Strength Evaluation of Double Lap Adhesive Joint

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Abstract- *This paper summarizes the evaluation of strength of double lap adhesive joint. It is necessary to calculate the stress and deformation of double lap adhesive joint under impact tensile loading. Stress and deformation is evaluated by using ANSYS and strength of double lap adhesive joint is evaluated by using experimental method. Stress is calculated of various double lap adhesive joint and out of that, the joint having minimum stress is taken for estimation of strength. It is necessary to estimate strength of double lap adhesive joint as it is used for various purposes in vehical industry and aerospace industry. By the estimation of strength of joint, load carrying capacity of the joint will come to know and according to it double lap adhesive joint will be used in industry. For that the effects of the length of adherend, width of adherend, the overlapping length of the joint, the thickness of the adhesive layer and the initial impact velocity of the dropping weigtht hammer on the double lap adhesive joint are studied. Early detection of the stresses and rupture in the joint are crucial for the prevention of total damage of the system.*

Keywords- Strength, Double lap, Adhesive, impact tensile load..

I. INTRODUCTION

An adhesive is a substance which when applied to the surfaces of material binds that surfaces together and resists separation. The strength of the adhesive joint 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 may rupture or may not rupture. It depends on the how much load has been applied on the joint, type of adhesive material used for joining and the contact area of the two material.

This paper consists of adopted experimental procedure in details. It provides details about experimental test rig preparation, preparation of double lap joint, testing of double of double lap joint at various working conditions. The experimentation is carried out on a developed model test rig as shown in fig.3. The test rig is designed to study the dynamic behavior of double lap joint under impact tensile loading. The best double lap joint obtained from ANSYS result (130×35×30) is used for the study. Dropping weight hammer is freely dropped from top on top circular disc and rupture or no rupture of double lap joint is obtained. It produces impact tensile loading on the joint.

II. OBJECTIVES

The following are the objectives of the research:

1) To develop experimental set-up for evaluation of strength of double lap adhesive joint.
2) To analyze the effect of overlapping length and the initial impact velocity of the dropping weight- hammer on the double lap adhesive joint.
3) To analyze the strength of the double lap adhesive joint.
4) To calculate deformation in length of double lap adhesive joint.

III. SCOPE OF WORK

In this case, we have found out one best double lap adhesive joint. It is found out through 54 no. of iterations of double lap adhesive joint. One best is taken out having least stress among all. It is carried out through ANSYS.

Strength is carried out through experimental method by considering the weight of 10 kg.

As we all know that, double lap adhesive joint is used in aircraft industry and in space mostly. Hence that object should have as much as less weight as possible and maximum strength to bear the sufficient load, so that aircraft will fly in air smoothly and it will not fall down. In this paper, we have considered specific double lap adhesive joint with its specific properties and experiment is carried through specific charactreristics. According to this result we can found out different results for the joints which are to be used in space with required strength. So as per the aircraft or automobile manufacturing requirement, we can produce such object. Whatever changes in success and failures are happening in it, we can produce best automobile vehical and aircraft for the commercial use and for industrial purpose.

IV. RESULTS AND FINDIGS

Material used for formation of double lap adhesive joint is aluminium and adhesive is acrylic. Through ANSYS best joint came out is (130×35×30), where 130 mm is length

of adherend, 35 mm is the width of adherend and 30 mm is the overlapping length. Stress of this joint is 0.379 MPa and deformation is 0.00047 mm.

