other man-made materials in the world. So, there is a need to study the vibration behavior of laminated composite structure precisely. In recent years, many adequate theories/formulations have been proposed by the researchers to overcome composite structures and advanced structural materials over conventional materials. The vibration responses of laminated composite plates have been investigated extensively by a number of researchers. However, the analysis of laminated composite plate much more research is carried out. Some of the selected research is discussed in the following lines.

2.1 Previous Works Carried Out Related To Project

As stated in the introduction, the vibration and stability studies of composite plates is an active field ofresearch in all over the world. Among the various composites material mostly used, is Fiber reinforced polymer (FRP) for study because of their superior properties such as high strength, light weight, corrosion resistance and many other attractive dynamic characteristics such as Damping and High Stiffness. But the reliability of the materials can be depends upon the proper assessment of the various static and dynamic properties of the composite and their behavior under different loading and boundary conditions. In the field of laminated composite plates cutouts extensive research was done in the past three decades covering various geometric parameters. Some of the previous studies have been summarized below in this paper.

C.V. Srinivasa, Y.J. Suresh, W.P. Premakumar[5] have studied the free vibration of isotropic laminated composite skew plates by experimentally also these isotropic plates are analyzed using NASTRAN software.Both these analytical and experimental results were compared .They have studied the effects of parameters such as skew angle ,aspect ratio, fiber orientation angleand laminated sequence of that isotropic skew plate. Also they studied that the natural frequencies of antisymmetric composite laminates. After experimental and numerical results they concluded that experimental values of natural frequencies are good as compared with the finite element solutions. As the skew angle increases natural frequencies also increases, while aspect ratio has negligible effect on variation of natural frequencies.

KanakKalita and AbirDutta[6] was worked on free vibration of isotropic composite plate. For that plate a different boundary condition is used, aspect ratio and the thickness of a plate which is vary by using finite element method analysis of a plate is carried out considering all condition. Boundary condition cases for the plate such as involving clamped, simply-supported and free edge conditions. In that analysis isotropic square plate was used having different lamina layers and finding the natural frequencies of the plate. This square plate is analyzed for a different boundary condition with a different thickness ratio. The obtained results of the analysis that the natural frequencies of the plate is increased with increase in aspect ratio and as the thickness of a plate is decreased natural frequencies is also decrease for a plate.

ParsuramNayak[7] have studied on experimental and numerical free vibration of woven glass fiber Epoxy composite plates. They worked experimentally on tensile test of the specimens for finding elastic parameters of the plate .A computer program is generated based on finite element method which can perform all necessary computations. This program is generated for various layer of woven glass fiber epoxy composite plate with a cantilever boundary condition and compared withcomputer developed program. The results obtained experimental value and program result were compared.

Girish Kumar Sahu[8] worked on the static and vibration responses of laminated composite plates or skew plates. For that plate a finite element model is developed based on first order shear deformation theory using ANSYS parametric design language (APDL) code. After studied of this shear deformation theory they show a linear variation of shear stresses along the longitudinal direction of the laminates. In APDL code model has been discretized .A free vibration analysis is perform by using a Block-Lanczos and Gauss elimination algorithm and finds various parameter such as transverse deflections, normal and shear stresses and natural frequencies of composite laminates plate in APDL codes. This plate is considered with a various geometric parameter such as support conditions, ply orientations, number of layers, thickness ratio, geometry of cutout, cutout side to plate side ratio and skew angle and perform a static analysis as well as free vibration analysis of that skew plate.

Sharayu U. Ratnaparkhi, S.S. Sarnobat[9] worked on free vibration analysis of glass epoxy composite plate. For this glass fiber epoxy plate a free free boundary condition is studied, natural frequencies and mode shape is find out .Vibration some time produce in a plate during a dynamic loading results in damage of the structure .Hence vibration analysis is very important for designing of the structure. Effect of different parameter is considered for that plate such as aspect ratio, and fiber orientation of woven fiber composite plates. Analysis of the plate is done by using finite element method numerically and validates that result experimentally

by modal analysis technique for free free boundary condition of the plate.

SunithBabu L, H. K. Shivanand[10]were studied on impact property on the composites such as glass fiber epoxy composite and carbon fiber epoxy composite laminated. The behavior of laminated composite plate is study experimentally under the impact of steel projectile which is maintained at low velocities. This impact test on laminated composite plate is performed as per ASTM standards D3029 and D7137.Instruments were used for impact test of glass fiber epoxy composite laminated plate and carbon fiber epoxy composite laminated plate is drop weight test .For that laminated plate the orientation of fiber is in [0 - 90] combinations. Due to the impact force acting on a plate at center a deflection of plate takes place .Results shows that as we change the projectile velocities of plate for different orientation behavior of plate is different in all cases.

