Structural analysis of wing skin made up of different types of composites

MASTER OF TECHNOLOGY

(PRODUCTION AND INDUSTRIAL ENGINEERING)

DELHI TECHNOLOGICAL UNIVERSITY

SUBMITTED BY

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UNDER THE GUIDANCE OF

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STUDENT'S DECLARATION

I, ARSH NAWAZ (Roll No. 2K19/PIE/16), hereby certify that the work which is being presented in this report titled "Structural analysis of wing skin made up of different types of composites" is submitted in the partial fulfillment of the requirement for the degree of Master of Technology (Production and Industrial engineering) in Department of Mechanical Engineering at Delhi Technological University is an authentic record of my work carried out under the supervision of Prof. A.K. Madan and Dr. M.S. Niranjan. The matter presented in this report has not been submitted to any other University/Institute for the award of Master of Technology Degree. Also, it has not been directly copied from any source without giving its proper reference.

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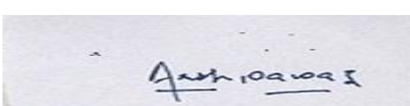

CERTIFICATE

This is to certify that this report titled, "Structural analysis of wing skin made up of different types of composites" is being submitted by ARSH NAWAZ (Roll No. 2K19/PIE/16) at Delhi Technological University, Delhi for partial fulfillment of the Degree of Master of Technology as per the academic curriculum. It is a record of bonafide research work carried out by the student under my supervision and guidance, towards partial fulfillment of the requirement for the award of Master of Technology degree in Production engineering. The work is original as it has not been submitted earlier in part or full for any purpose before.

26/10/2021

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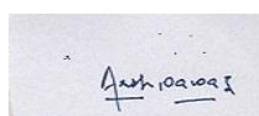
I would like to extend my gratitude to Prof. S. K. Garg, Head of, Mechanical Engineering Department for providing this opportunity to carry out the present work.

Finally, and most importantly, I would like to thank my family members for their help, encouragement, and prayers through all these months. I dedicate my work to them.



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Abstract

A wing is the most crucial part of any flying machine. It creates a lift due to the momentum phenomenon as air molecules are suppressed down by the aerofoil shape. So, in reaction, air molecules apply some force which has two components that can be resolved in two components one is drag and the other one is lifted. Wing mainly consists of three parts skin, spars, and Ribs. In the design of the wing, I consider 15 ribs and two spars. Front spars are made up of an I section, and the back part is of a C section running longitudinally along the length of the wing. This study aims to apply different composite materials to wing skin e.g. Epoxy- carbon is woven, epoxy-carbon UD, and Epoxy E-glass, and compare their results in FEA analysis, and gets the best material for wing skin. The initial wing has been modeled in the Catia by taking coordinates of NACA 4412 from the NASA website and then performing structural analysis to get deformation and stresses with different speeds. The best material for wing skin has been identified by structural analysis of different types of composites and Epoxy – Carbon UD has been found as the best material for an aircraft wing.

