ISSN: 2350-0328

International Journal of AdvancedResearch in Science, Engineering and Technology

Vol. 5, Issue 7 , July 2018

Characterization of Drill Holes in Jute and Epoxy Resin Composites along Horizontal axis by Open and Bolt Filled Hole Tensile Test

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ABSTRACT: The research on natural fibre reinforced polymer composites is growing rapidly in terms of their industrial application. If any component is made to assembly with the product is necessary to drill hole in the component for assembly purpose. Suppose, if the blow holes, voids or small crack in the material will changes the strength of the material. Then the research has to make on material with pre-damaged defect (drill hole) to find out its actual strength of the material. In this work, the material is made to number of drill holes in the material with different parameters considering like open hole and filled hole tensile test to find its variation of the material strength in the horizontal axis. The results shows that the pre-damage made to the material will decreases its strength of the material but using bolt and nut in drill hole will slightly increases the strength of the material.

KEYWORDS: Composite, Fabrication, Open Hole Tensile Test, Filled Hole Tensile Test, Damage Characterization Test, .

I. INTRODUCTION

The fiber reinforced polymer composite materials is growing rapidly in its demand due to its different combinations of immense performance, large versatility and also reasonable manufacturing costs. These composites includes impressive properties like high strength and stiffness, light weight material, low thermal expansion, corrosion properties and non-magnetic properties. The materials like boron, carbon and glass of fiber reinforced composites are widely used in the structural applications [1].

Ecological concerns are expanding step by step and the request of substituting the current engineered filaments with the biodegradable, sustainable and minimal effort normal strands for creation of composite materials increments. In contrast with the conventional strengthening materials normal fibre, for example, sisal, jute, abaca, pineapple and coir has worthy particular quality properties like low thickness, low scraped spot multi-usefulness, great warm properties, upgraded vitality recuperation and cause less skin and respiratory problems [1].

II. LITERATURE SURVEY

Vivek mishra and Sandhyarani biswas [2] has made an investigation on natural jute fiber due to its light in weight, high strength and abundantly available in nature. In this study, the jute fabric and epoxy resin is used as reinforcement and matrix materials respectively to develop and find physical and mechanical properties of the material. Hand layup technique is adopted to fabricate the natural fiber reinforced polymer matrix composites. Results shows that the tensile, hardness properties and impact strength increases to the increased fiber loading. The maximum tensile strength of the jute and epoxy composite is 110Mpa. Also, the voids formation is reduced with increasing the fiber loading.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
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X.L. Fan [3] has conducted experimental test to find-out the effects of friction, clamping pressure and washer diameter size on the net performance of the composite material by open and bolt filled hole tensile test. The comparison between open and bolt filled hole tensile tests with respect tensile strength and performance of the composite material were analysed. The results shows that whether the specimen has open hole or bolt filled hole will decrease the overall performance of the composite material. This shows that the composite material will influence the pre-existing damage to the tensile strength property. However, the inserting of bolt clamping, washer and friction force will increase the tensile strength of the composite material.

Mohd Hafiz Zamri [4] has studied the water absorption of the pultruted glass fiber and jute fiber reinforced hybrid composites which was conditioned to different types of water and analyse the effects of its mechanical properties. The tests of water absorption were conducted by immersing composite materials or specimens into 3 types of water like sea water, distilled water and acidic water. The duration of test is three weeks at absolute room temperature. In this study, the properties of compression and flexural were investigated by the different types of water conditions. The parameter like maximum moisture content and diffusion coefficient characteristics were found out from graph plotted from water absorption test. The result shows that the compression and flexural properties were found out to decrease with the increasing percent of water in the material.

The literature survey made on the above three articles gives the problem statement that the changing the number of drill holes in the specimen along horizontal axis by open hole tensile test, filled hole tensile test and damage characterization test with the use of jute fabric and epoxy resin materials. The particular tests and parameters considered for specific case are explained in the section 3.3.

III. METHODOLOGY

A. Materials

The materials used for this research work is jute fabric, lapox (L-12) and hardener (K-6). The jute is generally planted and raised all over the India, Brazil, China, Bangladesh and Indonesia. The jute fibers are extracted from bark which is in the stem after get rotten [5]. The pulled out fibers are made in the form of fabric like cloth as shown in this figure 1 (a) and also acts as reinforcement material in this work. The lapox (L-12) is a resin where a solvent, un-modified resin of absolute viscosity and room temperature curing properties used for con-structural holding in fiber reinforced composite materials as shown in the figure 1 (b). The hardener (K-6) is a curing agent where the curing process is depends on the quantity added to the resin as shown in the figure 1 (c).

