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Fabrication, Experimental and Structure Analysis of Hybrid Nano Composites

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ABSTRACT: *One of the major scientific challenges for the composite engineers is the development of new stronger and tougher lightweight structural materials supporting latest technologies and design concepts for the complex shaped structures like aircraft, automotive structures, and large wind turbine blade structures. The development of composite materials improving their performance limits based on the reinforcement of two or more fibers in a single polymeric matrix, which leads to the advanced material system called hybrid composites. This is a major challenge that can only be met through an understanding of the relationships between materials architecture and mechanical response. The hybrid effect of selected mechanical property from the rule of mixture behavior of glass, carbon and epoxy resin added with mwcnt composites were studied. The effectiveness of reinforcement essentially depends on the adhesion between matrix and fiber, so this is a key factor in determining the final properties of the composite material. In the present work, an attempt has been made to study the influence of glass fiber and carbon fiber with carbon nano tube reinforced epoxy polymer matrix on the mechanical properties. The various mechanical properties were studied as per the ASTM standards. The carbon and glass fiber with carbon nano tube has a shows a high mechanical strength of the materials.*

I. INTRODUCTION

One of the major scientific challenges for the composite engineers is the development of new stronger and tougher lightweight structural materials supporting latest technologies and design concepts for the complex shaped structures like aircraft, automotive structures, and large wind turbine blade structures. The development of composite materials improving their performance limits based on the reinforcement of two or more fibres (synthetic fibre with another synthetic fibre or synthetic fibre with natural fibre or synthetic fibre with metallic fibres) in a single polymeric matrix, which leads to the advanced material system called hybrid composites.

Recently, hybrid composite is being investigated throughout the globe as it has enhanced properties than their mother composites which is relatively cost effective method. This is a major challenge that can only be met through an understanding of the relationships between materials architecture and mechanical response. The positive or negative hybrid effect of selected mechanical property from the rule of mixture behavior of glass, carbon and epoxy resin added with mwcnt composites were studied. The effectiveness of reinforcement essentially depends on the adhesion between matrix and fiber, so this is a key factor in determining the final properties of the composite material. In the present work, an attempt has been made to study the influence of glass fiber and carbon fiber with carbon nano tube reinforced epoxy polymer matrix on the mechanical properties. The various mechanical properties were studied as per the ASTM standards.

II. LITERATURE SURVEY

S.y.fu, B.Lauke, E.Mader (2000):In this study was carried out the tensile properties of injection melled composites reinforced with SGF and SCF have been investigated and the result indicate that the mean glass and carbon fiber

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lengths decrease with increasing fiber volume fractions and the combined effect of fiber volume fraction and fiber length determines the final tensile properties of the composites.

K. Poyyathappan (2014):In this study was carried out the tensile strength of the hybrid composites lie in between the CFRP and GFRP. From the flexural results obtained in this investigation on the 0 ± 90 fiber orientation sample, it is observed that the hybrid samples have intermediate strength after the specimens were subjected to cyclic load. But, the hybrid composites have more flexural strength than that of the GFRP laminates after cyclic load.

T D Jagannatha (2015) : In this study the inclusion of carbon fiber mat reinforcement composite significantly enhanced the ultimate tensile strength, yield strength and peak load of the composite. the micro hardness and ductility of the hybrid composite were also found by doing experiments like tensile test and hardness test as per ASTM standard.

Karthick Saravanan.S(2016):In this study to understand the improvement in the mechanical properties due to the changes made in the carbon/ glass fiber ratio in three different laminates. As you can see the tensile strength, flexural strength and the impact strength increases as the ratio of the carbon fiber reinforcement is increased in the matrix.

III. EXPERIMENTAL DETAILS

Material selection:

Carbon fiber and E-glass fiber were selected as reinforcement and epoxy and matrix material

Reinforcement: bidirectional glass fiber (300GSM)

T-300 bidirectional carbon fiber (200GSM)

Matrix (liquid): Epoxy resin (LY 556)

Hardner HY 951 and multi walled carbon nano tube

Fabrication:

Bidirectional GFRP, CFRP and multiwalled carbon nano tube hybrid composite of 3mm thickness have been prepared. Epoxy resin LY-556 has been used as the matrix and HY 951 has been used as hardener. The laminates have been made by hand-lay up method. Required layers of fibers were taken as a $300\times 300\times 3$ mm. The thickness of the laminates was maintained approximately 3mm. equal amount of resin is taken in a ratio 10:1 hardner is added.