Keywords- wing, Drag, lift, FEA, Structural analysis, composite, ribs, spars

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1. INTRODUCTION

Aircraft are very complicated machines that are designed very extensively to get the accurate lift and drag to get aircraft moving there are three phases in Airplane flying first is takeoff, cruise, and landing. we only need lift force whenever we change our altitude. There are many theories related to lifting generation one is in form of momentum change and another one is Bernoulli's theorem which is due to the change in velocity of air molecules in a downward section of the wing which causes pressure difference in the upward direction which generates lift. Because it is exposed to alternately recurring loads during flight, the wing must have properties e.g., high strength to weight ratio and long fatigue life. The main goal of this research is to find appropriate material for the wing skin, such as composite, to substitute the orthodox Aluminum used to make the wing's skin. The cross-section profile of a wing is known as an airfoil, and it is designed to be aerodynamic in shape to reduce drag and the lift/drag ratio is used to express the aerodynamic efficiency of a wing. Additional structural machinery of an aircraft includes the fuselage and empennage. The fuselage houses the aircraft's passengers, crew, and cargo on board while the empennage delivers necessary stability during flight time. Aluminum is a popular and widely used material for a variety of applications. Approximately 75% of the structure in the industry is made of aluminum and their aluminum alloys The matrix, which environs and impasses the reinforcement material, and the reinforcement material are the two components of composite material. In this investigation, Epoxy serves as the matrix material, and other fiber serves as the reinforcement material. Glass fiber, carbon fiber, and other materials can be used as fibers. A composite laminate is a gathering of layers of fibrous material in a specific pattern such as carbon fibers, glass fibers, and aramids that are laid in a matrix material and can be joined to provide the required specific and desired properties. A laminate is made by stacking several individual laminas one on top of the other in the desired orientation. The load is carried by a fiber entrenched in the lamina in various orientations. The matrix material supports the fibers while also protecting them from damage. The matrix's primary function is to transference the load to the fiber part while keeping it in a predefined position and orientation.

2. LITERATURE REVIEW

Mohamed Hamadan and Nithya Kalyani amylase their research in ribs and spars and finding their stresses and displacement caused by external loads and the best design specification were taken and then model was created and the model of wing thoroughly described and explained and also different types of load and their effect are calculated[1] "Bret K. Stanford and Peter D performed investigation on different optimization problems that were analyzed within the ribs and spars of the wing box. It was done so to determine the best position of holes and, truss/bracing, and so on for each of these problem specific sets of aeroelastic material were developed. Elastic wing stiffness under tensile stress, stress distribution, and compressive load. Aileron effectiveness when the rolling rate is continually considered as are alternative metrics natural vibration frequency and fluster. This method elucidates the relationship between topology and aeroelasticity in subsonic wings, which can aid in understanding the complex aircraft design process, which must ultimately reflect all of these metrics and load cases concurrently" [2].
W.J Godey studies his article on two wings spar stress analysis by using the distortion energy theorem that rib elasticity has no considerable effect on the distribution of stress in the wing. this assumption is equivalent to disregarding the strain energy stored in the ribs. Other authors, in effect, made the same assumption by disregarding the change in the profile of cross-sections under varying load" [3].

"Pritish Chitte et investigated the initial sizing and examination of a wing box. The chief goal is to construct a suitable structure within the constraints of the available space. Sizing is accomplished through the application of classical engineering theories and FEA. The skin and web are regarded as elements. Beam elements include the flange, spar, and stringer. Iterations are used in the analysis, such as with different sections such as rectangular sections, Z-sections, and L-sections, panel breakings, and varying skin thicknesses. Based on the analysis, the construction has been designed to meet the strength and stability resisting criteria, but there is still room for improvement by reshaping components such as Ribs and Spars. The most important aspects of aircraft design[4].

according to P. Murugesan and P. Thermogram" are safety and structure weight. The wing is a chief constituent of an aircraft. "The lift required for flight is created by the wing. The major structural elements of the wing are spars, ribs, and skins. Spars are structural members that run from the fuselage to the wing tip through the wing root. The major wing bending loads are carried by the spars. Ribs are structural members that run in the chordwise direction. Ribs support the wing's shear and compression loads. Ribs also assist the wing in maintaining its aerodynamic shape when loaded. The current research includes a composite wing configuration with five ribs and two spars. At wing stations, shear force, bending moment, and torsion moment are generated by the aerodynamic distributed load on the wing. Linear static stress analysis is used to determine the wing spar's static load-carrying capability. During wing bending, the top part of the skin of the wing box will bear axial compression. The buckling analysis will take into account the upper skin pieces between the spar part and ribs. The buckling critical loads of these panels will be evaluated using an analytical approach" [5].

