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Study on Analysis of Bolted Joint in Composite Laminates: Review Paper

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Abstract:- When composites are employed as structural materials, joining of composites to other materials is necessary because manufacturing structures with composites only is not generally feasible, Clamping force is a key element that alters the mechanism and sequence of failure in bolted joints of composite laminates this failure in bolted joints can be controlled by geometrical parameters To increase the efficiency of whole structures with the composite bolted joints, the laminate with stacking sequence. Hence this bolted may be analysis to tensile increase the behaviour and strength of bolted joints.& can be understood a good comprehension of the local behaviour of the fasteners and surrounding composite is needed this can be done by using experiments.

I. INTRODUCTION

The main objective of bolted joints is to transfer applied load from one part of the joint structure to the other through fastener elements. The introduction of composite materials in the automotive industry, places new demands on the materials and manufacturing processes in terms of cost, cycle time and automation. Manufacture and assembly of composite structures require knowledge of reliable joining techniques. Mechanical fastening is a common method used to join
composite materials. The increased use of composite materials in aeronautical applications over the last three decades has generated the need for developing reliable models able to predict the static behaviour of critical composite aircraft components, In aircraft, composite structures usuallyhave relatively thick parts which are designed to carry high levels of structural loads. The most preferred method of joining such structures is, therefore, mechanical fastening by means of bolted joints. Major structural components are subjected to repeated loads during service of aircraft Since most composite materials exhibit brittle failure, with little or no margin of safety through ductility, the mechanism of the brittle failure propagation in bolted composite joints must be fully understood. The bolted laminates develop local failures or exhibit local damage such as matrix cracks, fiber failure, fiber-matrix shear-outs and delaminations. The ability to predict initiation and growth of such damage, which is essential for assessing the performance of the joints and design them with safety, can only be offered by progressive damage modeling techniques. no of researcher works to improve the performance of bolted.

II. REVIEW WORK CARRIED

Gordon Kelly, Stefan Hallstro¨m in March 2003Division of Lightweight Structures, Department of Aeronautical and Vehicle Engineering, Kungl Tekniska Ho¨gskolan, S-100 44 Stockholm, Sweden works on The "bearing strength of carbon fiber epoxy laminates manufactured from non-crimp fabric from heavy tow yarn has been investigated have been determined experimentally together with the effect of" initial bolt-hole clearance on the bearing strength at 4% hole deformation and at ultimate load. Significant reduction in bearing strength at 4% hole deformation was found for both pin-loaded and clamped laminates as a result of bolt-hole clearance. It was concluded that the effect of bolt-hole clearance is significant with regard to the design bearing strength of mechanically fastened joints he conclude that The effect of the geometrical parameters such as width to hole diameter ratio ðw>dÞ; edge distance to hole diameter ratio ðe>dÞ and the thickness to hole diameter ratio ðt>dÞ on the ultimate bearing strength were determined. The effect of lateral clamping load on the bearing strength was also determined. Bearing failure occurred in pin-loaded laminates with w>d2 and e>d 1:5: Application of a lateral clamping load increased the minimum width and edge distance ratios necessary to avoid net-section failure to w=d 3 and e=d 2:

Eui-Sup Shina,*, Seung-Jo Kimb works on "Finite element analysis of pin-loaded composite laminates by connecting independently modeled sub domains" the a *Department of Aeronautics and Space Engineering, Tohoku University, Aoba-ku, Sendai 980-8579, Japan* , A sub domain-based variation formulation for a class of contact problems is carried out to analyze the mechanical behavior of pin-loaded composite laminates. The inequality constraints on contact surfaces are re-stated by using an exterior penalty method. The penalty method

is also used for connecting independently modeled sub domains that satisfy interface compatibility conditions. By this method, any complex configuration of the laminate can be easily modeled and divided into finite element sub domains without considering the conformity on interfaces. In this section, making use of the developed finite element code, the bolted joint problems of composite laminates are treated as a representative contact problem. A basic numerical study is first carried out in the case of a single pin joint, and then the application to the case of multi-pin joints is illustrated.

