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"Overlap Shear Strength Determination In Composite Materials Using Finite Element Approach For Single Strap Butt Joint"

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Abstract

A composite material consists of a mixture of a base material called the matrix, with grains of other materials called the inclusions. These materials are very common in engineering applications like the construction industry. Yet the role of the composite in the efficiency of such device is not well understood. Modelling composite materials is difficult due to the random nature of such mixtures. However if some controls are established during the production process, it is reasonable to assume homogeneity and isotropy. Evaluation of shear strength in different types of joint configuration is imperative because shear strength contributes the biggest role for any kind of failure. Merely determining of different stresses produced under different load conditions using conventional methodology does not give a precise picture of the pattern of failure moreover it is become very tedious to identify the exact location of the failure as well .So, using finite element approach it becomes possible to find the exact pattern and location of the different failure points. In the present work single strap butt joint is considered for the analysis. It is found that Maximum shear stress obtained when the gap is not filled with adhesive layer between butt plates. Bonding strength of the structural joints are depends upon the geometric and material parameters.

1. Introduction

Adhesive bonding is a material joining process in which an adhesive, placed between the adherend surfaces, solidifies to produce an adhesive bond. Adhesively bonded joints are increasing alternatives to mechanical joints in engineering applications and provide many advantages over conventional mechanical fasteners. Among these advantages are lower structural eight, lower fabrication cost, and improved damage tolerance. The application of these joints in structural components made of fiber-reinforced composites has increased significantly in recent years. The traditional fasteners usually result in the cutting of fiberss, and hence the introduction of stress concentrations, both of which reduce structural integrity. By contrast, bonded joints are more continuous and have potential advantages of strength-to-weight ratio, design flexibility, and ease of fabrication. In fact, adhesive bonding has found applications in various areas from high technology industries, such as aeronautics, aerospace, electronics, and automotive to traditional industries, such as construction, sports, and packaging.

2. Problem Identification

These applications are in the form of single skin as well as sandwich configurations. The structures could potentially be made up using different fiber types, fiber architectures and weaves, and resins. Bonded joints are frequently expected to sustain static or cyclic loads for considerable periods of time without any adverse effect on the load-bearing capacity of the structure. A lack of suitable material models and failure criteria has resulted in a tendency to 'overdesign' composite structures. Safety considerations often require that adhesively bonded structures, particularly those employed in primary load-bearing applications, include mechanical fasteners (e.g. bolts) as an additional safety precaution. These practices result in heavier and more costly components. The development of reliable design and predictive methodologies can be expected to result in more efficient use of composites and adhesives. To design structural joints in engineering structures, it is necessary to be able to analyse them. This means to determine stresses and strains under a given loading, and to predict the probable points of failure.

3. Solution Approach

There are two basic mathematical approaches for the analyses of adhesively bonded joints: closed-form analysis (analytical methods) and numerical methods (i.e. finite-element analyses). On the other hand, sandwich composite constructions are increasingly used in various applications in many industries due to the combination of high strength and low weight, leading to a highly efficient structure. Other advantages offered by sandwich construction are elimination of welding, high insulating qualities, and design versatility. In its simplest form, this type of construction usually consists of two thin outer face sheets of stiff, strong material (in this case, a composite) separated by a thick, lightweight layer of core material (e.g. foam, honeycomb, or corrugated). Joints represent one of the greatest challenges in the design of structures in general and in composite structures in particular since they entail discontinuities in the geometry of the structure and/or material properties, and introduce high local stress concentrations. Unlike surface preparation, joint configuration is usually a product of design.

4. Finite Element Approach

The finite-element method has the great advantage that the stresses in a body of almost any geometrical shape under load can be determined. Linear and non-linear finite-element analyses have been carried out on different types of adhesive joints, and the adhesive effective stresses and strains have been evaluated. Since the adhesive layer is thin compared with the thickness of the adherends, a fine mesh in these areas is required so that the number of degrees of freedom in a joint is rather high. A full finite-element analysis should include the effects of bending, adherend shear, end effects, and non-linear behaviour of the adhesive and adherends .Numerous studies on the analysis of bonded joints with composite adherends have been published, many of them being concerned with the definition of appropriate failure criteria for improved joint strength predictions. Adhesive bonded joints contain inherent defects from their manufacture. The crack initiation starts from these defects and leads later to failure of the assembly. The fracture strength of adhesive joints depends on a number of factors and their combinations, e.g. adhesive type, cure cycle, adherend type, bond line thickness, and so on. However, a lack of reliable failure criteria still exists limiting in this way a more widespread application of adhesively bonded joints in structural applications. An accurate strength prediction of adhesively bonded joints is essential to decrease the amount of expensive testing at the design stage. Currently used approaches for predicting the strength of adhesively bonded joints are: the continuum mechanics approach (stress based), fracture mechanics, and damage mechanics approach..

5. Finite Element Model

5.1 Geometry

In this part, a typical single strap butt joint used for the study. The overlap length is 50mm, the thickness of outer adherend, inner adherend and adhesives are 10, 10, and 0.35 mm, respectively. Geometrical details are shown in figure1

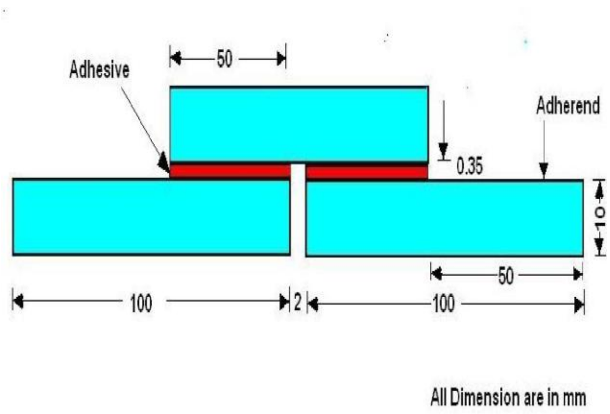

Figure 1. Single Strap Butt Joint Configuration

5.2 Material Properties

Linear-Elastic material properties are as follows:

Epoxy adhesive: Young's modulus Ea =0.056 GPa,

Poisson's ratio μa =0.39

Aluminium Adherend: Young's modulus Ea =70 GPa,

Poisson's ratio μA=0.33

Due to symmetry of the structure, only one-half of the joint was considered. The behaviour of all the members is assumed to be linear elastic. The adhesive layer was assumed to be linear elastic. The numerical analysis of the joint was done by using ANSYS-10 software. The PLANE 82 elements were used for meshing the member as shown in Figure 2 These elements have 8 nodes and 2 degrees of freedom at each node. The elements size in the adhesive layer was refined to get better results, Fig.2. There are a total of 1460 elements and 3,948 nodes.

5.3 Boundary condition

In ANSYS, the following loads and constraints are applied.

Displacement: v = 0 (along the bottom edge)

u = symmetry condition (along the right edge of upper adherend)

Pressure: p = 10N/mm2 (at the left edge of lower adherend)

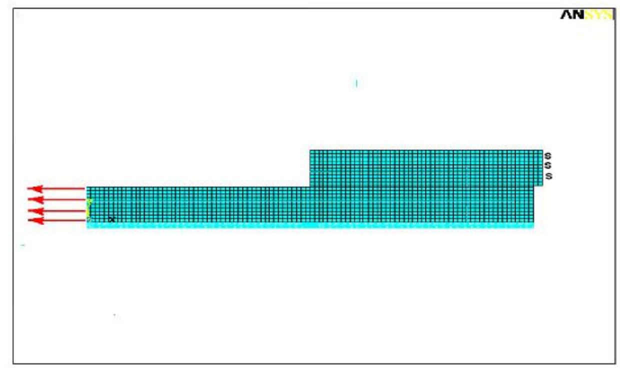

Figure 2. Meshing Members

6. Results

Due to the stress singularity, stress concentration etc. the joint is susceptible to fail at the free edge. Maximum shear stress obtained when the gap is not filled with adhesive layer between butt plates. Bonding strength of the structural joints are depends upon the geometric and material parameters. The variation of shear stress along the overlap length of the joint is shown in figure 3.

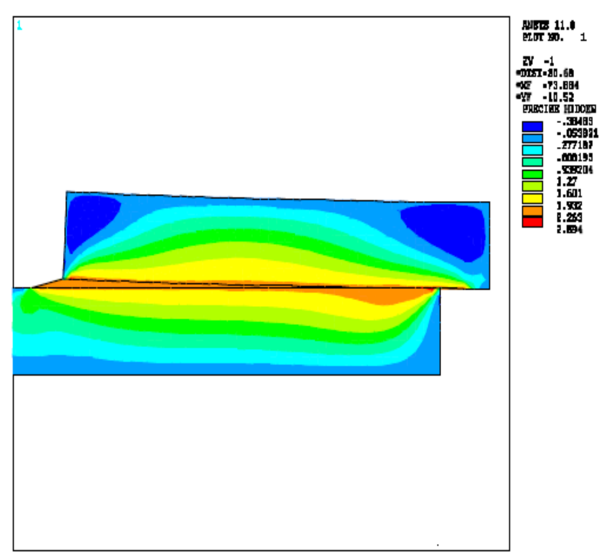

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Figure 2. Shear stress distribution along the overlap length

7. Conclusion

Since the adhesive joints the applied loads on the adherends are transferred on to the adhesive layer mainly by shear stress, this stress was considered for analysis. Shear stress is largest at a very small distance from the free edge. Due to the stress singularity, stress concentration etc. the joint is susceptible to fail at the free edge. Maximum shear stress obtained. When the gap is not filled with adhesive layer between butt plates. Bonding strength of the structural joints are depends upon the geometric and material parameters. Overlap length adhesive thickness, adherend thickness and material properties are influence the adhesive bond strength. Most of the researchers has studied the effect of parameter on the bond strength for different type of structural joint. So it is necessary to study the effect of geometric parameter on the adhesive bond strength which is helpful for design purposes. Overlap length, adhesive thickness and adhrend thickness are the geometric parameter while shear modulus of adhesive, young's modulus of adhrend are the important material factor which decide the adhesive bond strength.

8. References

[1] Khalili SMR, Khalili S, Pirouzhashemi MR, Shokuhfar, Mittal RK (2008) "Numerical study of lap joints with composite adhesives and composite adherends subjected to in-plane and transverse loads" International journal of adhesion and adhesive Vol-28:411-418.

[2] Zgoul M, Crocombe AD (2004) "Numerical modeling of lap joints bonded with a rate dependent adhesive." International journal of adhesion and adhesive volumel-24:355-366.

[3] Aydin I, Colakoglu G, Hiziroglu S (2005) "Surface characteristics of spruce veneers and shear strength of plywood as a function of log temperature in peeling process" International journal of solids and structures Vol-43:6140-6147.

[4] Hiziroglu S and Rabiej R (2005) "Factor affecting adhesive shear strength of overlaid composite panel." American Journal of Applied Science Vol-14:112-118.

[5] Valle'e T, Correia JR, Keller T (2006) "Probabilistic strength prediction for double lap joints composed of pultruded GFRP profiles part 1: Experimental and numerical investigations" Vol-66:1903-1914.

[6] Li G, Sullivan PL (2001) "Finite element and experimental studies on single-lap balanced joints in tension." International journal of adhesion and adhesive V0l-21:211-220.