Figure 1 :Fabrication Process

the vacuum bag technique is carried out on the laminate to uniformly distributed the resin and also to remove any trapped air the process time required for 2 hours then the specimen will be placed in atmospheric condition for 5-6 hours and cured in 100°C temperature about 1 hour. In CFRP and GFRP laminates all the layers are carbon fiber mat and glass fiber mat respectively. hybrid laminates made by three layer of carbon and eight layer of glass fiber added to 3% and 4% of multi walled carbon nano tube was fabricated.

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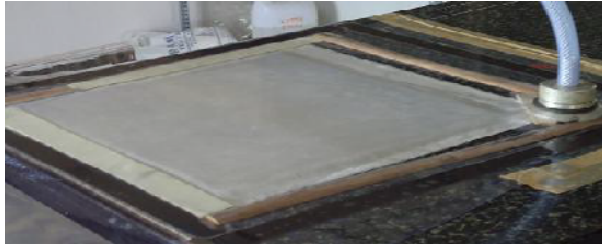


Figure 2: Vacuum Bag Technique



Figure 3: Fabricated Material



Figure 4: Test Specimen

The specimen was cut as per the ASTM standard for tensile and compressive tests and tested for its tensile and compressive strength respectively

TESTING DETAIL :

Mechanical properties like ultimate Compressive Strength, ultimate Tensile Strength, Impact Strength, Hardness And Water Absorption test will be evaluated.

Tensile test:

The tensile tests can be performed on unidirectional composites. Fiber glass tabs are placed on either side of straight sided specimens which, are gripped in the testing machine. Streamlined(reduction-section) specimen can also

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be used.

ASTM A 378:2017 is followed for tensile test. The specimen was fixed between two adjustable grips of computerized Universal Testing Machine (UTM) at room temperature and load was applied till it fractures. The elongation and maximum load is noted during the experiment.

Compressive test :

Compressive strength or compression strength is the capacity of a material or structure to with stand loads tending to reduce size, as opposed to tensile strength, which with stands loads tending to elongate. Here the test spicemen should be prevented from buckling

Impact test :

ISO 148-1-2016 Method is followed for charpy impact test. The test is performed by fixing the specimen at the both ends and the striker impacts the specimen.

Hardness Test:

Hardness is defined as theresistance to indentation, and it is determined by measuring the permanent depth of the indentation.more simply put,when using a fixed force and a given identer, the smaller indentation,the harder the material.ASTM D 2240 method is followed for the Shore-D Hardness test.

Water Absorbtion:

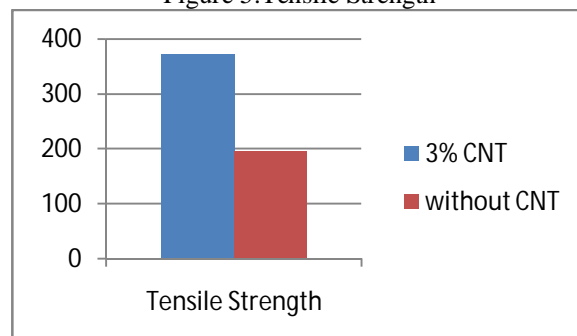
Water absorbtion is used to determine the amount of water absorbed under specified conditions.ASTM D 570:1998 method is followed for water absorbtion test.

IV. RESULT AND DISCUSSION

TENSILE STRENGTH:

	Hybrid composite with 3% CNT	Hybrid composite Without CNT
Cross sectional area	35.786mm ²	37.913mm ²
Load at yield	10.651 kN	5.911 kN
Elongation at yield	15.103 mm	12.159mm
Yield strength	267.619 N/mm ²	155.897 N/mm ²
Load at peak	13.330 kN	7.42 kN
Elongation at peak	16.003 mm	12.159 mm
Tensile strength	372.481 N/mm ²	195.896 N/mm ²