K.I. Tserpesa, G. Labeasb, P. Papanikosb, Th. Kermanidisa,* Laboratory of Technology and Strength of Materials, Department of Mechanical Engineering and Aeronautics, University of Patras, Patras 26 500, Greece November 2001 works on the Strength prediction of bolted joints in graphite/epoxy composite laminates A parametric finite element analysis was conducted to investigate the effect of failure criteria and material property degradation rules on the tensile behaviour and strength of bolted joints in graphite/epoxy composite laminates. The analysis was based on a three-dimensional progressive damage model (PDM) developed earlier by the authors. The PDM comprises the components of stress analysis, failure analysis and material property degradation. The predicted load–displacement curves and failure loads of a single-lap single-bolt joint were compared with experimental data for different joint geometries and laminate stacking sequences he performed, the macroscopic failure mechanism of the joint and the damage progression were. In order to modify, improve and further verify the 3D PDM By comparing load–displacement curves and failure loads with respective experimental results the model predictions were assessed, and investigation on the effect of failure criteria and material property degradation rules on model predictions was conducted. The PDM predicts accurately the stiffness of a composite single-lap single-bolt joint subjected to quasi-static tensile loading. The predicted stiffness was not influenced by the failure criteria and material property degradation rules incorporated in the model. The inclusion of the shear stress term in the fibre tensile Hashin-type failure criterion leads to overestimation of this damage in cases where this term is large compared to the longitudinal term. This phenomenon is usual in pin/bolt loaded laminates where high shear stresses develop in the contact area in the 458 direction with respect to the loading direction. As a consequence, the analyses using this criterion stopped prematurely giving conservative predictions of strength. To overcome this problem the Maximum Stress criterion is proposed for use instead to the Hashin-type criterion.

An analytical model for the prediction of through-thickness stiffness in tension-loaded composite bolted joints done by P.J. Gray, C.T. McCarthy Materials and Surface Science Institute, Department of Mechanical and Aeronautical Engineering, University of Limerick, Ireland February 2012 he presents the development of an analytical model for replicating the through thickness stiffness of single-bolt, single-lap composite joints subjected to secondary bending. The model is an extension of a spring-based method, where bolts and laminates are represented by a series of springs and masses. The method is validated against detailed three-dimensional finite element models of bolted composite plates and good agreement was obtained. The method is subsequently employed to calibrate the through-thickness stiffness of single-bolt, single-lap joints in highly-efficient numerical models.

A highly efficient bolt tension model for single-bolt joints has been developed in this paper. This method addresses the out-of plane loading mechanism in single-bolt joints. Similar to an analytical model developed for in-plane loading it was found that a spring-based approach was suitable for modeling bending effects in the laminate, clamping effects around the hole and axial tension in the bolt.

Roman Starikova, Joakim Scho¨ nb aDivision of Lightweight Structures, Department of Aeronautics, Royal Institute of Technology, SE-100 44 Stockholm, Sweden November 2001 works on the Local fatigue behaviour of CFRP bolted joints, Measurements of the local strain between two bolts were made by using strain gauges on composite joints with different configurations. Bolt movement was measured on bolts during cyclic loading. It was found that the presence of the bolt affects the strain development between the bolts. The measured bolt movement and strain loops show the influence of friction forces, bolt pre-stress, and fatigue damage in the joint system on the fatigue behavior of bolted laminates. Fractographic observation showed that bolted joints tested at high loads sustained severe damage around the bolt holes. The fatigue behavior of the particular fastener influenced the amount of fatigue damage observed at different bolt holes

He conclude that Fatigue degradation of the fastener system involved washer failure, reduction in bolt pre stress, and fatigue damage at the bolt holes. Broken bolts usually failed in the middle of the bolt shank where the largest strain occurred along with Bolt movement was found to increase measurably during fatigue testing. Changes in the bolt behavior occur very early in the fatigue life of bolted joints and reflect rapid changes in the damage state of the fastener system and the adjacent composite.

In August 2011 A. Atas G.F. Mohamed C. Soutis Department of Mechanical Engineering, University of Sheffield, Sheffield S1 3JD, UK works on the Effect of clamping force on the delimitation onset and growth in bolted composite laminates The mode of failure in bolted joints can be controlled by geometrical parameters and the preferred fail safe mode of failure is ‘bearing’ which generally consists of matrix cracks, elimination and fibre microbuckling. Three dimensional (3-D) pinned (without clamping force) and bolted(1 kN clamping force)

joint models were developed in [0/90]s carbon fiber reinforced plastic (CFRP) laminates to show the clamping force effect on the onset and growth of delimitation. It is shown that delimitation was resulted from the shear stress components (Mode II & III) at the interface and the contribution of the out-of-plane component (Mode I – opening), so the clamping force, was negligible without modeling the in-plane failure modes and their coupling with desalination, which will be considered in future work. He conclude that A 3D FE model incorporating CZE in order to predict the effect of clamping force on the onset and growth of delimitation damage in mechanical joints of composite laminates is presented. The stress distribution around the pin-loaded hole and delimitation prediction capability has been verified with the widely used cosine stress distribution model and with the X-ray images from the literature, respectively. It is showed that without modeling the in-plane failure modes (transverse ply cracking and axial splitting), the effect of Mode I component is insignificant on the onset and growth of delimitation; of course in the case of a bolted joint with a certain clamping force Mode I fracture is also restrained.

