

Finite Element Analysis of Single Adhesive Joint

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Abstract: - The stresses in adhesive-bonded single-lap joints peak at edges, where failure usually begins, while the center adhesive stress is almost zero. To reduce the stress concentrations, and improve joint strength and efficiency, the mixed-modulus adhesive bonded technology of variable the adhesive stiffness along the overlap was presented. The report also includes an evaluation of the perforated single-lap joint, assumed to promote accelerated ageing by shortening the diffusion path of moisture. A series of stress and deformation analyses using finite element analysis (FEA) has been conducted on the single-lap configuration for this purpose. The analyses also showed that peel stresses tend to be higher than shear stresses for most practical test geometries.

Index Terms- Adhesive Joint, Finite Element Stress Analysis.

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I. Introduction

Adhesive is used very successfully in field like railways, automotive, aerospace, wind energy, construction and medical because of its favorable mechanical properties. It plays a big role to joint in home appliances for different material. We can joint by various methods like Screwing, fitting, clamping, welding etc. But sometimes material cannot be bolted, riveted or welded. So in such situation the adhesive joint is used and is increasingly rapidly. The joints which connect two components together in a common way of technology for assembling structures, and increasingly being used in various industries like Aerospace, Automotive and civil engineering. An adhesive, also known as glue, cement, mucilage, or paste is any nonmetallic substance applied to one surface, or both surfaces, of two separate items that binds them together and resists their separation. Adjectives may be used in conjunction with the word "adhesive" to describe properties based on the substance's physical or chemical form, the type of materials joined, or conditions under which it is applied.

The use of adhesives offers many advantages over binding techniques such as sewing, mechanical fastening, thermal bonding, etc. These include the ability to bind different materials together, to distribute stress more efficiently across the joint, the cost effectiveness of an easily mechanized process, an improvement in aesthetic design, and increased design flexibility. Disadvantages of adhesive use include decreased stability at high temperatures, relative weakness in bonding large objects with a small bonding surface area, and greater difficulty in separating objects during testing [1]. Adhesives are typically organized by the method of adhesion. These are then organized into reactive and non-reactive adhesives, which refer to whether the adhesive chemically reacts in order to harden. Alternatively they can be organized by whether the raw stock is of natural or synthetic origin, or by their starting physical phase.

Adhesives may be found naturally or produced synthetically. The earliest human use of adhesive-like substances was approximately 200,000 years ago[2], When Neanderthals produced tar from the dry distillation of birch bark for use in binding stone tools to wooden handles.[3] The first references to adhesives in literature first appeared in approximately 2000 BC. The Greeks and Romans made great contributions to the development of adhesives. In Europe, glue was not widely used until the period AD 1500–1700. From then until the 1900s increases in adhesive use and discovery were relatively gradual. Only since the last century has the development of synthetic adhesives accelerated rapidly, and innovation in the field continues to the present.

II. Literature Review

Adhesives produced from the traditional tools have been used for thousands of years. The advantages of using adhesively bonding techniques instead of classical mechanical fasteners can be listed as joining similar or dissimilar materials, significantly reducing the stress concentration, providing more-uniform stress distributions along the overlap length, savings in weight and cost, eliminating any cuts/holes in the joint, etc.[4]

There are several analytical methods for the calculation of stress distributions in adhesively bonded joints. However, the implementation and use of analytical models is difficult because of complex nonlinear functions of material properties and geometry.[5] This has resulted in a wide range of solutions developed, each with different assumptions and simplification.

Single lap joints are by far the most widely used adhesive joints and have been the subject of considerable research over the years. The stress distribution within a joint varies with the adhesive and adherend properties, and with the geometric dimensions. The stresses induced by the externally applied forces to the joints are non-uniformly distributed over the bonded area. Even when relatively low modulus adhesives are employed, the stress is never uniformly distributed through the bond line.

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III. Methodology

Dog bone Specimen Selection: Dog bone tensile test samples are primarily used in tensile tests. The sample has a shoulder at each end and a gauge section in between. The shoulders are wider than the gauge section which causes a stress concentration to occur in the middle when the sample is loaded with a tensile force. This stress concentration ensures a higher probability that the sample will rupture away from the ends. When the rupture of a sample occurs in the midsection it is attributed to the material reaching its maximum tensile strength, whereas if the sample ruptures at one of the ends or in the grip itself the failure may be attributed to improper loading or a pre-existing defect in the material.