"A. Ramesh Kumar et al elaborated. Skin, ribs, and spar sections make up the wing structure. While on the ground, the spar supports flight loads as well as the weight of the wings. Other structural and founding members, such as ribs parts, are connected to the spars by stressed skin. The wings are the most significant working part of the aircraft for generating lift. Wing designs can vary depending on the type of aircraft and its intended use. Wing structure experimental reporting is a more expensive and time-taking process. The stresses at the wing construction are again computed in software using a stress analysis of the wing structure. The wing structure's response will be assessed. The forecast of fatigue life for the crack beginning is performed in this study at the maximum stress location" [6].

"According to Vikas Kumar et al. when designing a wing skin, the structure of the wing should be robust enough to withstand the variable load and forces under extreme circumstances under which the airplane must function. The wing is like a beam that conveys and wrinkles all loads useful to the fuselage. The wing's main components are the spar, ribs, stringers, and skin. The main function of a wing is to produce greater lift. Wings require longitudinal members to endure the bending moments and bending stress experienced by aircraft during flying and landing Ribs are mechanical members that keep the wing's aerodynamic shape intact. In this paper, we investigate a wing box

that is exposed to flight loads. This paper also investigates load distribution on the wing" [7]

"According to Hashiguchi et al a group of low density, high elastic modulus aluminum-beryllium alloys are being developed to incorporate the necessities of cutting-edge aerospace designs. Those alloys are aluminum-based with 12% to 75% beryllium and combine beryllium's very high specific stiffness and the high ductility properties and ease of manufacturing of aluminum. Densities ranging from 2.1 to 2.59 g/cc have been achieved and outstanding strength and ductility are been harnessed AlbeMet alloy group was created using both powder metallurgy techniques Tensile, fatigue, and fracture mechanics evaluations were performed on the extruded bar and rolled sheet properties[8].

"According to Zlatan Kapid these materials are subjected to different design input and certification requirements as a result of these differences. The following issues arise during hybrid structure certification: thermal-induced loads, an array of failure modes, impairment tolerances, buckling, and enduring deformations, material properties are scattered, important load states, and so on. The present study's goal is to test and analyze the strength, toughness, and thermomechanical behavior of a hybrid composites aluminum wing assembly. The effect of hybrid structure constitution and requirement profiles on mass, strength, fatigue durability, stability, and thermo-mechanical behavior is investigated. Based on the conceptual studies, a hybrid concept is selected for use in the following structural reporting. The second research paper emphasizes the wing structure's simulated testing. The finite element method is used to prototypical the local behavior of fastener joints in feature, and the results are then combined into a global perfect using line rudiments. Special consideration is given to the accumulation of damage and the failure behavior of the composite material. In the experimental setup, computations of progressive fastener failure are performed. The results of the analysis show the risky features of the hybrid wing structure in terms of static study, fatigue study, damage tolerance, and thermo-mechanical properties" [9].

"According to P. K Mallick the important empathetic of fiber reinforcement has not

changed, but new research has occurred in the materials field, mainly since the unearthing of carbon nanotubes. There has been an increase in the use of composite materials, which began primarily in aerospace manufacturing but are now found in a variety of non-aerospace manufacturing such as public goods, vehicle industry, power transmission, and biomedical industry. It is now coming in the mainstream part of the of "regular" materials" [10]

"According to Deborah D.L Chung carbon fiber carbon are very useful for the high-temperature application such as spacecraft application as time grow we can see the cost of composite reducing due to surge in manufacturing these induces the use of composite in other fields like construction industry which uses carbon-reinforced metal matrix in concrete this helps us to provide information about the total range of matrix e.g. metal matrix, carbon matrix, semi hybrid, and hybrid composite this all crisply gives us information about and smoothing our design process so we also need previous information to grow our research in this field.

A large number of up-to-date references are included at the end of each chapter, allowing the reader to concentrate on additional information if necessary. As a result, the book focuses on composites with a variety of matrices but only carbon fibers as fillers. This focus permits for an in-depth examination of the fiber-matrix boundary and composite dealing out for a wide range of matrices" [11].