(a) (b) (c)

Fig.1 Raw materials used for composites: (a) jute fabric, (b) Lapox L-12 epoxy resin and (c) hardener k-6

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International Journal of AdvancedResearch in Science, Engineering and Technology
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Table 1 Properties of jute fiber and Epoxy Resin (L-12)

Material	Jute fiber		Epoxy resin	
Properties	Values	Unit	Values	Unit
Density	1.3	g/cm^3	1.25	g/cm^3
Tensile strength	393-773	Mpa	50-60	Mpa
Young's modulus	26.5	Gpa	4.4-4.6	Gpa

B. Methodology

The methodology used in this research work is old and simple process called hand layup technique. Before the making fabrication process, the mould is prepared with size of 220×220×10 mm in mild steel material because the composite board will infirmly fits in the mould and tightly compacted. The composition of composite material is of jute fabric - 60%, resin lapox (L-12) - 40% and hardener (K-6) is 10% of resin. The procedure of fabrication process of this research work as follows, first we should prepare the resin and hardener mixture in a small bowl before starting the fabrication process. Then the mould is placed and jute fabric layers of size 210×210 mm are kept inside one by one in the mould. Between the jute layers, the resin and hardener mixture is applied uniformly throughout the layer. The process is repeated as per the calculation to meet its composition percentage. The composite board is pressed by dead weights for 24 hours to compactly tightly between the layers and also dried for 24 hours. Finally the specimens are made as per the ASTM standards.

C. Types of Test Conducted with Parameters

A. The drill hole of 6mm is made in the specimen center, two holes are made of same size in the another specimen with 10mm hole center to center distance and similarly three holes are made in the specimen with one in the center by open hole tensile test as per ASTM D 5766 standards as shown in the figure 2 [6].

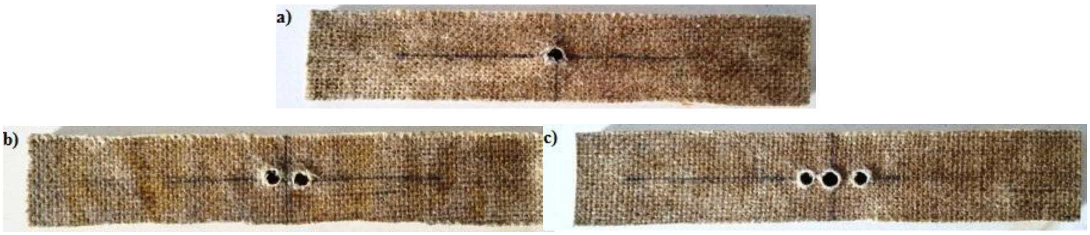

Fig 2 Number of holes in the specimen along horizontal axis; (a) 1 hole, (b) 2 holes and (c) 3 holes

B. Similarly to the case 3.3.1 specimens are made and placed with M6 bolt and nut to each hole by filled hole tensile test as per ASTM D 6742 standards as shown in the figure 3 [7].

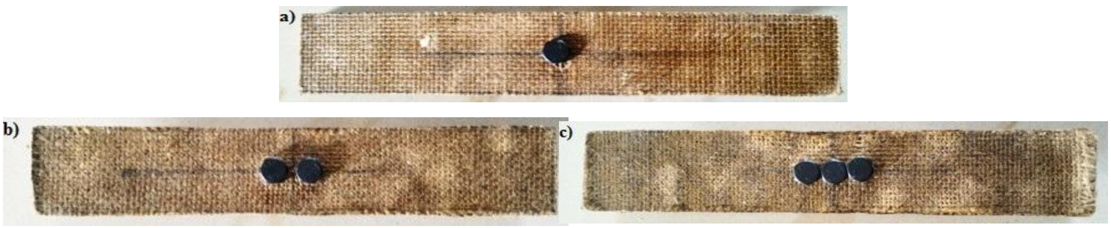

Fig 3 Number of holes in the specimen along horizontal axis is filled with M6 bolt and nut; (a) 1 bolt, (b) 2 bolts and (c) 3 bolts

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International Journal of AdvancedResearch in Science, Engineering and Technology
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C. Similarly to the case 3.3.1 specimens are made and kept in sea water for damage test by open hole tensile test as per ASTM D 5766 standards as shown in the figure 4.

