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A REVIEW OF INVESTIGATIONS ON STRENGTH ANALYSIS OF LAP JOINTS FOR ALUMINUM- EPOXY COMPOSITE PLATES USING FINITE ELEMENT METHOD WITH EXPERIMENTAL VERIFICATION

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ABSTRACT:

Currently, composite joints have become vital since the structural properties of the composite structure are determined by its joints. Around 70% of composite structure damage occurs in the joint, thereby making the failure load and failure mode of these joints more critical to investigate. However, failure mechanisms of composite materials are rather complex due to their non-homogeneous nature composed of constituents which have significantly different properties and remain distinct in a laminates final composition. Therefore the present study reviews the parameters of the failure of bolted joints and theirby focussing towards the tensile strength of the composite single lap bolted joint.The fibre orientation of the composite sandwich plate is also taken as a matter of consideration for this study.

KEYWORDS: Progressive failure, Lap joints, Laminate, Fiber orientation.

I .INTRODUCTION

Composites are widely used in different disciplines of engineering and structural systems as in aerospace and automobile industries, power plants, etc. These applications generally use mechanical fasteners, such as pinned and bolted joints for joining parts (to each other) in assemblies. Under loading, defects such as fibre breakage, matrix cracks, fibre/matrix de-bonding occurring in a ply do not cause the immediate collapse of a laminate when they appear. Therefore, investigation on strength analysis of Lap Joints of Composite plate is an essential.

Rashmi Gill, Veerendra Kumar:

This paper reveals that, a review of publications associated with the failure of bolted composite joints in this paper has been carried out. The study covered the work done from 2005 to 2012. Mechanical fasteners often cause a reduction of load capacity of the composite structure because of the complicated stress field near the hole area. Consequently, special attention must be given to design of fasteners. The design of efficient structural attachments represents one of the major challenges in the development of composite structures. Because of its generic nature, the joint design deserves a separate treatment as a case study. Characterization of joint failure in bolted composite laminates is complicated because of the large number of parameters involved. Characterization of joint failure in bolted composite laminates is complicated because of the large number of parameters involved. A large part of the research, done on mechanically fastened joints so far, has been concerned with the experimental determination of the influence of geometric factors on the joint strength. In this paper, the advances that took place in analytical approaches, experimental tests and finite element analysis associated with composite bolt designing have been studied.

Aidy Ali , Ting Wei Yao, Nuraini Abdul Aziz, Muhammad Yunin Hassan and Barkawi Sahari:

This paper presents the simulation and experiment work on the prediction of stress analysis in a single lap bolted joint under bending loads. A three-dimensional finite element model of a bolted joint has been developed using MSC Patran and MSC Nastran FEM commercial package. In the simulation, different methods in modelling the contact between the joint, which affects the efficiency of the models were detailed. Experimental work was then conducted to measure strains and deformations of the specimens for validation of the developed numerical model. A four-point bending load type of testing was used in both the simulation and experiment works. The results from both simulation and experiment were then compared and show good agreement. Several factors that potentially influenced the variation of the results were noted. Finally, critical areas were identified and confirmed with the stress distribution results from simulation.

Kradinov, E. Madenci:

Even though two-dimensional is accurate in prediction of contact stresses and load distribution in bolted composite joints with multiple bolts, it is unable to predict the thickness on strength. Generally the piles near the interface of laminates are heavily loaded and hence due to bolt deformation, it usually fails firstly. The study carried out presents the analysis method to account for variation of stresses in the thickness direction by augmenting a two-dimensional analysis with a one-dimensional through the thickness analysis The two-dimensional in-plane solution method based on the combined complex potential and vibrational formulation satisfies the equilibrium equations exactly, and satisfies the boundary conditions and constraints by minimizing the total potential.

V.P. Lawlor, M.A. McCarthy, W.F. Stanley:

An experimental study is presented on the effects of bolt-hole clearance in single-shear, single-bolt, composite bolted joints. Variable clearances were obtained using specially manufactured reamers, ranging from neat-fit to 240 microns (which is somewhat larger than the largest allowed clearances in the aircraft industry). The specimens were manufactured in accordance with the appropriate ASTM standard from graphite/epoxy HTA/6376, with quasi-isotropic and zero-dominated lay-ups. Both protruding head and countersunk bolts were used, with two different applied torque levels.

Sreesankar K. K., AmalHisham E. Shereef, Adarsh Dinesh, DhanushV,Rasil Raj P. V.:

In structural applications such as aircraft, spacecraft and civil engineering structures, composite components are often fastened to other structural members by bolted joints. Bolted joints being very often the critical part of the structure, it is therefore important to design them safely. In this study, Three-dimensional finite element model have been developed. Investigations on the effect of failure criteria including the behaviour of bolted joints in aircraft using aluminium laminates are examined. The joint type studied is single - bolt, single - lap joint. Load bolt displacement curves and stress around the hole is analysed. The model is generated in Finite Element Software, FEASTSMT and attempts are made to validate it by X-ray diffraction technique.

Noah M. Salih, Mahesh J. Patil:

The mechanism of load transfer in hybrid joints is complicated because of differences among alternate load paths stiffness. The load distribution in hybrid composite single-lap joints has been predicted through use of a three-dimensional finite element model including the effects of bolt–hole contact and non-linear material behaviour. The effect of relevant joint design parameters on the load transferred by the bolt have been investigated through a finite element parameter study. Joint configurations where hybrid joining can provide improved structural performance in comparison to adhesive bonding have been identified. In this project we focus on the load transfer in hybrid (bonded/bolted) joint single lap and also investigate the effects of material properties, tensile load, adhesive thickness, bolt diameter and overlap region.