Figure 5:Tensile Strength



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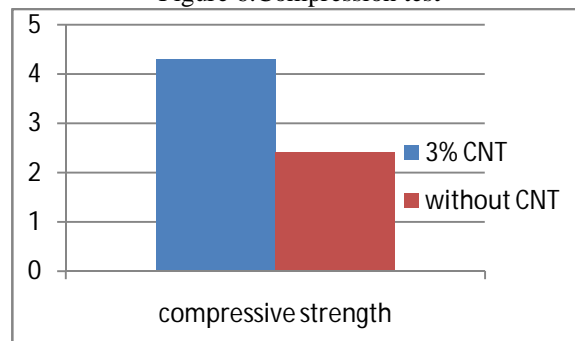
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The above chart shows the effect of reinforcements on UTS of the Fibers reinforced composites as can clearly see the increase in the ultimate tensile strength in different proposition of cnt specimens this proves that the strength of the material increases as the cnt content in the material increases.

COMPRESSION TEST:

	Hybrid composite with 3% CNT	Hybrid composite without CNT
Cross sectional area	55.31 mm ²	70.39mm ²
Load at peak	0.740 kN	0.540 kN
Compression strength	13.379 N/mm ²	7.671 N/mm ²

Figure 6:Compression test



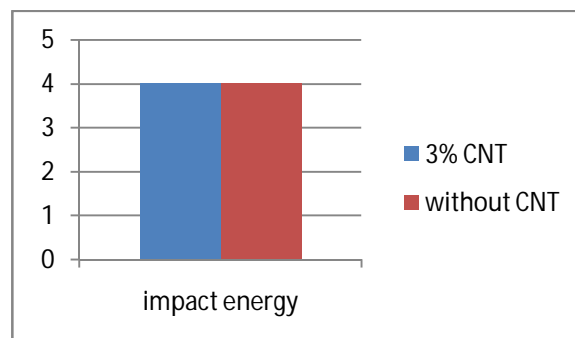
The test specimens were mounted with strain gauges on both sides of the specimens to observe test specimen bending ratio. The test setup and test specimen before the test and after the test

IMPACT TEST :

Charpy impact testing involves striking a standard specimen with controlled weight pendulum swung from a particular height. The specimen is fixed in a anvil and struck by the pendulum. The amount of energy absorbed in fracturing the test piece is measured

	Impact energy (Joule)
Hybrid composite with 3% CNT	4
Hybrid composite without CNT	4

Figure 7:Impact Result



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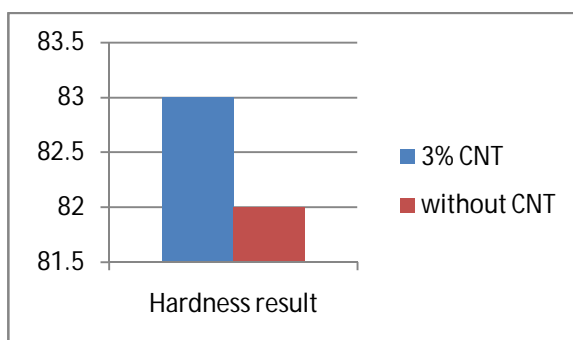
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HARDNESS TEST:

Hardness is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation. More simply put, when using a fixed force and a given indenter, the smaller indentation, the harder the material. ASTM D 2240 method is followed for the Shore-D Hardness test.

Samples	Specimen 1	Specimen 2	Specimen 3	Average
Hybrid composite with 3% CNT	83	82	85	83
Hybrid composite without CNT	82	81	84	82

Figure 8: Hardness Result

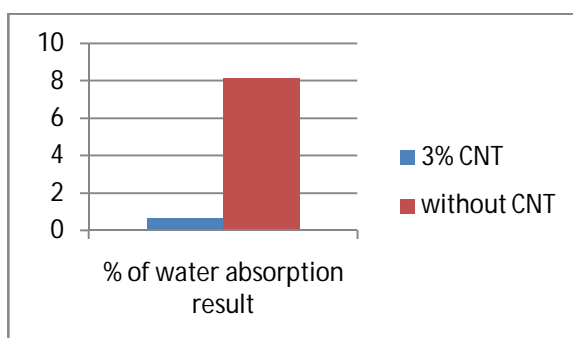


WATER ABSORPTION:

Water absorption is used to determine the amount of water absorbed under specified conditions. ASTM D 570:1998 method is followed for water absorption test.