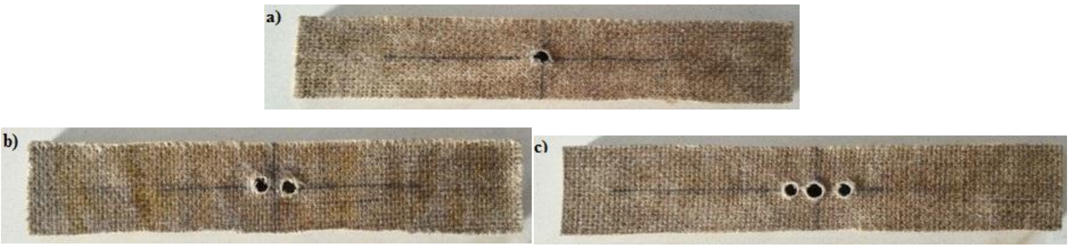

Fig 4 Number of holes in the damaged specimen along horizontal axis; (a) 1 hole, (b) 2 holes and (c) 3 holes

D. Similarly to the case 3.3.2 specimens are made and kept in sea water for damage test by filled hole tensile test as per ASTM D 6742 standards as shown in the figure 5.

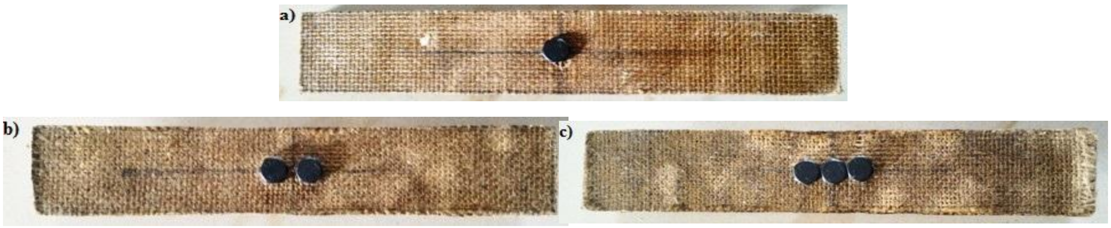

Fig 5 Number of holes in the damaged specimen along horizontal axis is filled with M6 bolt and nut; (a) 1 bolt, (b) 2 bolts and (c) 3 bolts

IV. EXPERIMENTAL RESULTS

A. Changing the holes number in specimens by open hole tensile test in the horizontal axis.

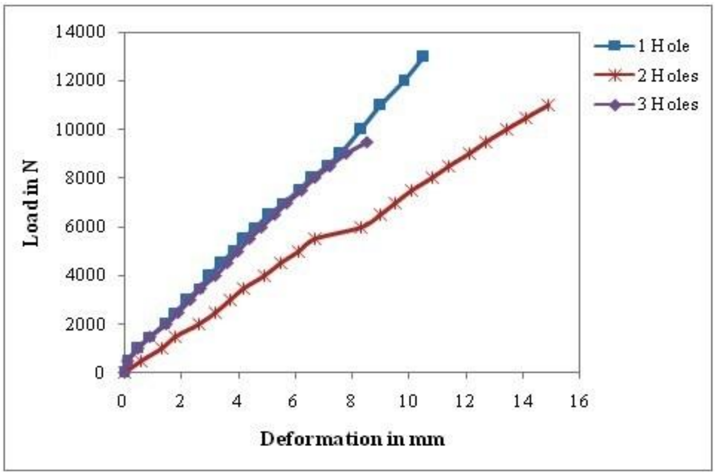

Fig 6 load v/s deformation curves for specimens have 1 hole, 2 holes and 3 holes

The jute fabric and epoxy resin composite specimens have 1 hole, 2 holes and 3 holes shows the mechanical behaviour in the load v/s deformation curve as shown in the figure 6. The higher load withstand by the specimen is 1 hole of 13 KN. The specimen with 2 and 3 holes are withstanding the load of 11 KN and 9.5 KN respectively. This explains that the load withstand capacity is becoming lower while the hole number is raised in the specimen.

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International Journal of AdvancedResearch in Science, Engineering and Technology
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B. Changing the holes number in specimens is placed with M6 bolt by filled hole tensile test.