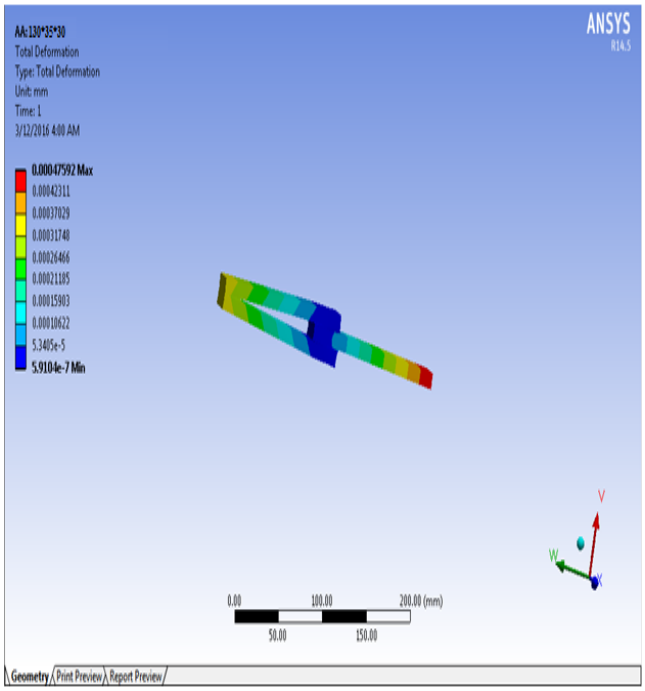


Fig.1 Deformation of 130×35×30

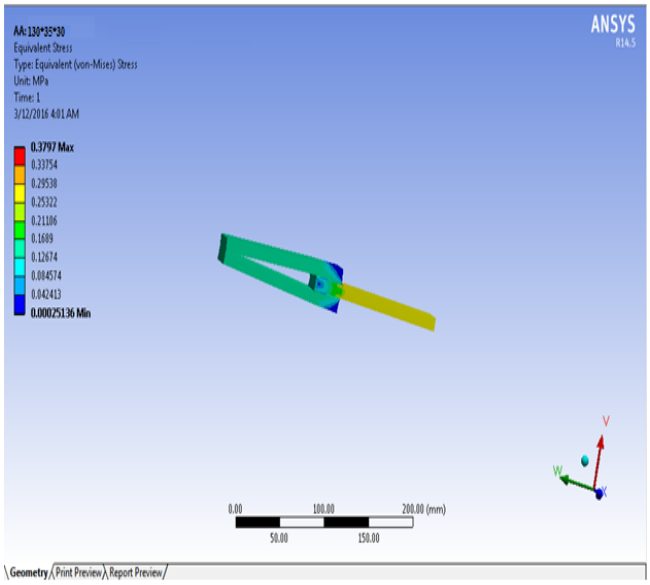


Fig.2 Stress of 130×35×30

Fig.1 and 2 are the ANSYS results of stress and deformation for joint 130×35×30.

Experimental set up to evaluate strength of double lap adhesive joint is as follows.