Description	Empty (grams)	30 Minutes (grams)	60 Minutes (grams)	90 Minutes (grams)	% of water absorption
Hybrid composite with 3% CNT	4.148	4.167	4.167	4.175	0.650
Hybrid composite without CNT	3.463	3.481	3.498	3.504	8.134

Figure 9: Water Absorption Result



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V. STRUCTURE ANALYSIS

It is software for finite element analysis and design. We can use this software to calculate the properties and operating conditions. It is a general-purpose program, which can be used for any type of analysis. In fact, the program can be in all discipline of engineering like structural, mechanical, electrical thermal, fluid and magnetic. The easiest way to communicate with the ANSYS program is by using the ANSYS menu system called graphical user interface (GUI). The GUI consist of windows, menus dialogue boxes and other components that allows you to enter input data and execute ANSYS function simply by picking button with the mouse (or) typing in responses to prompts, All users both engineers and advanced should use the GUI for interactive ANSYS work.

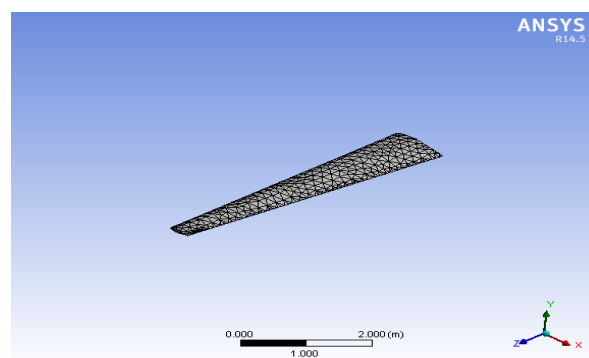
FINITE ELEMENT METHOD:

The role of analysis in engineering is to verify a design by predicting its behavior prior to manufacture. While there are several methods of engineering analysis, the most comprehensive is the finite element method (FEM). The finite element method represents one of the most significant developments in the history of computational methods. The concept of the finite element method is not new. It has been used throughout the centuries for evaluating certain quantities (particularly area and volume) by adding or counting well-defined geometric figures (elements). There are of course, many other approximate methods for the solution of boundary- value problems, such as finite-difference method, weighted-residual method, Galerkin method, and more. The primary difference between finite element method and other method is that in finite element method the approximation is confined to relatively small sub-domains. It is, in a way, the localized version of the Rayleigh-Ritz method. The power of general-purpose FEA program is that, it is not written to solve any specific problem for the novice user. It is a universal tool, which one understood, can be applied to, almost any type of problem. Commercial FEA system provide one, two and three dimensional elements, and solution procedures for problems in solid machines, structural mechanics, fracture mechanics, heat transfer, electromagnetic fields etc.

The mathematical theory underlying the FEM employs a variation or a weighted residual formulation valid for the exact solution as well as any approximation. It then introduces a discretization of the domain of interest into finite elements of different shapes, types and orders. Approximation of field variable(s) on each element domain produces a set of elements equations which are collected together to form global matrix statement.

The method then uses the various linear algebra techniques to solve the governing matrix equations, after enforcing appropriate boundary and constraint conditions.

The digital computer has exerted a profound impact on the engineering and scientific communities. The finite element method implemented on a computer, in the form of general purpose program provides a board foundation for engineering analysis.