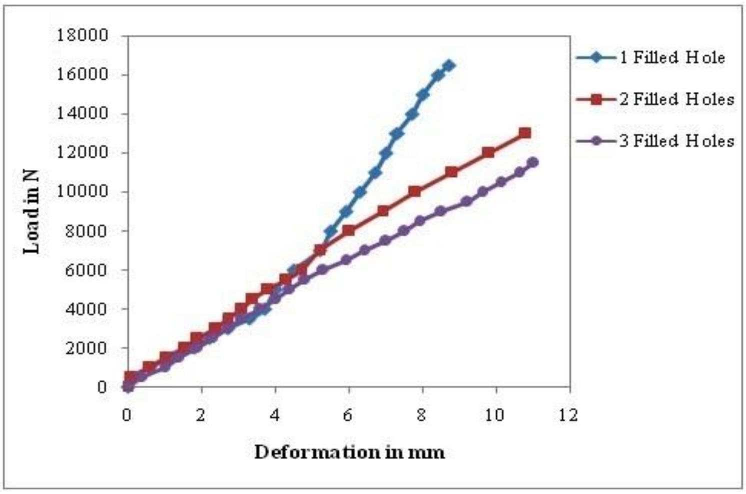

Fig 7 Load v/s deformation curve for specimens have 1 hole, 2 holes and 3 holes is placed with M6 bolt

The jute fabric and epoxy resin composite specimens have 1 hole, 2 holes and 3 holes is placed with M6 bolt and nut shows the mechanical behaviour in the load v/s deformation curve as shown in the figure 7. The higher load withstand by the specimen is 1 hole of 16.5 KN. The specimen with 2 and 3 holes are withstanding the load of 13 KN and 11.5 KN respectively. This explains that the load withstand capacity is getting higher while the using of bolt and nut in the specimens correlated with case A. The load 3.5 KN, 2 KN and 2 KN is improved to case A in specimens with 1 hole, 2 holes and 3 holes respectively.

C. Changing the holes number in specimens by open hole tensile test after damage test.

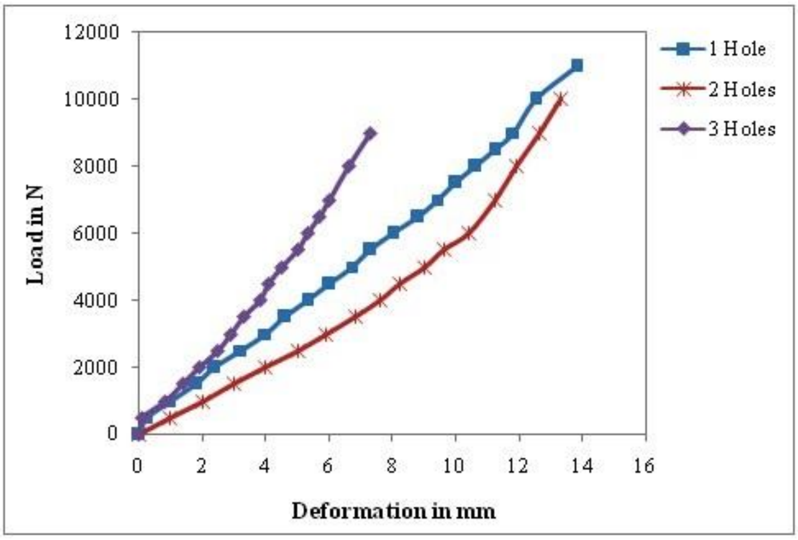

Fig 8 Load v/s deformation curve for damaged Specimens have 1 hole, 2 holes and 3 holes

The jute fabric and epoxy resin composite specimens have 1 hole, 2 holes and 3 holes after damage test shows the mechanical behaviour in the load v/s deformation curve as shown in the figure 8. The higher load withstand by the specimen is 1 hole of 11 KN. The specimen with 2 and 3 holes are withstanding the load of 10 KN and 9 KN respectively. This explains that the load withstand capacity is getting declined due to damage made by sea water in the

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specimens and correlated with case A. The load 2 KN, 1 KN and 0.5 KN is dropped correlated to case A in damaged specimens with 1 hole, 2 holes and 3 holes respectively.

