STRENGTH ANALYSIS OF STEEL ADHESIVE DOUBLE LAP JOINTS

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ABSTRACT

Adhesive joints are made up of adhesive bonding material. It is generally accepted that a bonded joint is stronger than a mechanically fastened joint and a well-designed bonded joint is stronger than a Adhesive joint. A 'Adhesive Joint' combines multiple joining methodologies. A basic example is the bonded-and bolted joint. It has been found that it is possible to improve strength and fatigue characteristics of bonded joints through the inclusion of a single, or multiple, reinforcing bolts. Advanced adhesive joints typically used for enabling greater control of stress distribution within the joint region. This works an advanced Adhesive joining method, which incorporates macro-scale interlocking pin elements and adhesive bonding.

Keywords – Finite Element Method, Adhesive Joint, , Resin to Hardener ratio, Steel Double Lap Joint

INTRODUCTION

Joints are inevitable in aerospace structures where the primary components are often made in parts due to operational requirements and they are assembled using various types of joints. These joints are sources of stress concentration (or elastic singularities) and are often potential sites for failure initiation. Adhesively bonded joints are preferred wherever possible over conventional fastener joints since they lead to fewer points of stress concentration. In particular, with the increased use of composite structures, adhesive bonding is the more favored method of joining whereas the structural integrity of composites with fastener joints is suspect. The subject matter of analysis of adhesively bonded joints has been extensively investigated in the literature [1] in the past. Lap joint is one of the simplest bonded joint configurations which has been analyzed by several in the past. It is recognized that the eccentricity in load path in these joints requires a geometrically non-linear analysis. The properties of the materials of adherent and adhesive significantly affect the load transfer in these joints. Further, the geometric parameters of the joint such as adherent configuration, adhesive thickness, lap length etc., have considerable influence on the performance of these joints. In spite of considerable extent of literature, there are still several aspects, which need detailed investigation.

PROBLEM STATEMENT

There is effect of changing the resin to hardener ratio on the strength of joints. The strength analysis was carried out for riveted, adhesive and adhesive (adhesive and rivet) joints. Although the lap joints are strong, the application of an adhesive increases the maximum force sustained by joint before final failure in comparison to a simple adhesive DLJ using FEA approach.

FINITE ELEMENT ANALYSIS

The finite element method is a numerical analysis technique for achieving fairly accurate results to a wide variety of engineering problems. Although originally developed to study stresses in complex airframe structures, it has since been extended and applied to the broad field of mechanics. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in engineering disciplines and in industry. [3]

The ANSYS software has many finite element analysis capabilities ranging from simple, linear, static analysis to a complex, nonlinear, transient dynamic analysis. Any problem in ANSYS has to go through the three main steps build the model, apply loads, obtain solution and review the results. [2]

FEA METHODOLOGY

Experimentation:

Based on the conditions manifested in the assembly of the given product or case-study, a suitable Test plan shall be evolved for validating the results obtained by the Finite Element Model technique. The analytical technique shall be put to test using physical prototype for the benchmark configuration of the joint. Upon validation of the results, the analytical model could be extended to iterations over the given range of values for the significant parameters.

3.1 Adhesive Joint (100 mm Overlap)

Resin to Hardener Ratio = 1:1

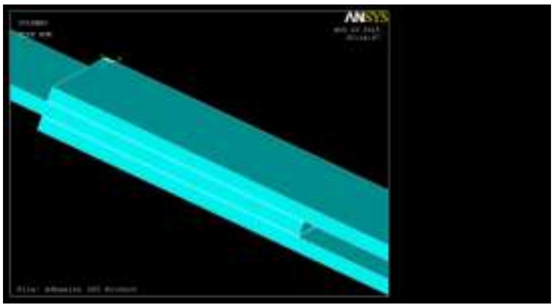


Fig.1 Adhesive Joint in ANSYS APDL

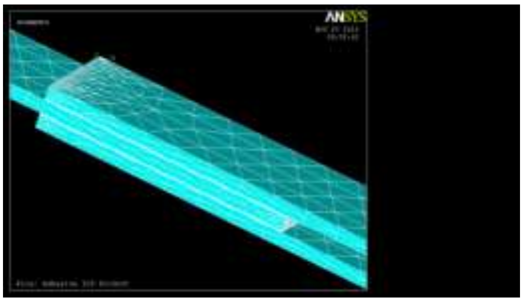


Fig.2 Meshing Using Tet. 10 Node

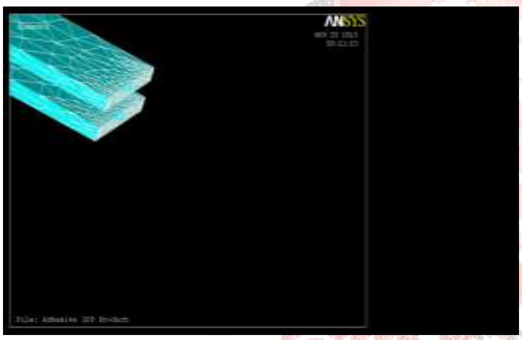


Fig.3 Constrained at end face (All Dof=0)