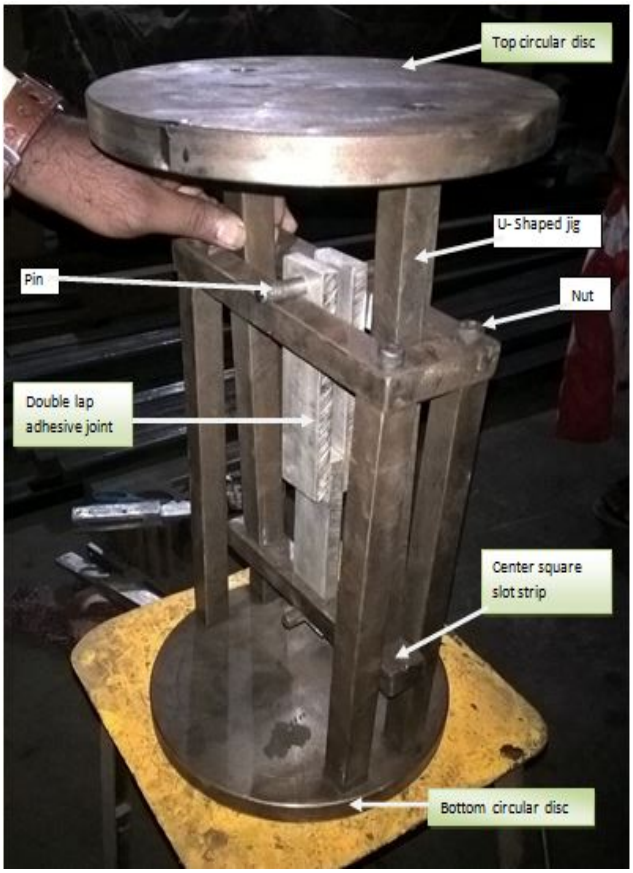


Fig.3 Experimental Set-up

The experimental set up is as shown in fig.3. Material used for formation of experimental model is mild-steel. It consist of two big circular discs out of which one is used at bottom and other is at top, six vertical rods out of which four are attached at the bottom disc and two are attached at the top disc. A right rectangular portion is formed by providing four drills at four corners. All six vertical rods are also provided with drills at both ends so that they can be attached to plates and many others. At the center one square plate is attached to two vertical rods, attached to top disc and that square plate is having square drill for adjustment of double lap joint.

Under experimental model, double lap adhesive joint is fixed between two U shaped jigs. Dropping weight hammer is freely fall down for various certain heights. Dropping weight hammer will produce impact tensile loading on the joint. Finally we will get rupture or no rupture of joint. This kind of experimentation is carried out on no. of specimen. Values are taken through maximum rupture of joint and minimum no rupture of joint at different heights.

On top disc, dropping weight hammer is freely dropped to calculate the strength of double lap adhesive joint, which is attached in between center.

Procedure of experimentation:

1. First prepare the double lap adhesive joint. The best outcome joint is (130×35×30), has to be taken. Three aluminum plates of 130 mm lengths are taken. They are attached each other in such a way that double lap joint is formed having overlapping length of joint is 30 mm. They are attached each other by using adhesive called as acrylic. They are placed for one hour in ideal condition so that it will become a stiff joint. In such a way no. of joints are formed to evaluate the strength.
2. Next all the parts used for the experimental method are needed to assemble.
3. Two circular discs are taken. One is top and another is bottom. Two vertical rods are connected to top circular disc by using nuts and it is through allen key. Similarly four vertical rods are connected to bottom circular disc by using nuts and it is through allen key.
4. Rectangular hollow square portion plate is attached to four vertical rods which were connected to bottom circular disc by nuts through allen key.
5. Center square plate with square drill slot is then attached to two vertical rods which were connected to top circular disc by nuts through allen key.
6. Mean while stiff adhesive joint would have become ready for use.
7. Pins are inserted to top two aluminum plates of double lap adhesive joint through drills.
8. That double lap adhesive joint is placed in between two U shaped jigs fixture by using top and bottom disc.
9. Next at the bottom of double lap adhesive joint having one aluminum plate, another pin is inserted so that double lap adhesive joint will be firmly fixed in the two U shaped jigs.
10. Through this way experimental set up would be ready with structure or experimental assembly would be formed.
11. Next, dropping weight hammer and scale are kept ready for use.
12. For calculation of strength we need to check the rupture of double lap adhesive joint at different height from dropping weight hammer.
13. Readings are taken at different height and for no. of same specimen.

Impact energy (I.E.) or strength is estimated by using the formula,

I.E. = $1/2MV^2$ …in J……where M= mass of dropping weight hammer (10 kg), V= initial impact velocity (mm/s).

Now,

V is calculated by using formula,

V= $\sqrt{2gH}$ ……in mm/s…...where g = 9.81, H= height of dropping weight hammer.

Following table shows measured joint strength under impact tensile load for required specimen i.e. 130×35×30 (stress= 0.379 MPa, deformation= 0.00047 mm).

Consider a height,

H= 300 mm, for the current specimen,

V= $\sqrt{2gH}$ = $\sqrt{2\times9.81\times300}$ =76.72 mm/s.

