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Strength Analysis of Steel Adhesive Double Lap Joints Reinforced by Rivet using FEA

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Abstract – *In this era of industrialization, requirement of modern technology is time's need. Extensive research work is being carried out from decades for suitability of appropriate joints in various engineering applications.*
In earlier mechanisms, a single type of joint may gives desired result however as mechanisms are improving; the joining procedure has to be upgraded. This paper demonstrates how Finite Element Method helps to investigate the strength of hybrid joint made up of Adhesive and Rivet in Steel Double Lap Joint specimen. Also the paper will showcase the effect of adhesive composition (Resin to Hardner ratio) on force sustained by joints.
Keywords – Finite Element Method, Hybrid Joint, Overlapping Length, Resin to Hardner ratio, Steel Double Lap Joint

I. INTRODUCTION

The existing demands in diverse branches of engineering require application of new multi component materials and structural systems. An appropriately chosen joining technology can offer significant enhancement of structural system performance in terms of effectiveness, reliability, safety and other design criteria. The modern applications of hybrid joints (e.g. bonded/riveted, with adhesively bonded columns, bonded/ pined, bonded/ bolted, etc.) are of more importance as they allow to combine and to improve the individual performance of each kind of joint. [2]
The steel adhesive double lap joints can be applied in different branches of engineering: aerospace, naval, mechanical, civil, etc. Earlier the experimental investigations of steel adhesive double lap joints (DLJ) are carried out for single overlapping length using 1:1 resin to hardner ratio for used adhesive. [1]
This paper illustrates the effect of changing the resin to hardner ratio on the strength of joints. The strength analysis was carried out for riveted, adhesive and hybrid (adhesive and rivet) joints. Although the rivet 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.

II. FINITE ELEMENT ANALYSIS

The finite element method is a numerical analysis technique for obtaining approximate solutions 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 continuum mechanics. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in engineering schools and in industry. [3]
In more and more engineering situations today, we find that it is necessary to obtain approximate numerical solutions to problems rather than exact closed-form solutions. For example, we may want to find the load capacity of a plate that has several stiffeners and odd-shaped holes, the concentration of pollutants during non-uniform atmospheric conditions, or the rate of fluid flow through a passage of arbitrary shape. Without too much effort, we can write down the governing equations and boundary conditions for these problems, but we see immediately that no simple analytical solution can be found. The difficulty in these three examples lies in the fact that either the geometry or some other feature of the problem is irregular or arbitrary Analytical solutions to problems of this type seldom exist; yet these are the kinds of problems that engineers are called upon to solve. [4]
Typical FE procedure using commercial tools. The FEA stages are as follows.

III. FEA METHODOLOGY

3.1 Adhesive Joint (100 mm Overlap)
Resin to Hardener Ratio = 1:1

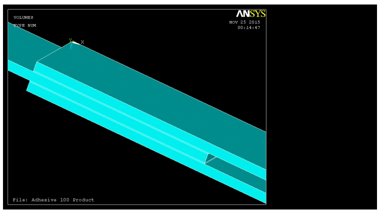

Fig.1 Adhesive Joint in ANSYS APDL

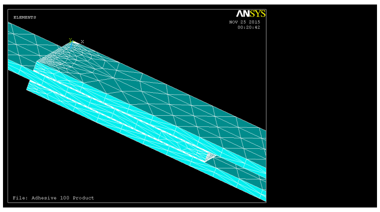

Fig.2 Meshing Using Tet. 10 Node

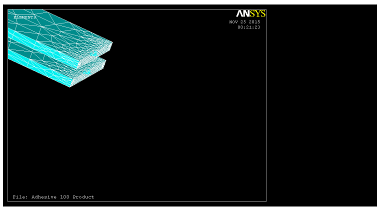

Fig.3 Constrained at end face (All Dof=0)