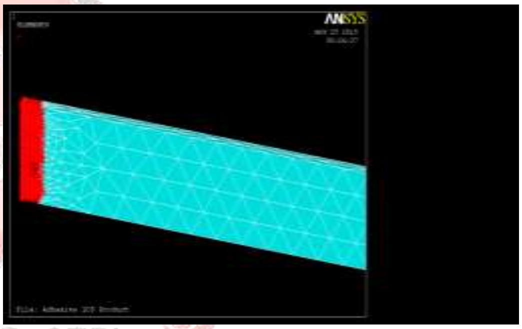


Fig.4 Load Application

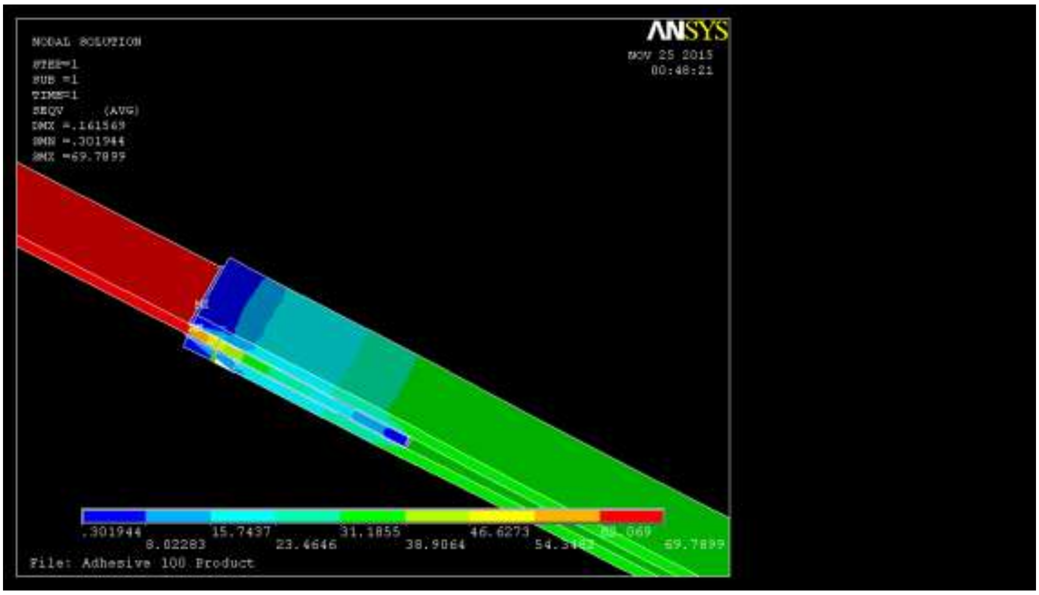
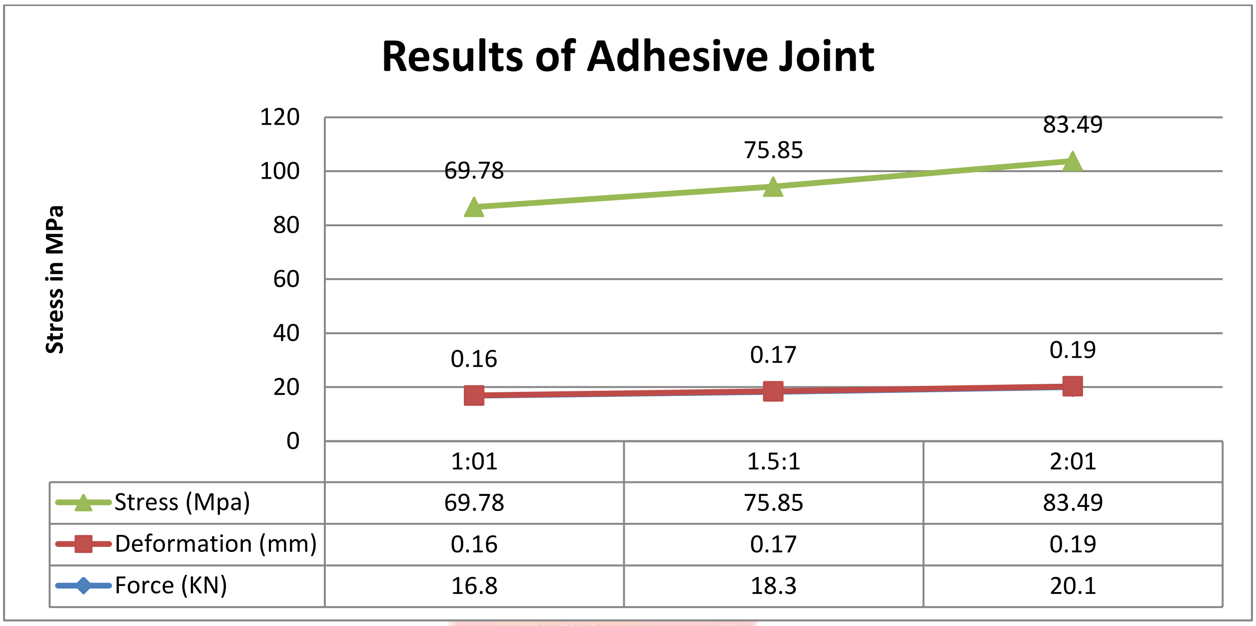