Tae Seong Lim, Byung Chul Kim, Dai Gil Lee in December 2004 Mechanical Design Laboratory with Advanced Materials, Department of Mechanical Engineering works on the Fatigue characteristics of the bolted joints for unidirectional composite laminates When composites are employed as structural materials, joining of composites to other materials is necessary because manufacturing structures with composites only is not generally feasible. Although the maximum static strength of the composite bolted joint is frequently realized by quasi-isotropic patterns, these patterns are seldom used in structural members under general load, such as bending, compressive, and tensile load. To increase the efficiency of whole structures with the composite bolted joints, the laminate with stacking sequence of [±h/08]S was proposed in this work. The fatigue characteristics of the [±h/08]S laminate bolted joint were investigated with respect to the angle h and the bolt clamping pressure and compared with the result of the [02/±453/902]S laminate, which was proposed as one of the optimum stacking sequence under the static load. From the experiments on the bolted joints, it has been found that the laminates whose major plies are stacked in the axial direction can be used for the bolted joint structures under fatigue load when an appropriate clamping pressure is applied to the bolted joint. He conclude that In order to increase the composite structural efficiency, the static and fatigue characteristics of the bolted joints for the laminates with stacking sequence of [±h/08]S tested with respect to the bolt clamping pressure and compared with those of the laminate with the stacking sequence of [02/±453/902]S, which was known as one of the optimum stacking sequence for the bolted joint. Also, the stress distributions of the [02/±453/902]S and [902/08]S laminates were calculated by the finite element analysis. From the test and analysis results.

A. Barut, E. MadenciThe University of Arizona, Tucson, AZ 85721, United States A semi-analytical solution method is developed for stress analysis of single-lap hybrid (bolted/bonded) joints of composite laminates under in-plane as well as lateral loading. The laminate and bolt displacements are based on the Mindlin and Timoshenko beam theories, respectively. For the adhesive, the displacement field is expressed in terms of those of laminates by using the shear lag model. The derivation of the governing equations of equilibrium of the joint is based on the virtual work principle, where the kinematics of each laminate are approximated by local and global functions and the bolt kinematics is assumed in terms of cubic Hermitian polynomials. The capability of the present approach is justified by validation and demonstration problems, including the analysis of bolted and bonded joints and hybrid joints with and without considering a disbond between the adhesive and laminates. a semi-analytical method was developed for the coupled in-plane and bending analysis of composite bonded– bolted single-lap hybrid joints. The bending is mainly due to the force couples created by the lap geometry. The laminates are joined through an adhesive bond layer along the overlap region between the laminates and a pre tensioned bolt placed right at the center of the overlap region. The validation against bolted and bonded joint analyses showed the ability of the present approach in tackling both problems separately. The comparison of the results proved the robustness and accuracy of the present approach in capturing the correct response of the contact stresses in the bolted joint analysis and adhesive shear and peel stresses in the bonded joint analysis. In the hybrid bonded–bolted joint analysis, it is not surprising that most of the load is transferred through the adhesive, even though it has low elastic modulus as compared to the bolt. This is due to the fact that the adhesive has a large area and small thickness, thus yielding substantially high adhesive shear stiffness that does not allow enough relative displacements between the laminates to exert forces on the bolt in opposite directions.he conclude that a semi-analytical method was developed for the coupled in plane and bending analysis of composite bonded– bolted single-lap hybrid joints. The bending is mainly due to the force couples created by the lap geometry. The laminates are joined through an adhesive bond layer along the overlap region between the laminates and a pre-tensioned bolt placed right at the center of the overlap region. The validation against bolted and bonded joint analyses showed the ability of the present approach in tackling both problems separately. The comparison of the results proved the robustness and accuracy of the present approach in capturing the correct response of the contact stresses in the bolted joint analysis and adhesive shear and peel stresses in the bonded joint analysis.

III. CONCLUSION

As bolted joints is to transfer applied load from one part of the joint structure to the other through fastener elements. and sequence of failure in bolted joints this failure can be removed by laminates many researcher works on this laminates to improve the strength & efficiency by doing different experimental set up with different models. but still lots of works to be done in future.

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