Review on Effect of orientation of Glass Fiber on the Strength of Ply laminate Using Experimental and Finite Element Analysis

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Abstract— The composite material having wide range of application in the every sector due to their inherent properties. The most commonly used composites are glass fiber and carbon fiber. There are too many mechanical parameters affecting on strength of ply laminate, like thickness, number of layers, type of fiber, orientation of fiber and their stacking sequence. In this paper we deal with study of orientation of fibers as well as their stacking sequence having fiber orientation 0^0 , 45, -45^0 , $90^0$and find out which stacking sequence gives good strength of laminate.

Index Terms—ASTM, FEA,

I. INTRODUCTION

A composite material is formed by the combination of two or more distinct material to form a new material for intensifying the properties. For example rock is combined with cement to make concrete, which is as strong as the rock. It can be shaped more easily than carving rock. While the enhanced properties of concrete are strength and ease of fabrication, most physical, chemical and processing related properties can be enhanced by a suitable combination of material. The most common composite are those made with strong fibers held together in binder. Particle or flakes are also used as reinforcement, but they are not as effective as fibers.

Modern composites use metal, ceramic, or polymer binders reinforced with a variety of fibers or particles. For example, fiberglass boats are made of a polyester resin reinforced with glass fibers. Sometimes composites use more than one type of reinforcement material, in which case they are called hybrids. For example, consider reinforced concrete, a particle-reinforced composite (concrete) that is further fiber reinforced with steel rods. Sometimes different materials are layered to form an enhanced product, as in the case of sandwich construction where a light core material is sandwiched between two faces of stiff and strong materials.

II. RELEVANCE

Laminated composite materials are extensively used in aerospace, defense, marine, automobile and many other industries. They are generally lighter and stiffer than other structural materials. A laminated composite material consists of several layers of a composite mixture consisting of matrix and fibers. Each layer may have similar or dissimilar material properties with different fiber orientations under varying stacking sequence. Because, composite materials are produced in many combinations and forms, the design engineer must consider many design alternatives. It is essential to know the dynamic characteristics of such structures subjected to dynamic loads in complex environmental conditions.

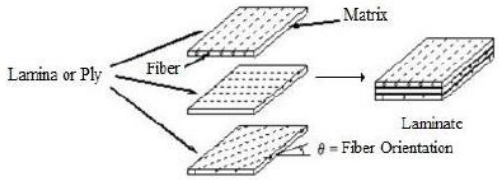

Fig 1: Typical example of ply laminate

Figure 1 show the different laminas having different fiber orientation and these laminas are stacked together to forming a laminates.

III. LITERATURE REVIEW

There are many researchers working in the field of composite material and FEA analysis, following is the list literature of some notable researchers;

Yeow Ng et. al.[1] carried out experiment on optimized stacking sequence of 0° and 90° plies in compression test specimens such that the compression strength of a unidirectional 50 volume percent boron epoxy composite can be determined.

Umut Topal et. al[2]. Studied thermal buckling load optimization of symmetrically laminated angle-ply thin plates with centrally located different cutouts subjected to a uniform temperature load rise. The optimum results are given for maximum buckling temperature and the fiber orientation is adopted as design variable

K.AnandBabu et. al.[3] has focused study on the analysis of stress-strain and displacement for compressive load on the fiber- reinforced composite laminates. Three different orientations of fibers are analyzed with and without the circular cut-outs. Also different dimensions of circular cut-outs are applied on the laminates at different compressive loading conditions. This analysis is carried out using the finite element software ANSYS. From the result, it is identified that cross-ply composite laminates possess the highest strength as compared to other types of angle orientations. Also it is concluded that the maximum load bearing capacity decreases as the cut-out size increases.

Ban. Bakir et. al.[4] this study was designed to evaluate the effect of glass fiber orientation of reinforced composite material on mechanical properties: tensile strength, hardness, toughness, also microstructure were tested.

Patil Deogonda Et.Al.[5] **–** Studied and described describes the development and mechanical characterization of new polymer composites consisting of glass fibre reinforcement, epoxy resin and filler materials such as TiO2 and ZnS. The newly developed composites are characterized for their mechanical properties. Experiments like tensile test, three point bending and impact test were conducted to find the significant influence of filler material on mechanical characteristics of GFRP composites. The tests result have shown that higher the filler material volume percentage greater the strength for both TiO2 and ZnS filled glass epoxy composites, ZnS filled composite show more sustaining values than TiO2.

Sharad D. Pawar, et. al.[6] studied development optimization procedure to maximize the stiffness and minimize the weight of composite laminate subjected to in-plane loading .The design variables for optimization problem are fiber orientation angles, thickness of lamina and number of laminas.

Sandeep M.B. Et.Al.[7] Polymer matrix composite materials are anisotropic in nature, the mechanical properties of these materials are different for different constituents and orientation of reinforcing material. In this paper, the effect of fiber orientation on the flexural strength for pure glass/epoxy composite material is presented. The experimental results showed the difference in flexural strength in bidirectional glass fibers at $0\text{-}90^0$and $-45\text{+}45^0$ orientation

Abhishek Jha[8] author studied the first ply failure analysis which is widely accepted method to predict strength of laminated composite structures and also considered as its design criterion. Previously the first ply failure load is calculated through experiments which consume time and labor. In this work the first ply failure load is predicted using finite element analysis on ANSYS mechanical APDL. Failure criteria adopted is maximum stress theory. It is found that results obtained in present works are in good agreement with previously obtained experimental results.