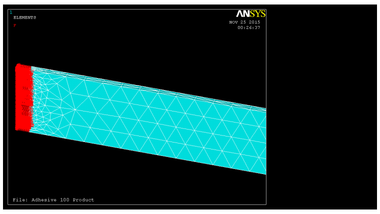

Fig.4 Load Application

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

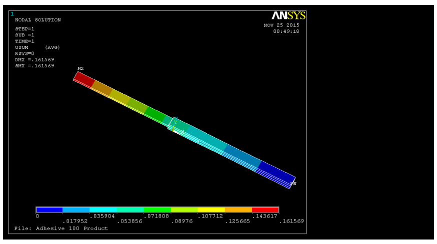

Fig.5 Max. Deformation (At 16.8 KN) = 0.16mm

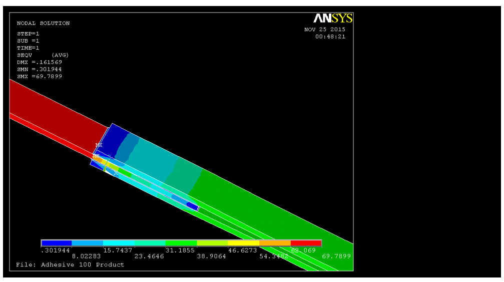

Fig.6 Max. Von Misses Stress (At 16.8 KN) = 69.78Mpa

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

Table 1 Results of Adhesive Joint

Sr. No.	Resin to Hardener Ratio	Force (KN)	Deformation (mm)	Stress (Mpa)
1	1:1	16.8	0.16	69.78
2	1.5:1	18.3	0.17	75.85
3	2:1	20.1	0.19	83.49

3.2 Rivet Joint (100 mm Overlap)

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

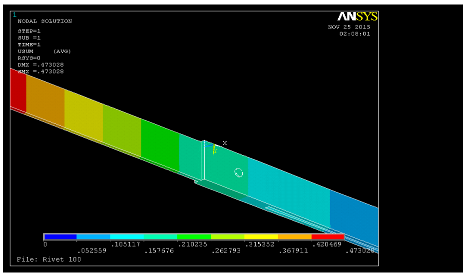

Fig.7 Max. Deformation 0.47mm (at51.2KN)

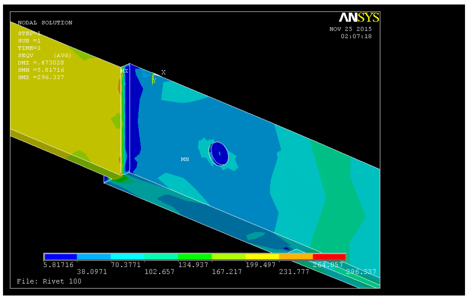

Fig.8 Max. Von Misses Stress= 296.34 Mpa (at 51.2KN)

3.3 Hybrid Joint (100 mm Overlap)

Resin to Hardener Ratio = 1:1

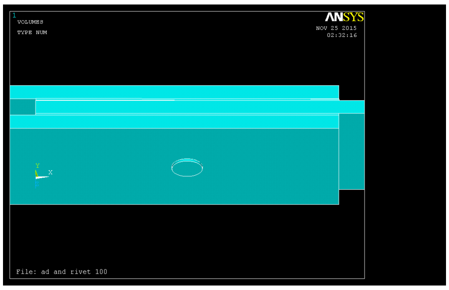

Fig.9 FEA Model

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

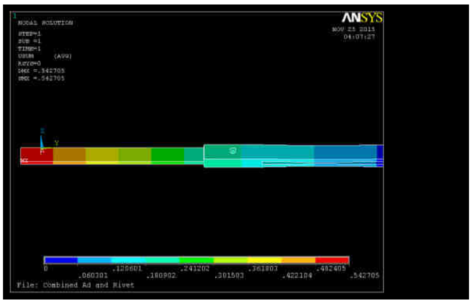

Fig.10 Max. Deformation 0.54 mm (at 59.10 KN)

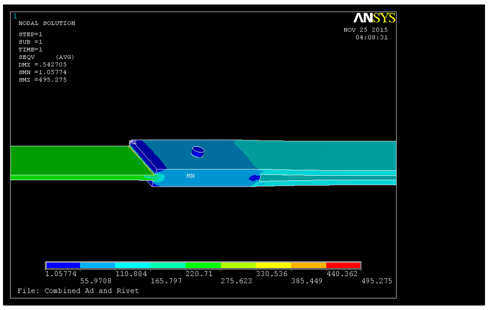

Fig.11 Max. Von Misses Stress= 495.27 Mpa (at 59.10 KN)

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

Table 2 Results of Hybrid Joint

Sr. No.	Resin to Hardener Ratio	Force (KN)	Deformation (mm)	Stress (Mpa)
1	1:1	59.1	0.54	495.27
2	1.5:1	63.3	0.58	530.47
3	2:1	69.3	0.63	580.75

IV. 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 & Hybrid Joints. Results obtained as follows

1. The Max. Deformation obtained amongst three cases is 0.63 mm in Hybrid Joint as compare to only rivet and only Adhesive Joint. This indicates Maximum sustainability of that Joint.
2. The Max. Von Misses Stress obtained amongst three cases is 580.75 Mpa in Hybrid Joint as compare to only rivet and only Adhesive Joint. This proves Maximum sustainability of that Joint.

Hence this analysis will help to enhance the peculiarity of hybrid joints in engineering applications in coming time. Further in this investigation; these results need to be validated through experimentation.

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