Now,

I.E. = $1/2MV^2 = 1/2\times10\times(76.72)^2$ = 29.42 J.

Therefore strength for the given specimen at height 300 mm is 29.42 J. Similarly joint's strength is calculated for different heights as given in the table.

Table 1. Strength of 130×35×30 double lap adhesive joint.

Specimen no.	Height (mm)				
	100	150	200	250	300
1	X	X	X	X	O
2	X	X	X	X	O
3	X	X	X	X	O
4	X	X	X	X	O
5	X	X	X	O	O
I.E. (J)	9.8	14.7	19.62	24.52	29.42

Table 1, shows the experimental results for the joint strength estimation. In the experiments, initial height of dropping weight hammer H was varied as 100, 150, 200, 250 and 300 mm. Five (denoted as 1-5) specimens were subjected to impact tensile loads with the variation of initial height H for each specimen of double lap joint. The designation 'X' indicates no-rupture, while the designation 'O' demonstrates the rupture occurs in the experiments. The value I.E. (defined as 1/2MV2), which is used as description of the rupture strength, is varied according to the variation of the initial height of the dropping weight hammer H. The strength of the double lap adhesive joint can be estimated between 24.52 J (M=10 kg, H=250 mm, V= 70.03 mm/s) and 29.42 J (M=10 kg, H= 300 mm, V= 76.22 mm/s).

When H= 250 mm, one specimen was ruptured. Then the experimental result is the average value of the other four specimens. The results are due to energy dissipation during vibration and transmit and unbalance of the jigs.

From above results, graphs are plotted to find out the effect of various heights on same specimen and strength of different adhesive joints.