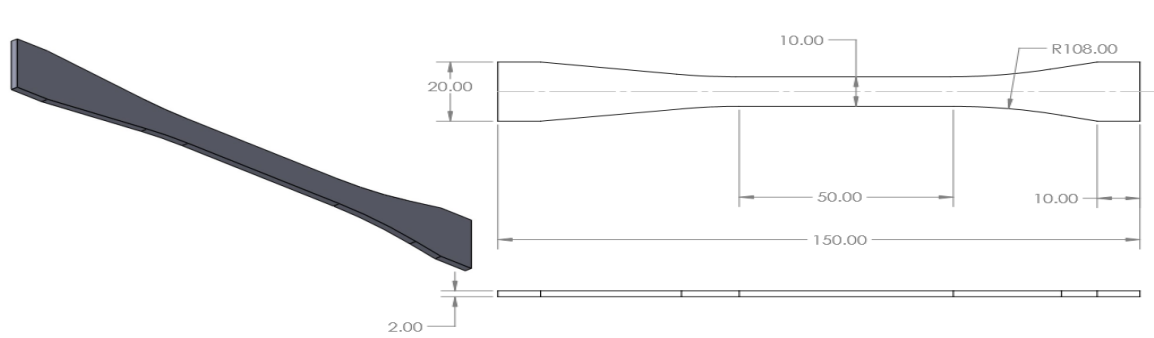


Figure 1 Dogbone

Material Selection:

There are many types of composite materials such as carbon-reinforced fiber plastic, glass fiber-reinforced aluminium, composites with carbon nanotubes, and many more. Other types of composite include metal-matrix and ceramic-matrix composites. Composites have vast usage in engineering applications.

Fixture:

A fixture is a work-holding or support device used in the manufacturing industry. Fixtures are used to securely locate and support the work, ensuring that all parts produced using the fixture will maintain conformity and interchangeability. Using a fixture improves the economy of production by allowing smooth operation and quick transition from part to part, reducing the requirement for skilled labour by simplifying how work pieces are mounted, and increasing conformity across a production run.

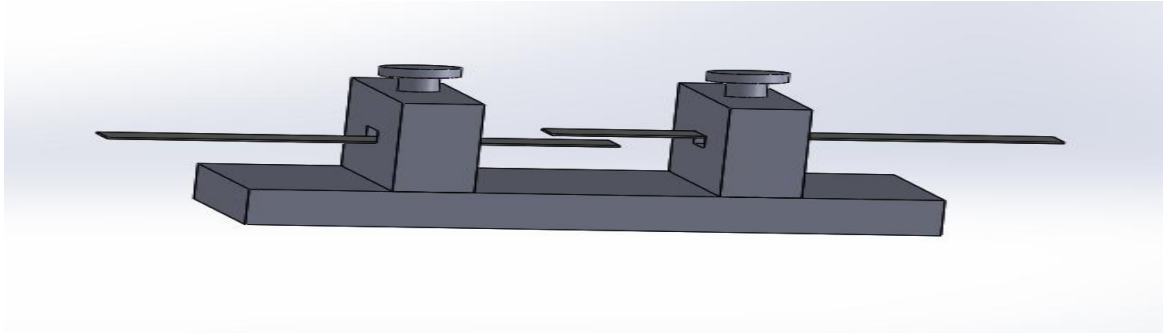


Figure 2 Fixture

Geometry And Material Parameter[10]

NO			Dimensions
1	Adherend thickness	T	1 mm
2	Adhesive thickness	η	1mm
3	Free Adherend length	L	100 mm
4	Overlap length	2l	25 mm
5	Applied Load	F	1000N
6	Adherend Young's Modulus	E₁	230Gpa
7	Adherend Poisson's Ratio	G₁	0.3
8	Adhesive Young's Modulus	E₃	1.392GPa(3)
9	Adhesive Poisson's ratio	G₃	0.33 (3)
10	Adhesive Central Region(ii)	2S	12.5mm

Description [10]:

Aluminum alloy 7075 is alloy with zinc as the primary alloying element. It has excellent mechanical properties, and exhibits good ductility, high strength, toughness and good resistance to fatigue.

Terokal is solvent free, impact resistance two components adhesive based on epoxy resin. This is used as flexible adhesive.

Hysol EA is two component, room temperature cure, and low viscosity epoxy paste adhesive having high peel strength. This is used as a stiff adhesive.

Key Properties:

- Toughened Paste
- High Strength
- Good temperature resistance
- High shear and peel strength.
- High chemicals resistance.
- Processing

Method of Application:

Apply the mixed adhesive to both surfaces of the joint and assemble carefully (a layer of adhesive 0.25mm to thick will normally impart the greatest lap shear strength to the joint).

Keep the joint supported until set (using clamps or tape, etc.) for about 45 to 50 minutes. Allow 2 hours before rough handling. Under normal conditions Araldite attains its full strength after 8 hours. Exact setting time depends on temperatures and the quantity mixed. Setting times may be shorter in hot weather and in cold condition the rate of curing of the mixed adhesive may be slowed down significantly and weak joints may result.