Fig. 5 Final Stress Analysis

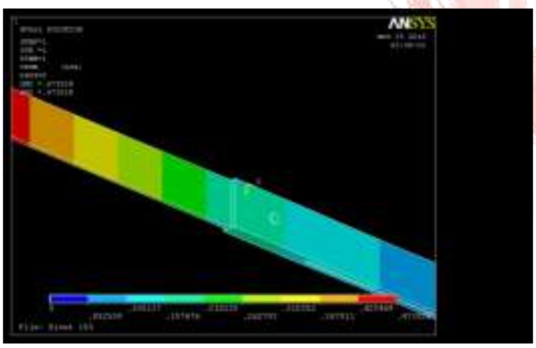
Similarly results are obtained for adhesive with Resin to Hardener Ratio =1:1.01, 1.5:1 and 2:1 as follows



	1:01	1.5:1	2:01
Stress (Mpa)	69.78	75.85	83.49
Deformation (mm)	0.16	0.17	0.19
Force (KN)	16.8	18.3	20.1

3.2 Rivet Joint (100 mm Overlap)

3.2.1 Results**:** Deformation and Stress for above conditions as shown below



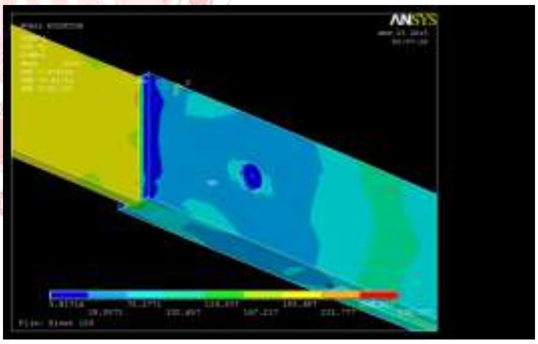


Fig.6 Max. Deformation 0.47mm (at51.2KN)

Fig.7 Max. Von Misses Stress= 296.34 Mpa (at 51.2KN)

3.3 Adhesive Joint (100 mm Overlap)

Resin to Hardener Ratio = 1:1

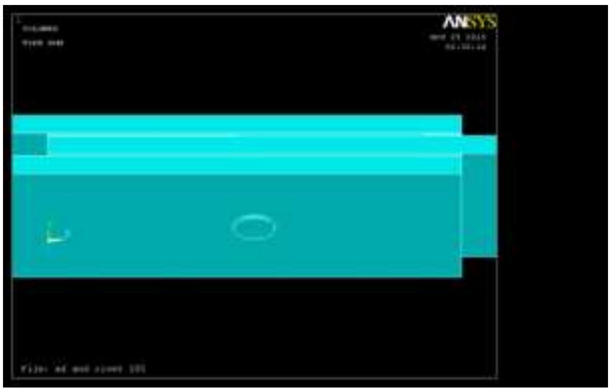


Fig.8 FEA Model

3.3.1 Results**:** Deformation and Stress for above conditions as shown below;

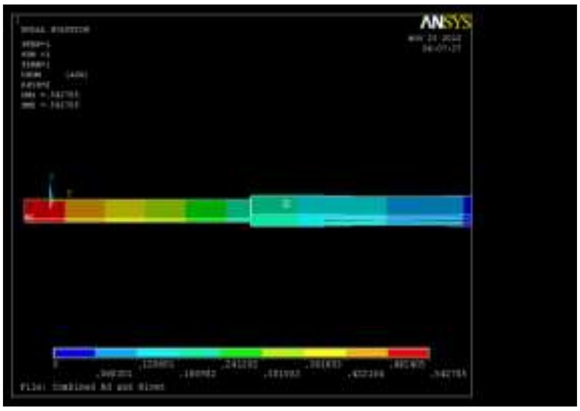


Fig.9 Max. Deformation 0.54 mm (at 59.10 KN)