DebasisBasa , SubhranshuDwibedi[11] have described static and vibrational characteristic of composite plate .The composite plate which is used is glass fiber epoxy composite ,plate used is having adifferent shape ,size ,with and without cutouts. Plate s manufactured by hand layup technique. Different type of boundary condition is considered such as simply supported, cantilever condition, fixed boundary condition. In finite element analysis plate is analyzed numerically and find out natural frequencies and mode shapes for different boundary condition also the size of cutouts in a plate is vary and study all the results of natural frequency and mode shapes this results were validated by using FFT analyzer. For a various boundary condition of plate with and without cutouts modal analysis is performed and calculated natural frequencies .Also as we change the size of cut outs is validated by experimental method .In modal analysis ,accelerometer was used .From this we obtained a natural frequencies of the mode shapes. Both the result obtained by experimental and numerical method were compared .The result from the modal analysis and finite element analysis software were found to have a vary less variations.

S. B. Singh, HimanshuChawla[12] has performed a work on dynamic characteristic of glass fiber laminated plates with and without cut outs. In this study a glass fiber composite plate is used the fiber are oriented in unidirectional .Plate is having a cutouts for that cutouts a natural frequency and damping coefficient is determined. In a plate a square shape of cutouts is taken with a different size and analyzed it by finite element analysis software. For and experimental work the modulus of elasticity of glass fiber is calculated on UTM machine .The natural frequency of a glass fiber plate is determined by transferring a force vibration on the plates. These types of force vibration were given by shake table to a plate which can be fixed to a supported table. The vibrations on a plate were controlled by means of “sine vibration controller” software. In this type of experimental method a setup of a two accelerometers were used to control and monitor the vibrations of the glass fiber composite material plate .The response of the vibration of the plate is noted through the software which is installed in the data acquisition system. Experimental results of the composite plate can be depending on the stiffness of plate. It have been shows that the size of the cutouts of a plate is affect on the natural frequencies of composite laminated plate .After experimental and numerical study of the glass fiber composite material plate concluded that as we increase the size of cutouts of the composite material plate the natural frequencies are decrease and damping of the plate is increase.

SanthoshPushpaRaj D[13] was worked on the dynamic analysis of composite plate which is laminated with and without square cutouts. The composite structure is sometimes having a hole in it for various applications in industry such as passage for cable wires, inspection and maintenance of the other unit which is maintaining on the assembly. Plate with a cutouts used in aerospace, aircraft, and automotive application subjected to dynamic vibration of the plate. Due to this dynamic nature of plate large amplitude is produce so that a failure of plate takes plate and sometimes resonance condition is produce when the natural frequency of plate is match with external excitation frequency. They can be worked on dynamic analysis in which study the different type of shapes of hole in a plate by maintaining a length to height ratio same and studied a hole ratio. For that type of plate different boundary condition is used such as CFFF-(clamped free free free) and CFCF-(clamped free clamped free).Analysis is done by finite element method for different type of hole size and boundary condition. Fibers of the plate are oriented in various angle .After all analysis is performed shows that a composite plate with arbitrary geometric and boundary condition subject to various types of loading used in aerospace. The plate when subjected to dynamic loading stresses produce on a plate is not uniform so that they greatly affect the dynamic behavior of the structure [13].

3. DISCUSSION

From the above literature survey we discussed that the free vibration analysis of a composite material plate with and without cutouts considered with a various geometric parameters such as size of cutouts, boundary conditions, ply orientation and perform a finite element analysis to find out all results and compared this numerical results with experimentally measured.

4. CONCLUSION

From the above study of this literature survey it is concluded that –

- In all type of boundary condition the frequency range is different in case of glass fiber composite material plate with cutouts.
- After study of this paper for a fixed boundary condition there is decrease in frequency range but increase in frequency range as increase size of cutouts.
- For simply supported and cantilever cases there is decrease in frequency for all modes of vibration of plate as increase in size of cutouts.
- There are so many advantages of finite element for analyzing the plate for different layer of glass fiber epoxy composite plate. From the above study of this paper it is successfully studied the vibration characteristic for finding natural frequencies of rectangular plate with and without cutouts subjected to various boundary conditions.
- From the literature study it is concluded that natural frequency of composite plate is increase as increases the aspect ratio (a/b).
- Natural frequencies are low for free boundary condition of plate whereas for clamped boundary condition natural frequencies are high.
- As we increase the thickness of composite plate natural frequencies is increase as we decrease the thickness of composite material plate natural frequencies is decreased.
- A natural frequency is also increase as we increase angle of the plies.

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