Direction of use:

The surface to be bonded should be cleaned, degreased, roughened and moisture free. The resin and hardener are mixed in the prescribed quantities on a plate. A thin film of the mix is applied on the surface which is to be bonded.

IV. FEA(Finite Element Analysis) WORK

Model Information (Single Lap Joint):

For the purpose of analyzing stress distribution in single lap adhesive joint which is made by Multi Adhesives the single lap joint was simulated on software. Several software is available for simulation purpose but SOLIDWORKS 2018 software used.3D geometry of the specimen considered in this analysis.

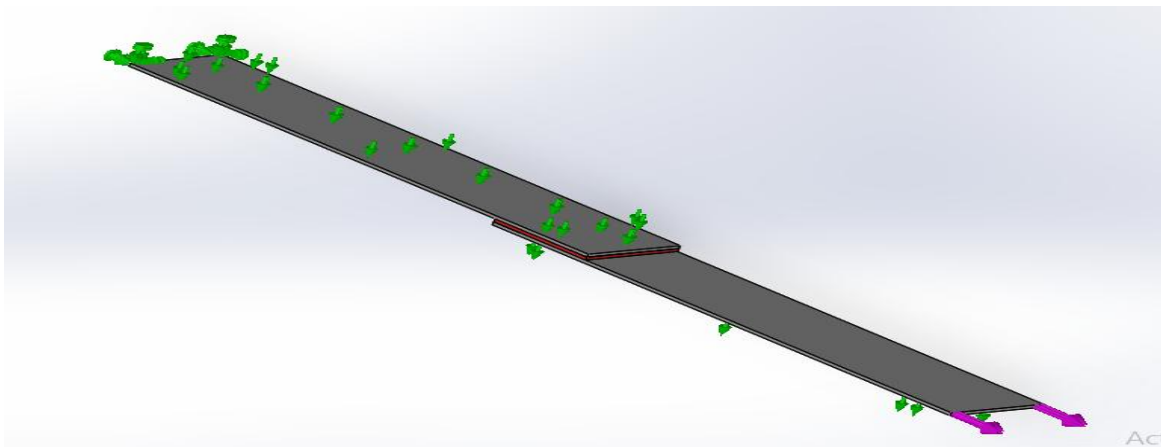


Figure 3 single lap joint

As Shown in figure 4 Boundary condition is applied to the single lap adhesive joint .Concentrated force is applied at the right side at. Where ever left side the fixed support for the lap joint. Roller supports is added at lower and upper adherened at top and bottom both surfaces.

Meshing:

Total 107019 elements and 154655 nodes have been generated in Geometry.Total Jacobian point are 4 point and curvature based mesh has been used in the problem. Now total 26 points are selected at middle portion of the adhesive and save as probe for further graphical result of stress analysis.

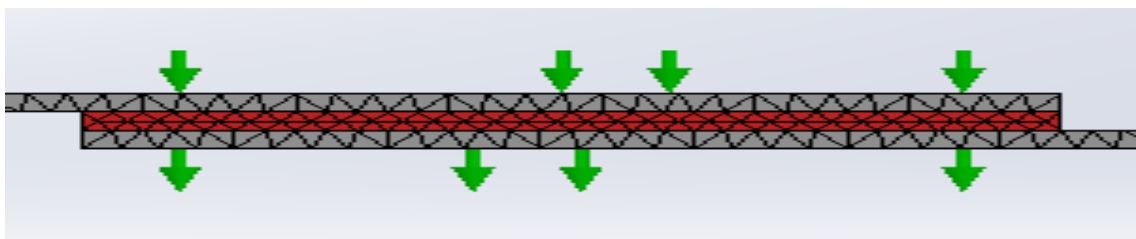


Figure 4 Meshing

FEA Stress Analysis:

For shear stress analysis we consider the shear in Y Dir. on YZ plane. After solving this problem we show the stress distribution in fig.