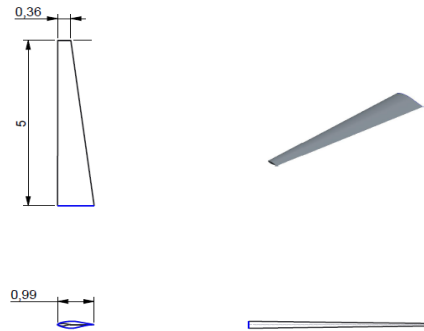


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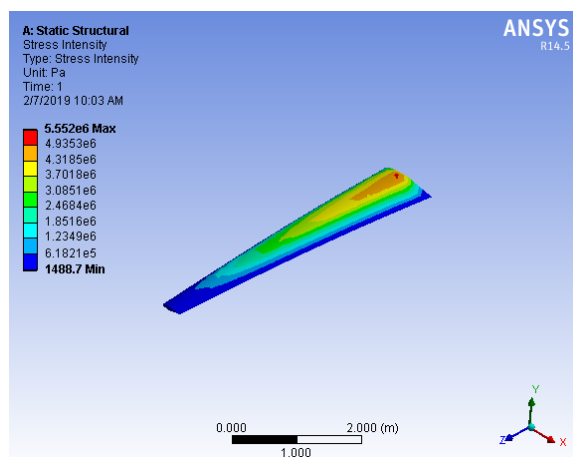
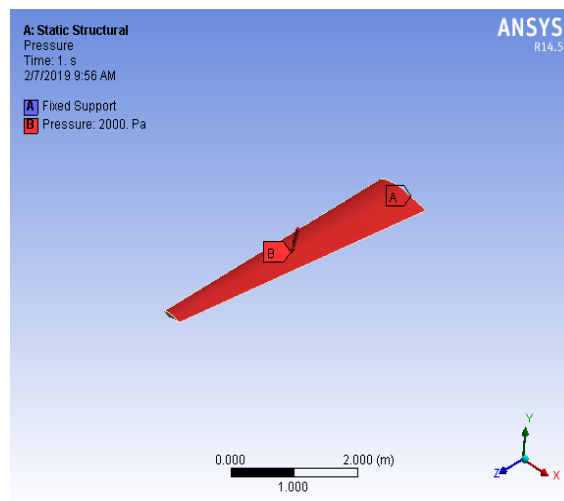
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CASE 1 – 3 % CNT

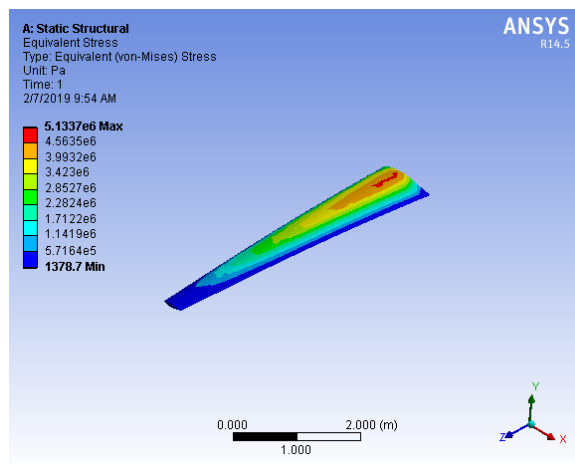
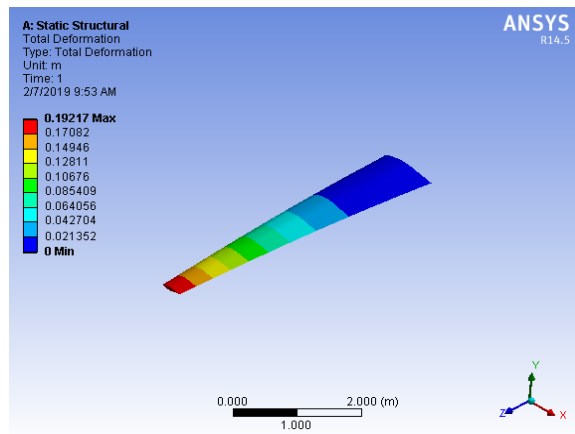
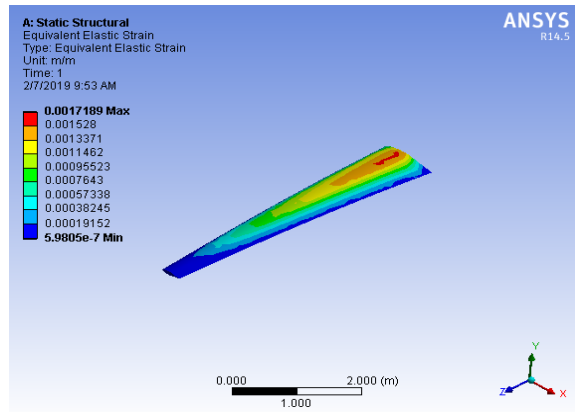