"Martin Alberto Masuelli has provided a brief evaluation of Fiber-reinforced polymers and summarized the extensive range of infrequent properties that these different products provide (Polymer's chain, Aramids chain, Composites, Carbon FRP, and Glass-FRP). While the science of chemistry is vital in crucial the range of submissions for which this material is suitable. It is also very important for us to maximize the value of very inherent properties of this material but there is one catch in these that we maintain the balance between functionality and processability of this material to use it correctly.

These variable properties help them to perform in variable extreme conditions and this should be balanced in a way that it could match economically side of this material. The mobility of a polymer material's molecules, which is characterized by specific molecular motions and relaxation mechanisms that are accelerated by temperature and stress, determines its ability to deform. These relaxation mechanisms are used here to

find the wanted link with the essential deformation performance because they are material precise and depend on the molecular assembly" [12].

"According to Maria Mrazova, new advanced materials required to improve and advance aviation since Orville and Wilbur Wright first decided to power their aircraft with a purpose-built and they cast aluminum engine to meet the specific requirements for larger power to low weight ratio. By improving the performance and processes of modern aircraft, this advancement in material properties has allowed us to travel quickly and around the world. The author introduces composite materials, along with their benefits and drawbacks, in the first section of this study. The second section of the thesis introduces Airbus and its composite material innovation. Composite material continues to move forward, and developed of properties or allow their application in new areas and roles for future use"[13].

"Nikhil v Nayak bring light on Fiber-reinforced composite material that this material is gaining accusation in the market of aircraft and spacecraft construction due to their efficient performance in flying and this is also getting appreciated and heavenly adopted in the industry this brings confidence in researcher and causes the industry to accept this material as the primary force for aircraft structure.

Even though numerous applications in the aerospace application are mentioned, the focus of the research is on composites as main materials, where they have seen a substantial increase in usage. First, a short overview of composites' use in the aerospace industry is provided. The behavior of composite materials is then discussed, as well as the unique challenges that come with designing and working with them. The issues raised concern influence damage and damage tolerance in general, as well as environmental deterioration and long-term durability"[14].

3. Wing structure Geometry

The lift required for an aircraft to fly is provided by the wing. The aerofoil shape of the wing causes the air to get accelerated from the top side as compared to the bottom side resulting in a pressure difference and lift. It all depends on the wing's internal structure; 3 systems are used to determine how wings are committed to the airplane body. The full cantilever wing structure is the strongest since it is devoted unswervingly to the fuselage and lacks any exterior stress, stress-bearing assemblies.

To preserve the sleek shape of the wing, it must be considered to preserve its outline even under dangerous stress. The main parts of wings are skins, stringers, ribs, and spars