D. Changing the holes number in specimens is placed with M6 bolt by filled hole tensile test after damage test.

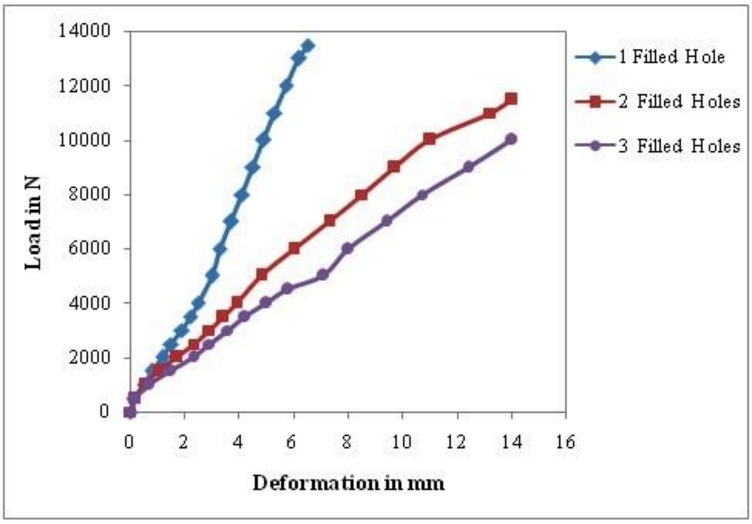

Fig 9 Load v/s deformation curve for damaged specimens have 1 hole, 2 holes and 3 holes is placed with M6 bolt

The jute fabric and epoxy resin composite specimens have 1 hole, 2 holes and 3 holes is placed with M6 bolt after damage test shows the mechanical behaviour in the load v/s deformation curve as shown in the figure 9. The higher load withstand by the specimen is 1 hole of 13.5 KN. The specimen with 2 and 3 holes are withstanding the load of 11.5 KN and 10 KN respectively. This explains that the load withstand capacity is getting higher while the using of bolt and nut in the specimens correlated with case C. The load 2.5 KN, 1.5 KN and 1 KN is increased correlated to case C in damaged specimens with 1 hole, 2 holes and 3 holes respectively. Also, the load 3 KN, 1.5 KN and 1.5 KN is dropped correlated to case B in damaged specimens with 1 hole, 2 holes and 3 holes respectively.

E. Analysing the tensile strength and young's modulus results between specimens of 1 hole, 2 holes and 3 holes

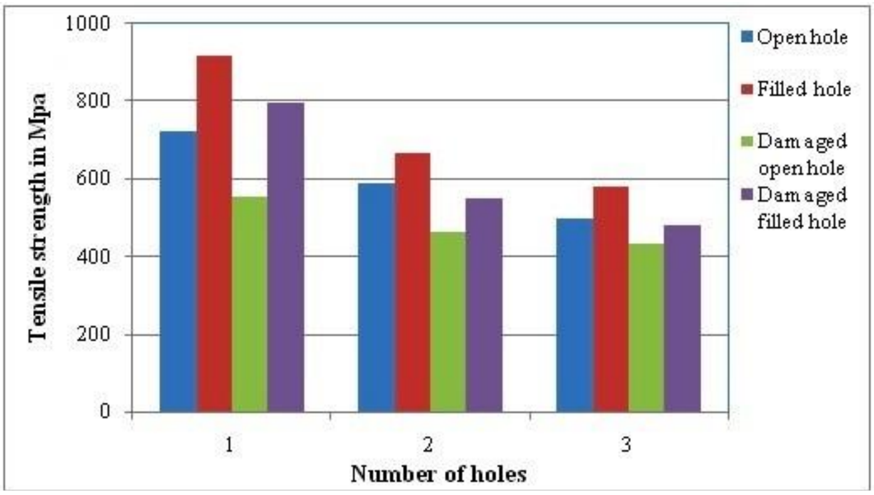

Fig 10 Analyses of tensile strength results of 1 hole, 2 holes and 3 holes in the specimens