IV. EXPERIMENTAL SETUP

Fig 2 shows the typical experimental setup used for the bending test of ply laminates. The test specimen is made as per ASTM standard. Now the specimen is placed on roller support at the end as shown in figure on a universal testing machine the load is applied at the center of the plate and increased load gradually till the failure occurs in the laminate.

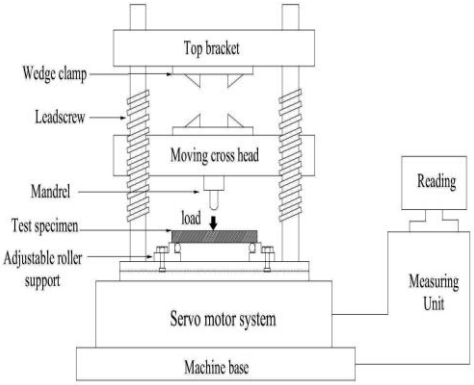

Fig 2: Typical Experimental Setup

V. METHODOLOGY

The methodology used for this research is having different stages like

Step I – Finite Element Analysis

After finding out all the possible combination of fiber orientation it is need to find out stress induced in a laminates by using FEA tool. Here applying a constant load i.e. same load on each laminate and analyze the stress variation in each laminate The result gives which stacking sequence is having better strength.

Step II – Fabrication of ply laminates

By referring a FEA results, fabricate selective laminates for validation purpose. Fabrication of laminates will be manufactured by different techniques

Step III – Experimental Testing

These Fabricated ply laminates will be tested on Universal testing machine in order to find out their breaking load in bending test.

Step IV– Validation

The experimental test gives the failure load of particular laminate the same load is applied in a FEA tool the result gives the exact stress induced in laminates which is used for validation

This methodology can be used for conducting similar type of studies to find out effect of orientation of fiber element on the strength of laminates.

VI. CONCLUDING REMARK

In this work the different research studies based on the composite laminates are presented. A laminate is constructed by stacking a number of laminas in one direction. Each layer is thin and may have different fiber orientation. The fiber orientation, stacking arrangements and material properties influence the response from the laminate. Here we have found that orientation of fibers changes the structural stability of laminates. Above studies are mostly conducted on 2 to 4 layers having 0^0 and 45^0 and 90^0 orientation of fiber elements of composite material. The researcher has deal with either experimental or theoretical study of ply laminates. The factors affecting on strength of laminates are stacking sequence, fiber orientation, type of fiber, fiber material, type of matrix used, and manufacturing method. The most of studies in composite laminates dealing with fiber orientation and their stacking sequence. For future study, fabricating a ply laminates with more layers and changing their orientation of fibers in each ply with different stacking with same material, in order to find out strength of the ply laminates. The past study is carried out either experimental or theoretical. So it is needed to find out stress variation in all the possible combinations of the laminates. This variation can be obtaining by using finite element tools. And result obtaining from FEA will be used for further experimental study.

REFERENCES

[1] Yeow Ng and Al Kumnick "Determination of cross ply laminate stacking sequence for the compression strength testing of unidirectional boron epoxy material" speciality material Manufacturers of Boron and SCS Silicon Carbide Fibers and Boron Nano powder, SAMPE Fall Technical Conference–Dallas, TX pp 1-6,November 6-9, 2006.

[2] Umut Topal and Omit Uzman "Effect of Rectangular/Circular Cutouts on Thermal Buckling Load Optimization of Angle-Ply Laminated Thin Plates" Science and Engineering of Composite Materials 17, 93-110 (2010)

[3] K Anand Babu ,Dr.M.D.Abid Ali. "Finite Element Analysis of Glass/Epoxy Composite Laminates with Different Types of Circular Cutouts",Indian Journal of applied research,pp1-3;vol.3;;ISSN-2249-555X. issue-6;Jan 2013

[4] Ban. Bakir, and Haithem. Hashem, "Effect of Fiber Orientation for Fiber Glass Reinforced Composite Material on Mechanical Properties", International Journal of Mining, Metallurgy and Mechanical Engineering (IJMMME) Volume 1, Issue 5 ISSN 2320-4052; EISSN 2320-4060. (2013)

[5] Patil Deogonda, Vijaykumar N Chalwa "Mechanical Property of Glass Fiber Reinforcement Epoxy Composites" International Journal of Scientific Engineering and Research (IJSER) ISSN : 2347- 3878, Volume 1 Issue 4, December 2013

[6] Sharad D. Pawar, Abhay Utpat, "Analysis of Composite Laminate for Maximum Stiffness" International Journal of Recent Technology and Engineering (IJRTE)ISSN: 2277-3878, pp 1-7,Volume-3, Issue-2, May 2014

[7] Sandeep m.b, d.choudhary, md. nizamuddin inamdar, md. qalequr rahaman "experimental study of effect of fiber orientation on the flexural strength of glass/epoxy composite material" IJRET: International Journal of Research in Engineering and Technology, eISSN: 2319-1163 Volume: 03 Issue: 09 | Sep-2014

[8] Abhishek Jha, "First Ply Failure Analysis of Laminated Composite Plates on ANSYS Mechanical APDL", International Journal of Engineering and Technical Research (IJETR), ISSN: 2321-0869 (O) 2454-4698 (P),pp 1-4, Volume-3, Issue-7, July 2015