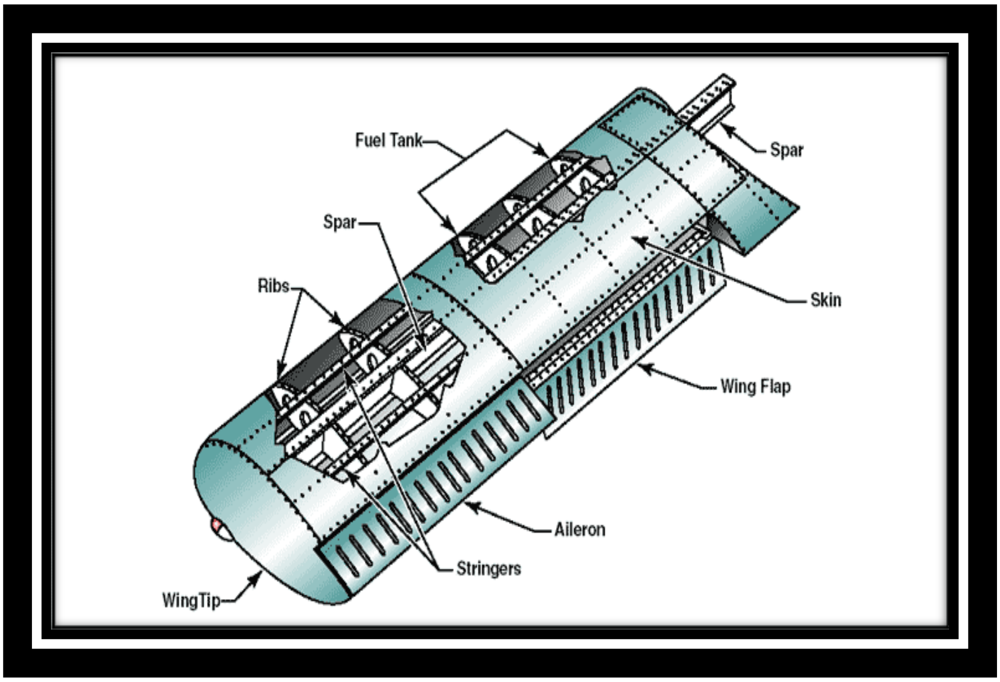


Fig 1 - (combine wing structure)[15]

<u>1. Skin</u>: The primary purpose of the wing skin remains to form the surface for helping the aerodynamic pressure difference that defines the wing's lifting abilities. Plate membrane action transmits forces from the skin to the ribs and stringers.

<u>2. Stringer</u>: The thin skin is effective at resisting shear and tensile loads, it buckles under low compressive loads, and increasing the thickness is not an option due to the weight penalty. Stringers are thus devoted to the skin and ribs, separating the casing into minor panels and growing the compressive and tensile stresses.

<u>3. Spar:</u> It is the wing's main load-carrying associate. It counters shear and torsional stresses moreover it supports the skin and spar flanges, allowing them to withstand great compressive stress.

<u>4. Ribs:</u> They keep the skin's airfoil shape and support it. Other wing attachments have no mechanical function but they are very important from an aerodynamic standpoint.

<u>5. Flaps</u>: it gives the extra aerodynamic lift at low speed for maneuver and landing.

<u>6. Ailerons</u>: During turning ailerons help to roll the aircraft to one side. When an aileron is positioned at one wing, it generates extra lift on that wing, causing the aircraft to roll in a conflicting direction.