II.LITERATURE SURVEY ON COMPOSITE LAMINATES:

Zhenqing Wang et al.:

Authors have discussed extended finite element method (XFEM) is used to predict the failure of single-lap bolted joints. To simplify calculation of XFEM model, composite laminates of joint have been modelled using linear elastic properties. Three-dimensional equivalent material properties have been calculated by the MATLAB code written. Progressive failure of bolted single-lap composite joint has been investigated, and the failure load of joint simulated by XFEM was compared with experiments in literature. Then the influences of geometric parameters on failure load of one bolt single-lap composite joint have been studied. Two geometric parameters include plate width-to-hole diameter ratio (W/D) and the edge-to-hole diameter ratio (E/D). At last the failure of single-lap joints with one bolt and two bolts have been compared.

Álvaro Olmedo, Carlos Santiuste:

A new set of failure criteria to predict composite failure in single lap bolted joints is proposed. The present failure criteria are an extension of Chang Lessard criteria considering a three dimensional stress field and including out of plane failure modes. The advantage with respect to other three dimensional failure criteria is the consideration of non-linear shear stress strain relationship. The failure criteria were implemented in a finite element model and validated through comparison with experiments in literature. Stresses were calculated by a non-linear finite element model developed in ABAQUS/Standard which con siders material and geometric nonlinearities. A progressive damage model was implemented in a USDFLD subroutine. The model predicted the effect of secondary bending and tightening torque showing an excellent agreement with experimental results. Moreover, results were compared with those reported in literature using Hashin failure criteria. In addition, a parametric study

was carried out to analyse the influence of friction coefficient and tightening torque.

X. Irisarri , A. Lasseigne , F.-H. Leroy, R. Le Riche:

This article introduces the concept of stacking sequence table (SST) for the optimal design of laminated composite structures with ply drops. The SST describes the sequence of ply-drops ensuring the transition between a thick guide laminate and a thinner one. A blended design is represented by a SST combined with a thickness distribution over the regions of the structure. An evolutionary algorithm is specialized for SST-based blending optimization. Optimization of the sequence of ply-drops with the proposed algorithm enables satisfying design guidelines that could not have been considered in previous studies. An extensive set of design guidelines representative of the actual industrial requirements is introduced. The method is applied to an 18-panel benchmark problem from the literature with convincing results. In particular, the present results show that strength-related guidelines can be enforced without significantly penalizing the stiffness behaviour and consequently the mass of the structure.

III. LITERATURES BASED ON THE FIBRE ORIENTATION

Prashanth Banakar1, H.K. Shivanandaand H.B. Niranjan:

The objective of this research was to gain a better understanding of tensile properties of epoxy resin composites reinforced with glass fibre. The effect of fibre orientation & thickness of laminates has been investigated & experimentation was performed to determine property data for material specifications, the laminates were obtained by hand layup process. The laminates were cut to obtain ASTM standards. The test ready specimens were subjected to tensile loads on UTM machine. This research indicates that tensile strength is mainly dependent on the fibre orientation & thickness of laminated polymer composites.

SandeepM.B ,D.Choudhary , Md. NizamuddinInamdar , Md. QalequrRahaman:

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 fibre 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 fibres at 0-900 and -45+450 orientation.

Mr. M. M. Jadhav, Mr. P. V. Gunjavate:

This paper deals to find optimum laminate which can sustain maximum critical buckling load. Along with that this study investigated to compare experimental and ANSYS result. This homogenization of method can be used to find optimum laminate. The fibre orientation [0/45/90/-45] and [45/90/-45/0] are having high buckling load than fibre orientation [90/-45/0/45] and [-45/0/45/90]. If outer fibre orientation having 0° at either surface, will have good buckling strength than 90º at outer surface. Difference of fibre direction and loading direction for all the lamina is decreased then critical buckling load also increases. E.g. [30-0-45-0-30] having 230.23N critical buckling load which is maximum for above laminate. All the fibres are having fibre direction near to loading direction.

D. G. Thakur:

Even though near net shape manufacturing of fiber reinforced plastics (FRP) is possible, drilling is an unavoidable operation, particularly for assembly of structures/panels having holes of specified dimensional tolerance, surface texture and integrity. In the present work drilling tests were carried out on GFRP composites with conventional HSS (18-4-1) drill bit and then by modifying the drill geometry (web or chisel edge) i.e. web thinning in order to show the effect of drill geometry in general and web (chisel edge) in particular on the performance of the drilling of GFRP composite. It is observed that the fibre orientations and drill geometry plays a vital role on the cut quality and delaminating.

IV. CONCLUSION:

The concluded summary from the literatures is as below**,** most of the reported literature focuses on studies of the progressive failure analysis of the composite laminates. Progressive failure of bolted single-lap composite joints has been investigated, and the failure load of joint simulated by FEM. Tsai-Wu criterion was used to determine bearing strength corresponding to the first failure load. The outcome of literature studied emphasizes on determining the ultimate strength of the joint by modelling adhesive failure and core shear failure of the sandwich panels. Therefore for various applications single bolted lap joint with its composite plate can be used which will provide good strength to weight ratio.

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