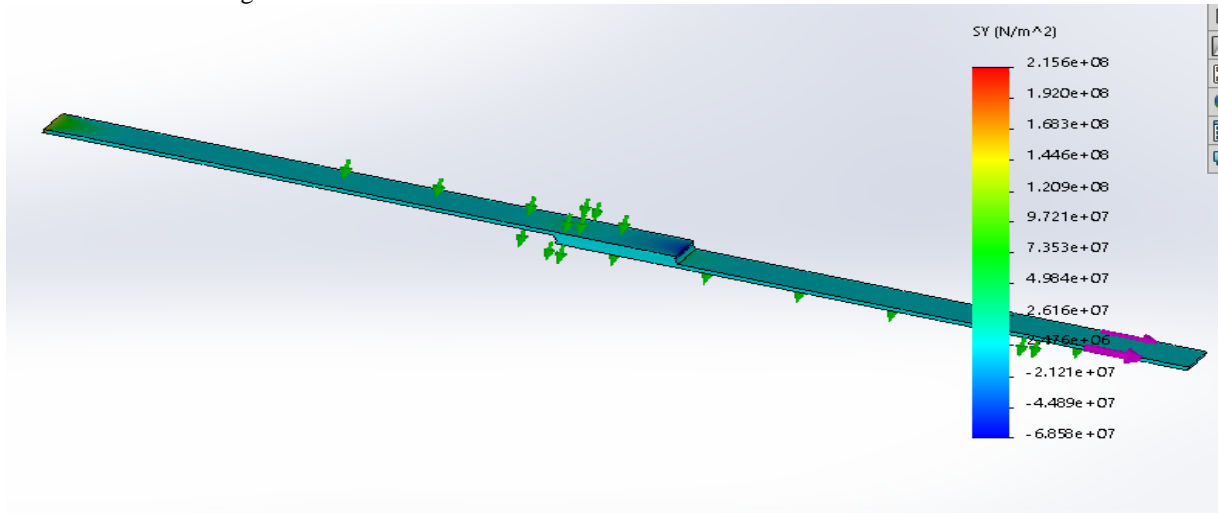


Figure 5 Analysis Of Strength

Graphical Results :

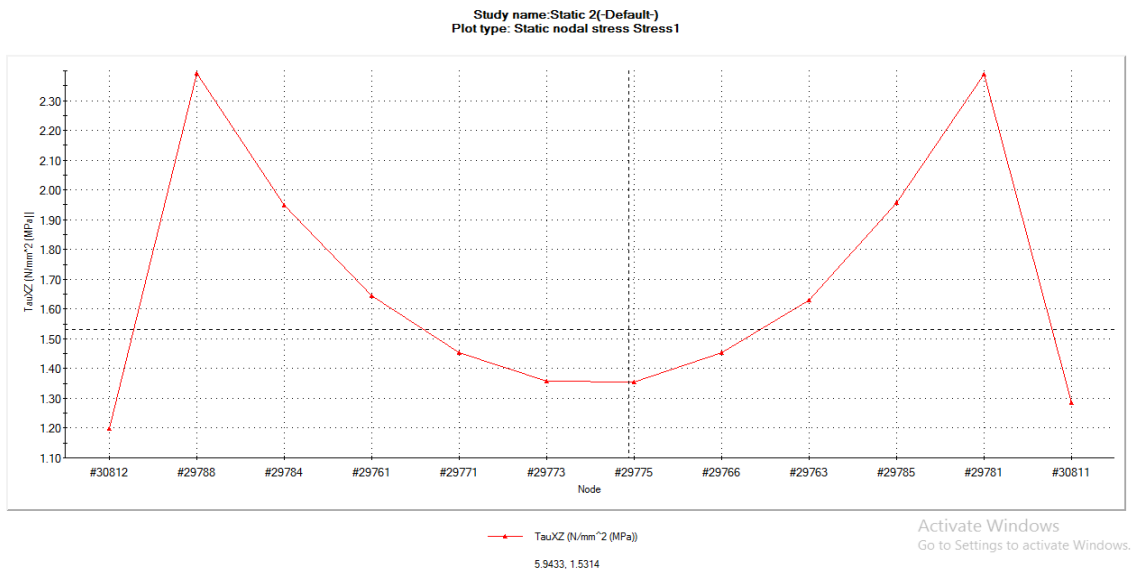


Figure 6 Graphical Result

As Show in Figure 6. this included the input of tensile test data to generate a stress-strain curve. Input might be generous as it was actually copying and pasting data from a spreadsheet into the custom material dialog. Data entry aside, sometimes you encounter a constraint that you either didn't know or possibly forgot about. In this case, it has to do with the number of allowable data points for creating a stress-strain curve. Most input for Solidworks Simulation materials are limited to 1000 points of data. Not so with a stress-strain curve

V. Conclusion

It is observed that the finite FEA predictions for Von Mises stresses and maximum shear stresses are different for different material combinations, which indicates direct proportion between modulus of elasticity and strength of the joint.

As stress induced has negative effect on the joint strength, the strength of the joint is decreased with the increase in the applied load.

Peak load value further utilized to find out the Shear Stress behavior in single lap joint by Analysis of FEA.

Examining the failure of adhesively bonding joints, the shear stress is the responsible for the failure.

The increase in thickness of adhesive causes a decremented in the residual shear stress.

If the adhesive thickness increases, the residual stress decreases. Thus, the thickness of the adhesive must be optimized to avoid the behavior of the adhesive as weak mechanical resistance.

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