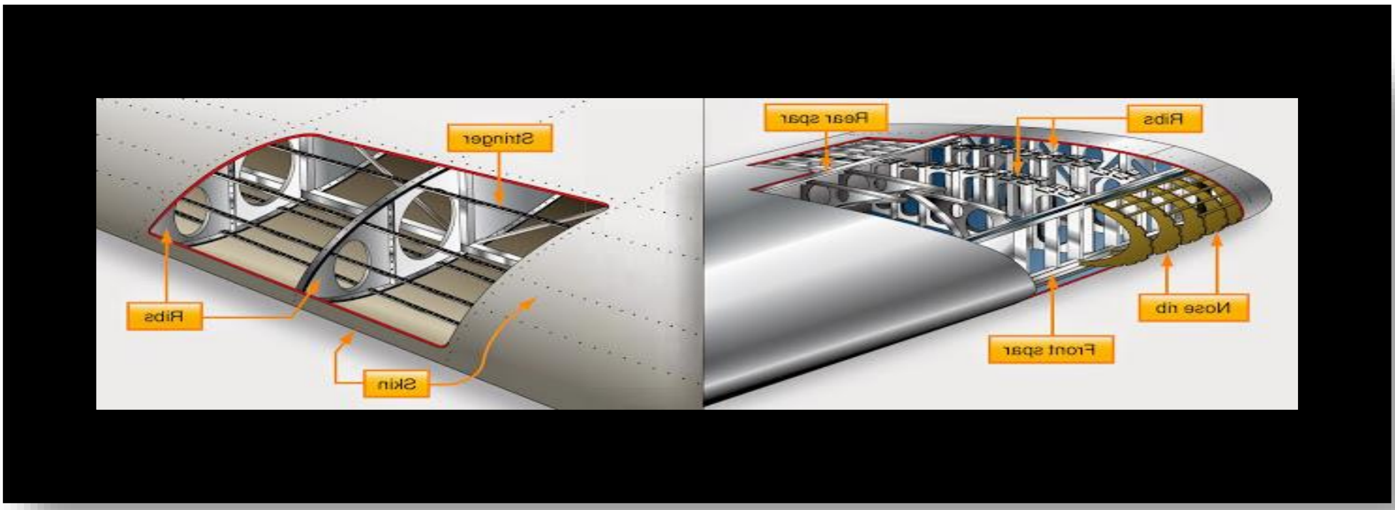


Fig 2. (Different parts of wing structure)[16]

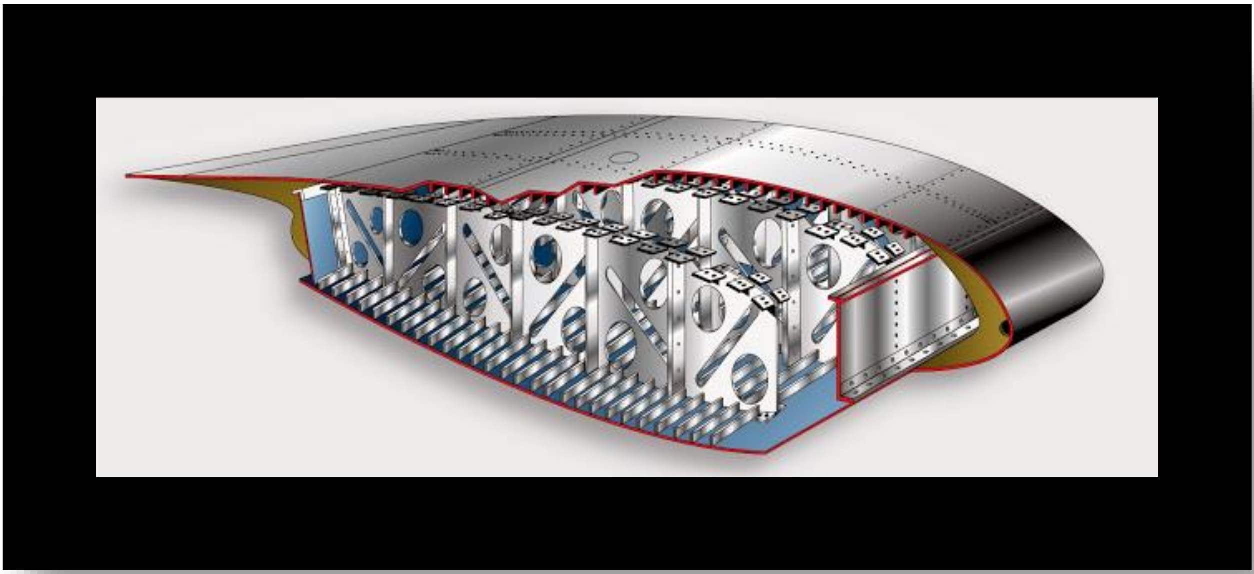
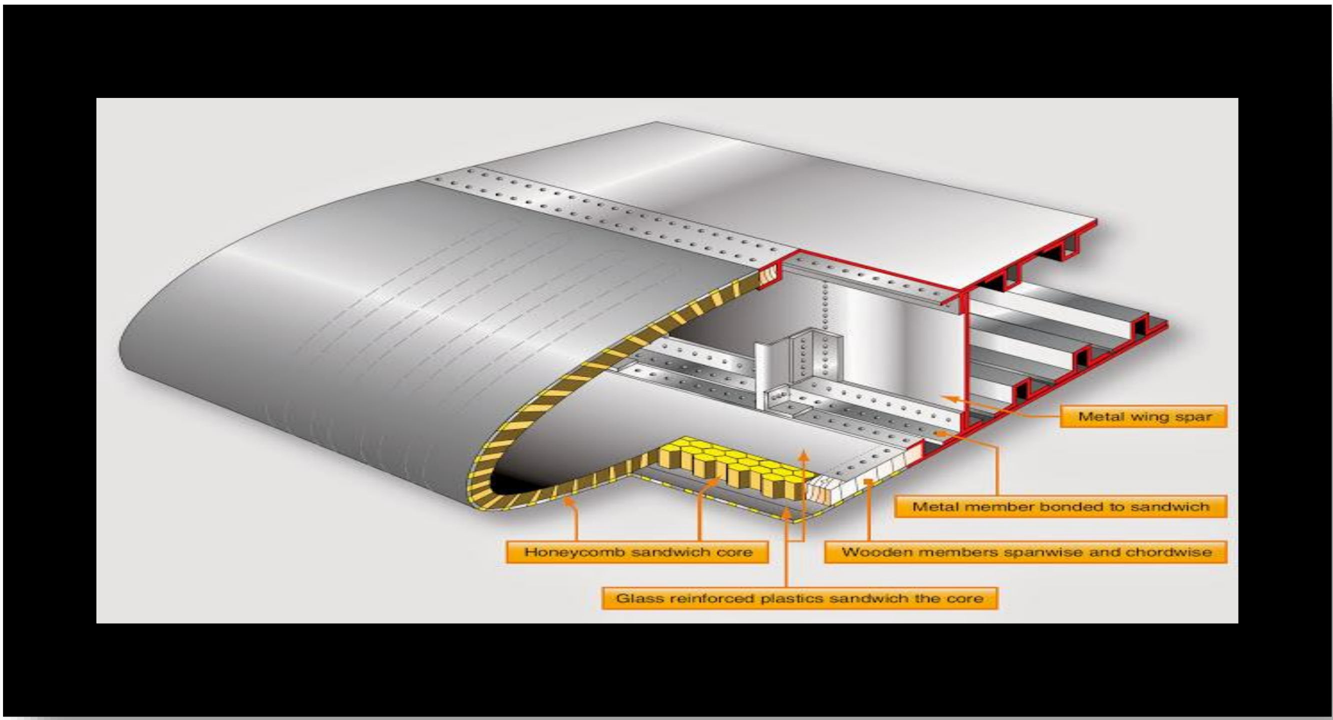