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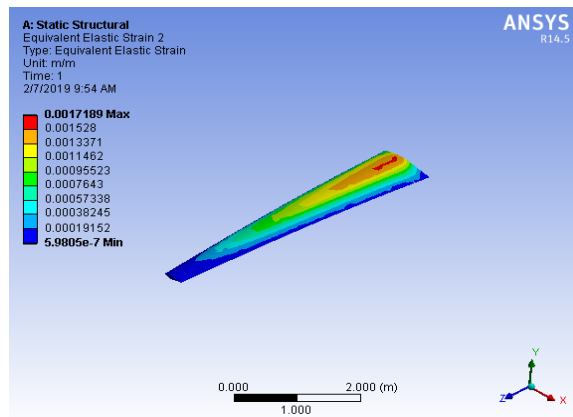
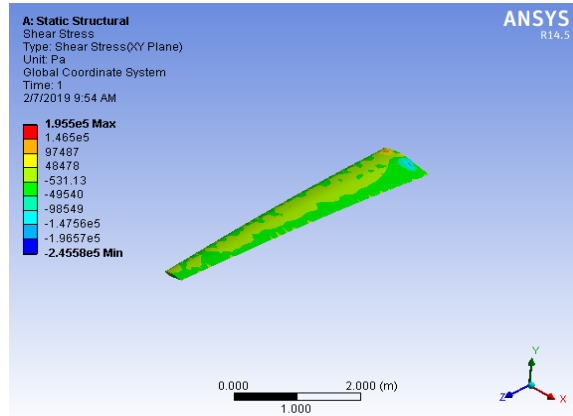


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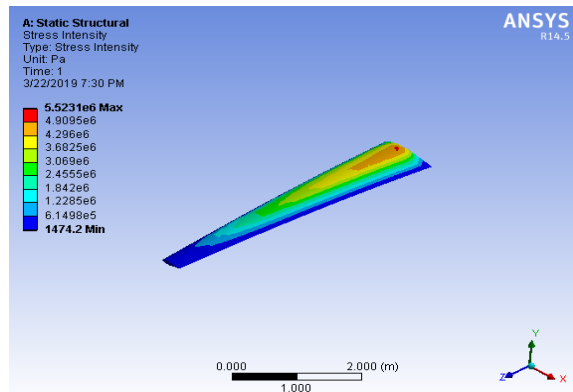
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CASE1	Stress Intensity	Equivalent Elastic Strain	Total Deformation	Equivalent Stress	Shear Stress
Minimum	1488.7 Pa	5.9805e-007 m/m	0. m	1378.7 Pa	-2.4558e+005 Pa
Maximum	5.552e+006 Pa	1.7189e-003 m/m	0.19217 m	5.1337e+006 Pa	1.955e+005 Pa

CASE 2 – WITHOUT CNT

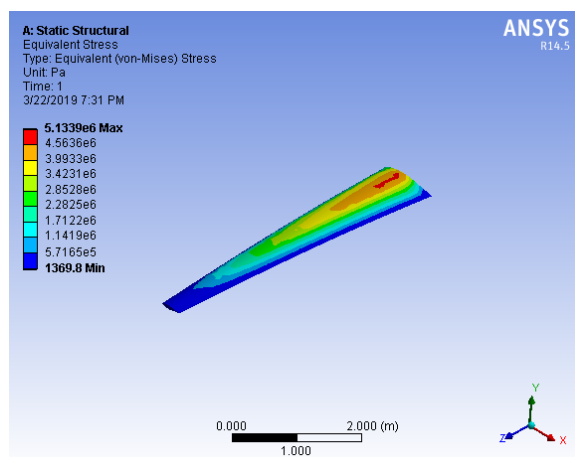
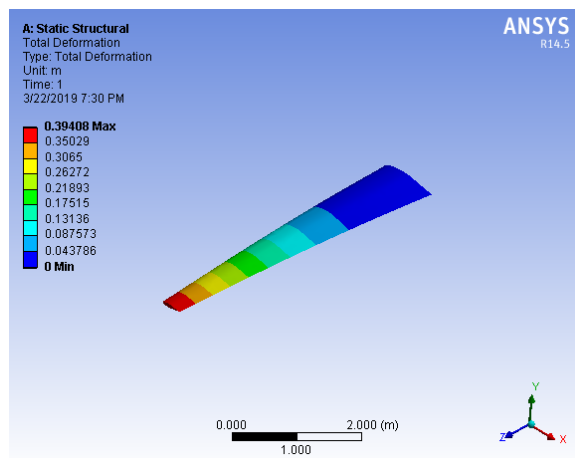
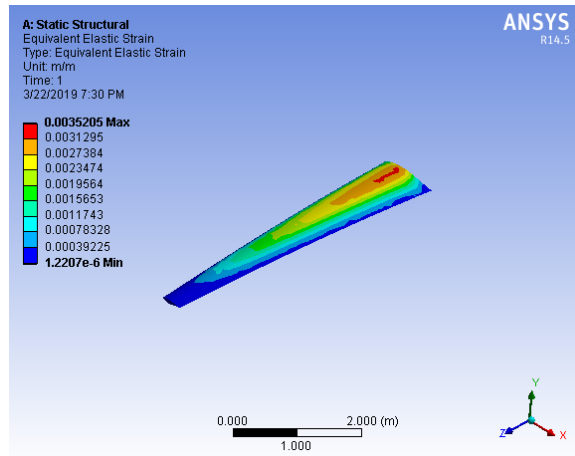