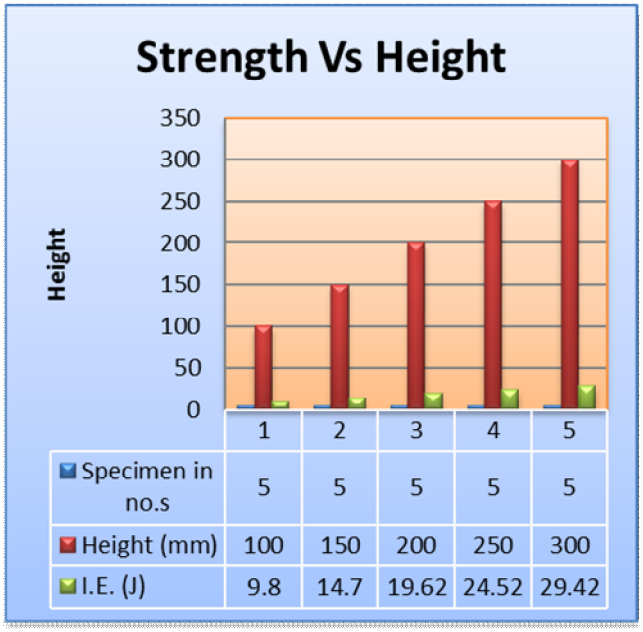


Fig. 4 Effect of height on strength evaluation

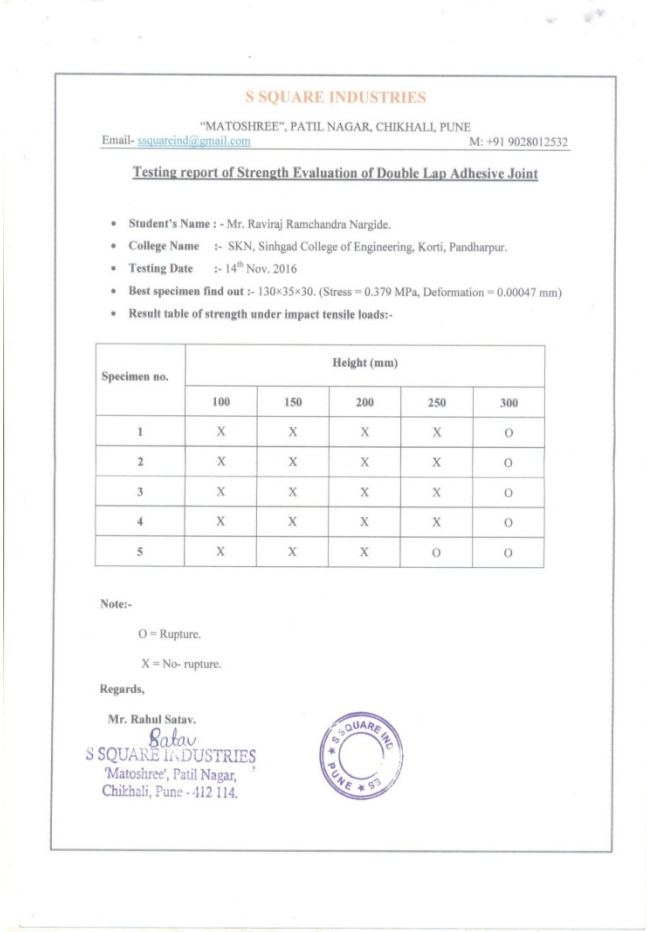
From fig.4, it is observed that, as height of dropping weight hammer goes on increasing, the strength of adhesive joint increases. Each specimen is taken for five times for experimentation. But at height 300 mm all specimens are ruptured and only one specimen was ruptured at 250 mm. This shows that strength of the given joint is in between 24.52 J to 29.42 J.

IV. CONCLUSIONS

1. The double lap adhesive joint of 130×35×30 is most suitable. It is so because it has given the most minimum stress as compared to all other double lap adhesive joints.
2. This joint gives the minimum deformation upto 0.00047 mm and minimum stress developed 0.379 MPa.
3. The change in the joint structure results in the change of deformation and stresses.
4. The ANSYS analysis proves to be a simple & cost effective method in the judgment of good double lap adhesive joint.
5. The rupture initiates near the middle area along the width direction under impact tensile loading.
6. Effect of overlapping length on stress is that, for minimum overlapping length maximum amount of stress is produced and for maximum overlapping length minimum amount of stress is produced i.e. overlapping length is inversely proportional to the amount of stress produced.
7. Effect of overlapping length on deformation is that, for minimum overlapping length maximum amount of deformation is produced and for maximum overlapping length minimum amount of deformation is produced i.e. overlapping length is inversely proportional to the amount of deformation produced.
8. Experimentally it is observed that, the double lap adhesive joint's strength is estimated experimentally and it is obtained between 24.52 J to 29.42 J for the present study.
9. For the concluded best double lap joint, there will be no rupture upto 250 mm height but total rupture occurs at 300 mm. It shows that strength of double lap joint lies in between height 250 mm and 300 mm.
10. It observes that other double lap joint doesn't able to carry large amount of load.
11. There will be no rupture for other joints for 100 mm height but beyond that rupture generation of specimens may occur or not.
12. For the weights upto 9 kg, the concluded joint doesn't rupture upto height 300 mm.

V. APPENDIX

Industrial testing report



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Testing report of Strength Evaluation of Double Lap Adhesive Joint

- **Student's Name :** - Mr. Raviraj Ramchandra Nargide.
- **College Name** :- SKN, Sinhgad College of Engineering, Korti, Pandharpur.
- **Testing Date** :- 14th Nov. 2016
- **Best specimen find out** :- 130×35×30. (Stress = 0.379 MPa, Deformation = 0.00047 mm)
- **Result table of strength under impact tensile loads:-**

Specimen no.	Height (mm)				
	100	150	200	250	300
1	X	X	X	X	O
2	X	X	X	X	O
3	X	X	X	X	O
4	X	X	X	X	O
5	X	X	X	O	O

Note:-

O = Rupture.

X = No- rupture.

Regards,

Mr. Rahul Satav.

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