Fig.3 Internal part of the wing
[16]



4. TYPES OF STRUCTURAL STRESS

Determine the five primary stresses acting on an aircraft.

Strength, mass, and reliability criteria are the three utmost significant factors to consider when designing aircraft assemblies. These factors determine the requirement that every used material meet. the structure must be both robust and light. An aircraft is in a way that constructed so hefty that it only provides a few hundred kgs more weight would be unusable. All constituents used in the creation of an airplane must be dependable. Reliability reduces the likelihood of hazardous and unanticipated failures. When an aircraft is moving or stationary, it is imperiled to the variability of forces and structural stresses. When the vehicle is stationary, gravity generates force, which is helped by the landing gear. The wheel gear is responsible for absorbing the forces that are imposed on the aircraft during takeoffs and landings. These forces are absorbed and transmitted to the fuselage system by each module of the wing assembly. The tail section absorbs and transmits the same stresses to the fuselage structure. Those stresses are referred to as loads, and the study of loads is referred to as stress analysis. When designing an aircraft, stresses are analyzed and taken into account.

TENSION

Pull is the definition of tension. It is the strain caused by stretching or pulling by the ends. Tension is the stretching of the material by different forces in the same horizontal line. for example, an elevator controller cable experiences increased tension.

COMPRESSION

Compression stress arises when forces acting on an airplane move toward each other in the same direction to compress the material. Tension is the reverse of compression. Tension is a pull, whereas compression is a push. Compression is the compressing resistance produced by two forces pushing in the same straight line. When an airplane is on the ground,

SHEAR

Shearing action is when you cut a piece of paper with scissors. Shear is a stress that occurs in an aircraft structure when two pieces of fastened material tend to separate. Shear stress occurs when one part is slid over another in opposite directions. An aircraft's rivets and bolts are subjected to both shear and tension stresses.

