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STRESS AND STRENGTH EVALUATION OF DOUBLE LAP ADHESIVE JOINT

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ABSTRACT :- An adhesive is a substance which when applied to the surfaces of materials binds that surfaces together and resists separation. The strength of the adhesive joints under impact loads has become more important because of their huge use to the aircraft and automobile industries. In industries, adhesives are used to join the different or same material. But when those joined material comes under use, It might or might not burst. It relies on the amount of load placed on the joint, the kind of adhesive material used to attach the materials, and the area where the two materials come into contact. Joint failures are a major factor in equipment breakdowns that result in expensive downtime. To prevent that, we should know the strength of the adhesive joint for that two particular material. Key wards: Adhesive Joints. Strength, Loading.

I. INTRODUCTION

Adhesive bonding technology has been widely used for many decades in various sectors of industry, for example, in modern aircraft structures of aerospace industry (Higgins, 2000). More importantly, it can be used to effectively join similar and dissimilar materials to form load-bearing engineering structural joints (Adams et al., 1997; Tong and Steven, 1999). Adhesive bonding can be particularly effective when used to join thin metallic and/or laminated composite sheets in the context of efficiently transferring load from one substrate to another. To efficiently use an adhesive joint in practice, it is important to predict its stresses and strength accurately. Adhesive joints with representative or simple configurations have been used as standard test methods and thus widely investigated. This paper deals with the development of finite element techniques for efficient stress analysis of structural bonded joints. The development of mathematical and numerical models to study or forecast the behaviour of those joints went hand in hand with the rising use of adhesive bonding for structural joining. The finite element approach has been widely applied to numerical models. Different special adhesive elements have been formulated both in two and three dimensions, to capture the main features of stresses in the adhesive layer, through a simple, efficient and cost-effective procedure. One of the first two-dimensional (2D) adhesive elements was presented by Rao et al. [1]. They developed a special six-noded isoperimetric element for the adhesive layer, compatible with the eight-noded isoperimetric quadratic element used to model the adherents. In a subsequent work, Yadagiri et al. [2] modified that element to include longitudinal and normal stresses and linear viscoelastic response. Hereditary integrals were used to represent the stress–strain relations. Andruet et al. [3] developed an ad hoc model for three dimensional (3D) analysis of adhesive joints based on shell and solid elements. The shell elements are used to model the adherends and the adhesive layer is modeled as a solid element with offset nodes in the midplane of the adherends. The element formulation includes geometric nonlinearities, together with thermal and moisture effects. Goncalves et al. [4] proposed a new 3D finite element model to study the behavior of adhesive joints. The model includes an interface element previously developed compatible with brick solid elements from the ANSYS software. The main objective was to calculate the stresses at the interfaces between adherends and adhesive. Tong and Sun developed a novel finite element formulation for adhesive elements specific for conducting quick stress analysis of bonded repairs to curved structures. The elements comprise a pseudobrick adhesive element and two shell elements located on either side of the adhesive layer. Shell elements are offset by half the thickness of the corresponding wall thickness of the element. The adhesive element provides an efficient and cost effective way to model the overlap area in bonded repairs. The presentation of the material and the identification of the rule are organized in three steps: 1. Testing of custom (non-standard) specimens, designed to attain adhesive failure under different combinations of peel and shear stresses 2. Calculation of peel and shear stresses in the adhesive 3. Analysis of the results and synthesis of the design rule.

1.1 Adhesive bonding

is a process of joining two or more solid parts with an adhesive substance. The materials of the joined parts (adherents, substrates) may be different or similar. The material of the adhesive layer is commonly a polymer (natural or synthetic). Thickness of the adhesive layer does not usually exceed 0.02” (0.5 mm).

Structure of adhesive joint a. Adhesion b. Wetting c. Failure of adhesive bonding

1.2 Structure of adhesive joint

Adhesive joint generally consists of two substrate surfaces with the adhesive material filled the gap between them. However the adhesive layer is not uniform. Besides the part of the adhesive layer, properties of which are not affected by the substrate, there are two boundary layers, which have been changed by impurities and products of reactions at the substrate surfaces. Boundary layer is a part of the adhesive layer adjacent to the substrate surface.

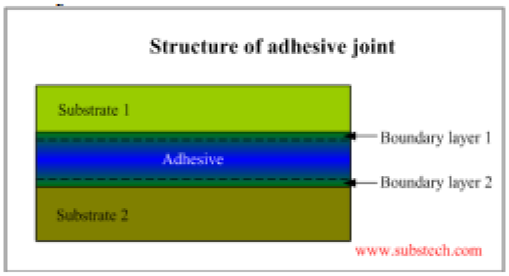

Fig. 1 Structure of adhesive joint

1.3 Adhesion

The principle basis of adhesive bonding is a phenomenon called adhesion Adhesion is a complex of physicochemical processes occurring at the interface of two materials brought into an intimate contact, which result in formation of an attractive force between the two materials. Adhesion strength is a force required for separation of two adhered parts along the interface. The following factors determine the value of adhesion strength of adhesive bonding: a. Mechanical factor Porous or roughened surfaces provide stronger adhesion due to:

a. larger interfacial area;

b. interlocking the adhesive material in the surface micro-voids.