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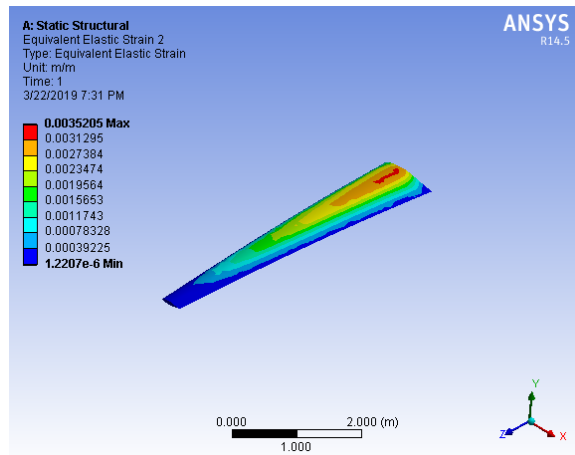
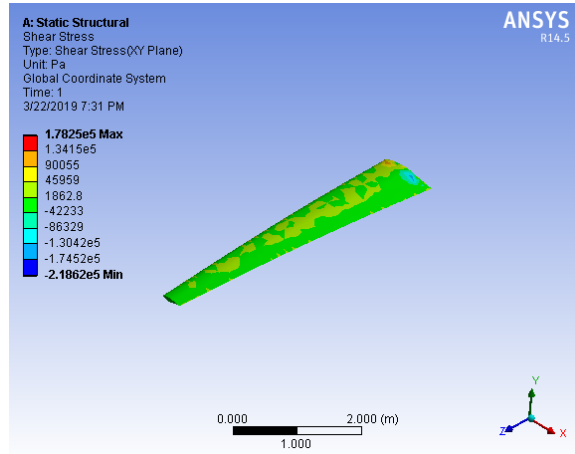


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CASE 2	Stress Intensity	Equivalent Elastic Strain	Total Deformation	Equivalent (von-Mises) Stress	Shear Stress
Minimum	1474.2 Pa	1.2207e-006 m/m	0. m	1369.8 Pa	-2.1862e+005 Pa
Maximum	5.5231e+006 Pa	3.5205e-003 m/m	0.39408 m	5.1339e+006 Pa	1.7825e+005 Pa

VI. RESULT

	Stress Intensity	Equivalent Elastic Strain	Total Deformation	Equivalent Stress	Shear Stress
CASE1	5.552e+006 Pa	1.7189e-003 m/m	0.19217 m	5.1337e+006 Pa	1.955e+005 Pa
CASE2	5.5231e+006 Pa	3.5205e-003 m/m	0.39408 m	5.1339e+006 Pa	1.7825e+005 Pa

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VII. CONCLUSION

By comparing Tensile stress Results of Experimental Analysis. From the test results of nano composites based on mechanical tests conducted a conclusion is reached from the study. All the result are compared to various proposition of carbon nano tube to increase the strength

From the study it's concluded that the composites used in aerospace and automobile applications abundant and highly reliable.

Now a days, in automobile field the glass fiber and carbon fiber hybrid composite material result of tensile strength and compression strength is increase compare between 3% CNT and without CNT respectively. This is less strength as compared to carbon fiber and glass fibre with CNT hybrid composites

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