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The tensile strength analyses made between the specimens of 1 hole, 2 holes and 3 holes as shown in the figure 10. The open and bolt placed hole tensile test carried a tensile strength of 722.22 Mpa and 916.16 Mpa respectively for 1 hole. This represents that the material strength is improved by adopting bolt and nut where the drill hole is made. The open and bolt placed hole tensile test after damage test carried a tensile strength of 555.55 Mpa and 797.87 Mpa respectively for 1 hole. This represents that the damaged material strength is reduced as correlate with the un-damaged material because the sea water made damage to the material and de-lamination as outcome. The open and bolt placed hole tensile test carried a tensile strength of 587.6 Mpa and 668.72 Mpa respectively for 2 holes. This represents that the material strength is improved by adopting bolt and nut where the drill hole is made. The open and bolt placed hole tensile test after damage test carried a tensile strength of 462.92 Mpa and 550.76 Mpa respectively for 2 holes. This represents that the damaged material strength is reduced as correlate with the un-damaged material because the sea water made damage to the material and de-lamination as outcome. The open and bolt placed hole tensile test carried a tensile strength of 497.9 Mpa and 580.8 Mpa respectively for 3 holes. This represents that the material strength is improved by adopting bolt and nut where the drill hole is made. The open and bolt placed hole tensile test after damage test carried a tensile strength of 431.03 Mpa and 478.92 Mpa respectively for 3 holes. This represents that the damaged material strength is reduced as correlate with the un-damaged material because the sea water made damage to the material and de-lamination as outcome.

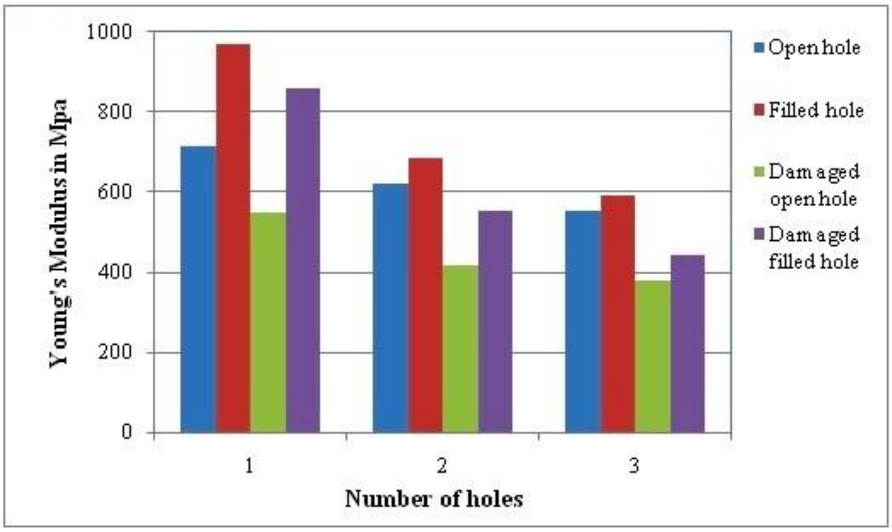

Fig 11 Analyses of modulus of elasticity results of 1 hole, 2 holes and 3 holes in the specimens.

The modulus of elasticity analyses made between the specimens of 1 hole, 2 holes and 3 holes as shown in the figure 11. The open and bolt placed hole tensile test carries a young's modulus of 713 Mpa and 970 Mpa respectively for 1 hole. This represents that the material performance is improved by adopting bolt and nut where the drill hole is made. The open and bolt placed hole tensile test after damage test carries a young's modulus of 551 Mpa and 859 Mpa respectively for 1 hole. This represents that the damaged material performance is reduced as correlate with the un-damaged material because the sea water made damage to the material and de-lamination as outcome.

The open and bolt placed hole tensile test carries a young's modulus of 622 Mpa and 686 Mpa respectively for 2 holes. This represents that the material performance is improved by adopting bolt and nut where the drill hole is made. The open and bolt placed hole tensile test after damage test carries a young's modulus of 419 Mpa and 553 Mpa respectively for 2 holes. This represents that the damaged material performance is reduced as correlate with the un-damaged material because the sea water made damage to the material and de-lamination as outcome.

The open and bolt placed hole tensile test carries a young's modulus of 553 Mpa and 590 Mpa respectively for 3 holes. This represents that the material performance is improved by adopting bolt and nut where the drill hole is made. The open and bolt placed hole tensile test after damage test carries a young's modulus of 380 Mpa and 445 Mpa respectively for 3 holes. This represents that the damaged material performance is reduced as correlate with the un-damaged material because the sea water made damage to the material and de-lamination as outcome.

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V. CONCLUSION

The tensile test results of any material is not good for application to the product due to the material is made to pre-damaging in the form holes for assembly purpose. This pre-defined damage will cause to lose its strength of the material. So the conducting of open hole tensile test is necessary to find it's actually strength of the material. The results also show that the strength of the material is reduced because of the pre-defined hole. Further the material subjected to environment condition like sea water to find variation of the strength of the material. The results show that the material will lose its strength of the material if its subjected environment condition.

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