1.4 Chemical bonding Molecules of the adherent material may form chemical bonds with the molecules of the adhesive across the interface. The chemical bonds may be either ionic or covalent.

1.5 Ionic bond is formed when an atom donates its electron to another atom. As a result of the electron transition two ions form: positively charged cation and negatively charged anion. The force of electrostatic attraction between the two ions forms ionic bond. Ionic bond may be formed between two materials with different electro negativities.

1.6 Covalent bond is a chemical bond, in which two atoms share one or more pairs of electrons. Covalent bond may be formed between two materials with similar electro negativities (the difference is lower than 1.7).

1.7 Metallic bond is a chemical bond, in which each of the atoms of the metal contributes its valence electrons to the crystal lattice, forming an electron cloud or electron "gas", surrounding positive metal ions. These free electrons belong to the whole metal crystal and hold together the atoms of a metal. In practice most adhesive materials are polymeric therefore metallic bonds do not form in adhesive joints.

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1.8 Intermolecular bonding Intermolecular bonds are result of relatively weak attraction forces between the neighboring molecules

1.9 Hydrogen bonding is an intermolecular bonding formed between a hydrogen atom chemically bonded to an electronegative atom and other electronegative atom of a neighboring molecule.

1.10 Van der Waals forces are the result of electrostatic attraction between neighboring molecules having permanent or instant transient dipole groups.

1.11 Diffusion Diffusion may become an important factor of an adhesive bonding if the adhesive and adherent (substrate) materials are similar and their molecules are mobile enough and capable to move across the interface.

II. CLASSIFICATION OF ADHESIVES

General classification of adhesives

2.1 Thermosetting adhesives Thermosets molecules are cross linked by strong covalent intermolecular bonds, forming one giant molecule. Cross-linking is irreversible therefore thermosets cannot be reprocessed (remelt). Cross-linking is achieved in curing process initiated by heat, chemical agents, radiation or evaporation of Solvents. Curing results in sharp increase of strength, elasticity and stability of thermosets. Most of thermosetting adhesives are based on epoxies, polyesters, polyimides and phenolics

2.2 Thermoplastic adhesives Thermoplastics are Polymers, which soften (become pliable and plastic) and melt when heated. No new cross-links form (no chemical curing) when a thermoplastic cools and harden. Thermoplastics may be reprocessed many times by heating or applying a solvent. Molecules of most of thermoplastics combine long polymer chains alternating with monomer units. Polyamides, cyanoacrylates, polyacrylates, polyvinyl acetate (PVA) are typical thermoplastic adhesives.

2.3 Elastomeric adhesives Elastomers are polymers possessing high elasticity - may be reversibly stretched at high degree. Elastomers consists of long lightly cross-linked molecules. Elastomers are set (strengthened) by thermal curing or solvent

evaporation. Curing results in increase of crosslinking of the molecules. Typical elastomeric adhesives are based on natural rubbers, silicones, acrylonitride butadiene(nitrile), neoprene, Butyl, polyurethan e, styrene-butadiene.

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III. PROBLEM DEFINATION

Adhesive joints are not effectively used even though adhesive bonding technology has several advantages over conventional joint processes. Because of the involvement of geometrical and fabrication variables in the configuration of scarf adhesive joint a deep understanding of these variables is required. Whenever scarf adhesive joint is loaded under tensile load, due to the scarf angle, mixed stresses are getting developed within the joint which is combination of shear and tensile stresses. The number of characteristics used to configure a scarf adhesive junction, such as scarf angle, adhesive layer thickness, adherend surface roughness, mixture ratio of components of adhesive utilised, etc., considerably affect the tensile strength of the joint. Therefore, it is crucial to research how changes in the scarf adhesive joint's governing factors affect its strength.Also in order to find maximum strength of scarf adhesive joint it is necessary to find optimized values of these controlling parameters which will result in maximum strength. So problem can be defined as experimental parametric study of scarf adhesive joint under static tensile load.

IV. FINITE ELEMENT ANALYSIS

In the present study, stress distribution in double lap adhesive joint is obtained as, Load = 100N (from both way in opposite direction). Material Properties: Modulus of elasticity (E) = 206 GPa Poisson's ratio = 0.3 Density = 7.843 × 103 kg/m3 Parameters selected for analysis: Length of adherends is 90mm, 100mm and 110mm. Width of adherends is 10mm, 15mm and 20mm. Length of adhesive layer is 25mm, 27mm and 30mm To obtain the stresses developed in the double lap adhesive joint under loading condition, analysis is carried out taking 100N load on both sides in opposite direction.