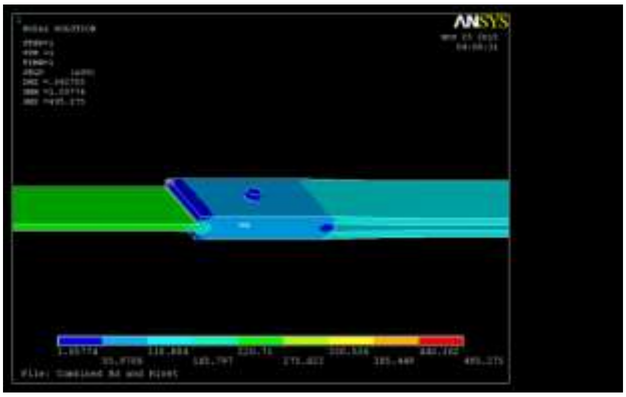
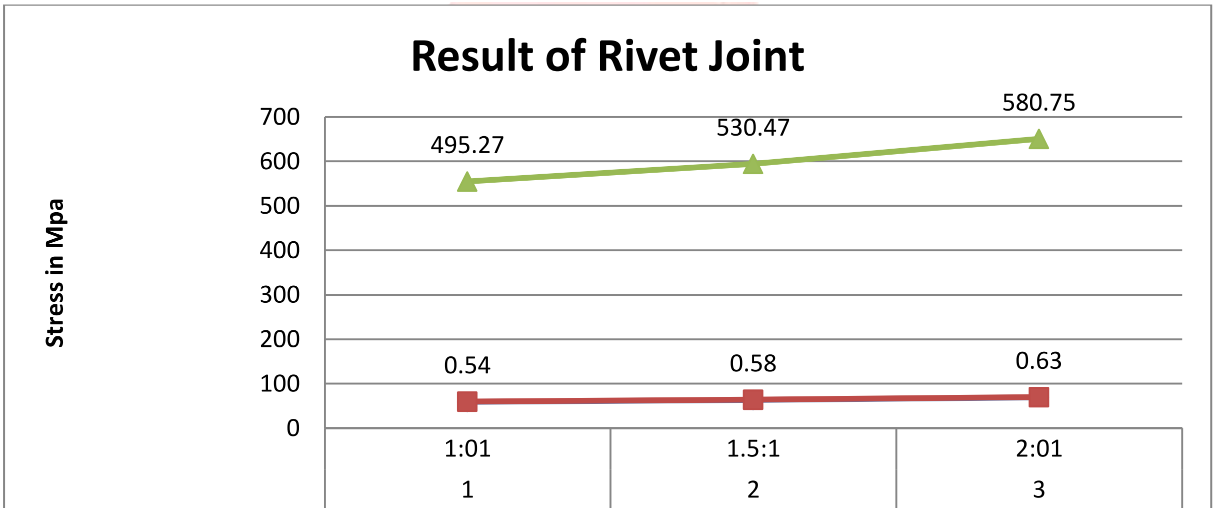


Fig.10 Max. Von Misses Stress= 495.27 Mpa (at 59.10 KN)

3.3.2 Similarly results are obtained for Adhesive Joint with Resin to Hardener Ratio = 1.5:1 and 2:1 as follows



	1:01 1	1.5:1 2	2:01 3
Stress (Mpa)	495.27	530.47	580.75
Deformation (mm)	0.54	0.58	0.63
Force (KN)	59.1	63.3	69.3

CONCLUSIONS

From FEA analysis; it is clear that when resin to hardener ratio is increased from 1:1 to initially 1.5:1 and then to 2:1, then the force sustained increases for Adhesive Joints. Results obtained as follows

1. The Max. Deformation obtained amongst three cases is 0.63 mm in Adhesive Joint. This indicates Significant sustainability of that Joint.
2. The Max. Von Misses Stress obtained amongst three cases is 580.75 Mpa in Adhesive Joint. This proves Significant sustainability of that Joint.

Hence this analysis will help to enhance the peculiarity of Adhesive joints in engineering applications in coming time.

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