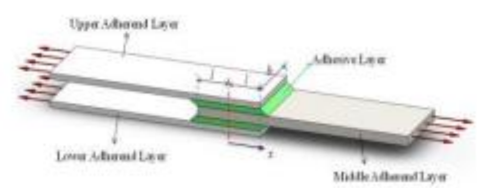

Fig. 2 Parameters used in ANSYS Analysis

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4.1 Cases of stress obtained:

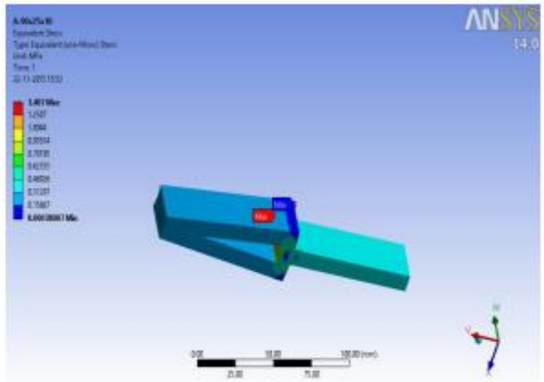

Fig. 3 Case 1.09×52×09

Figure shows that stress induced in lap joint due to applied load. In this join maximum stress induced is 1.23Mpa.

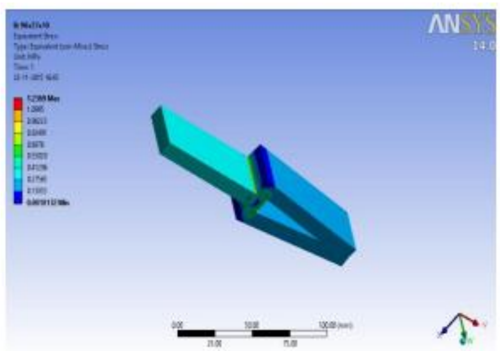

Fig.4 Case 2.09×52×09

Figure shows that stress induced in lap joint due to applied load. In this join maximum stress induced is 1.236Mpa

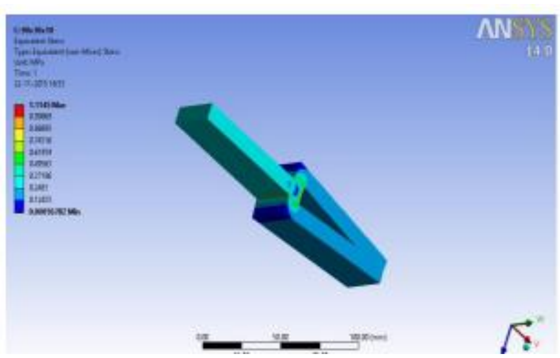

Fig.5 Case 3. 09×09×09

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Figure shows that stress induced in lap joint due to applied load. In this join maximum stress induced is 1.114Mpa.

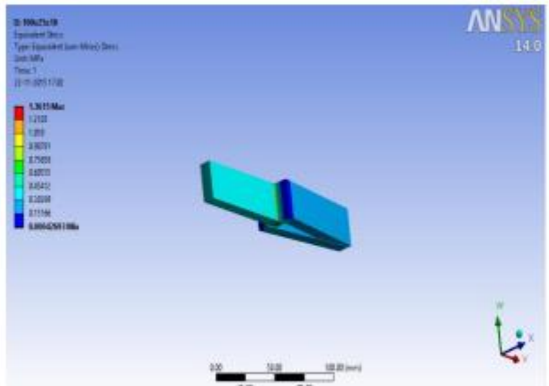

Fig.6 Case 4. 100×25×10

Figure shows that stress induced in lap joint due to applied load. In this join maximum stress induced is 1.36Mpa.

V. RESULTS & CONCLUSIONS

Case	Specification of joint	Total deformation (mm)	Stress (MPa)
1	90×25×10	0.00379	1.407
2	90×27×10	0.00350	1.236
3	90×30×10	0.00314	1.114
4	100×25×10	0.00423	1.361
5	100×27×10	0.00391	1.301
6	100×30×10	0.00351	1.120
7	110×25×10	0.00468	1.363
8	110×27×10	0.00415	1.203
9	110×30×10	0.00388	1.158
10	90×25×15	0.00126	0.732
11	90×27×15	0.00116	0.645
12	90×30×15	0.00104	0.580

13	100×25×15	0.00141	0.708
14	100×27×15	0.00130	0.678
15	100×30×15	0.00117	0.584
16	110×25×15	0.00156	0.766
17	110×27×15	0.00144	0.646
18	110×30×15	0.00129	0.605
19	90×25×20	0.00065	0.645
20	90×27×20	0.00059	0.562
21	90×30×20	0.00053	0.497
22	100×25×20	0.00072	0.619
23	100×27×20	0.00066	0.578
24	100×30×20	0.00060	0.502
25	110×25×20	0.00080	0.608
26	110×27×20	0.00074	0.568
27	110×30×20	0.00066	0.498

The ANSYS program was successfully carried out which can be used to determine the total deformation and stresses developed in double lap adhesive jointThe best option is the 903020 double lap adhesive junction. This joint has the smallest joint deformation (0.00053 mm) and the smallest stress development (0.497 MPa). The change in the joint structure results in the change of deformation and stresses. The ANASYS analysis proves to be a simple& cost effective method in the judgment of good double lap adhesive joint.

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