TORSION

Torsional stresses are produced by a twisting force. When you squeeze out a chamois skin, you put it through torsion. While the engine is running, torque is produced in the crankshaft. Torque is produced by the same forces that cause torsional stress.

ALTERNATING STRESS

All aircraft structural members are subject to one or additional stresses. A structural associate may experience alternative stresses, such as compression one moment and tension the subsequently. The aircraft material must be strong that it can withstand alternating stress. You must understand the stresses experienced by the aircraft's main components. Understanding why aircraft are built the way they are will help you understand why they are built the way they are. An aircraft's fuselage is subjected to five types of stress: torsion stress, bending stress, tension, shear stress, and compressive stress. Torsional stress in a fuselage structure can be generated in a variety of ways. Torsional stress, for example, is encountered in turboprop engine torque. Engine torque tends to rotate the aircraft in the opposite direction of the propeller's rotation. Torsional stress is created in the fuselage as a result of this force. demonstrates the effect of rotating propellers Additionally, when the aircraft is maneuvered, the ailerons create torsional stress on the fuselage. There is a bending force on the fuselage of an aircraft when it is on the ground. The weight of the aircraft causes this force. When the aircraft makes a landing, it bends more. This bending phenomenon causes tensile stress on the fuselage's lower skin and compression stress on the top skin. When the aircraft is in flight, those stresses are transferred to the fuselage base.

5. Material and their properties

(1) Epoxy-carbon woven

Elastic modulus	Poisson ratio	Modulus of rigidity	density
Ex=61.34	μ(xy)=0.04	Gxy (Gpa)=19.5	1420
Ey=61.34	μ(yz)=0.3	Gyz(Gpa)=2.7	
Ez=6.9	μ(zx)=0.23	Gzx(Gpa)=2.7	

2. epoxy carbon UD

Elastic modulus	Poisson ratio	Modulus of rigidity	density
Ex=121	μ(xy)=0.27	Gxy(Gpa)=4.7	1490
Ey=8.6	μ(yz)=0.4	Gyz(Gpa)=3.1	
Ez=8.6	μ(zx)=0.27	Gzx(Gpa)=4.7	

3. Epoxy E glass

Elastic modulus	Poisson ratio	Modulus of rigidity	density
Ex=45	μ(xy)=0.3	Gxy(Gpa)=5.0	2000
Ey=10	μ(yz)=0.4	Gyz(Gpa)=3.8	
Ez=10	μ(zx)=0.4	Gzx(Gpa)=5.0	

4. Aluminum 2024 T3

Elastic modulus	Poisson ratio	Modulus of rigidity	density
Ex=73.1	μ(xy)=0.33	Gxy(Gpa)=26.6	2770
Ey=73.1	μ(yz)=0.33	Gyz(Gpa)=26.6	
Ez=73.1	μ(zx)=0.33	Gzx(Gpa)=26.6	

6. RESEARCH STEPS AND PROCEDURE

(1) Input parameters of FEA analysis

In this complete study, I have taken an aircraft that have skin, spars, ribs and in my FEA analysis, the wing structure consists of 16 Ribs and 2 Spars, and the front one has an "I type" section structure and rear spar part having "c type" section.

Table 1. Input variable for wing structure

variables	Dimension
Root chords	2450mm
Tip chords	750
Semi-span length	5700
Uncovered Length of wing	4800
Airfoil (Root type)	NACA 4412
Airfoil (Tip type)	NACA 4412
Front Spar	18 -25% of chords

(2.) Creation of 3d model of aircraft wing structure in Catia

Firstly, we need to coordinate for 3d wing structure so I have taken NACA 4412 coordinates from the NASA website and then sent this into Microsoft excel and this model is created in Catia furthermore we divided the 16 sections at an equal interval from reference plane with thickness 103 mm and the overall files is transferred to Ansys workbench in IGS format

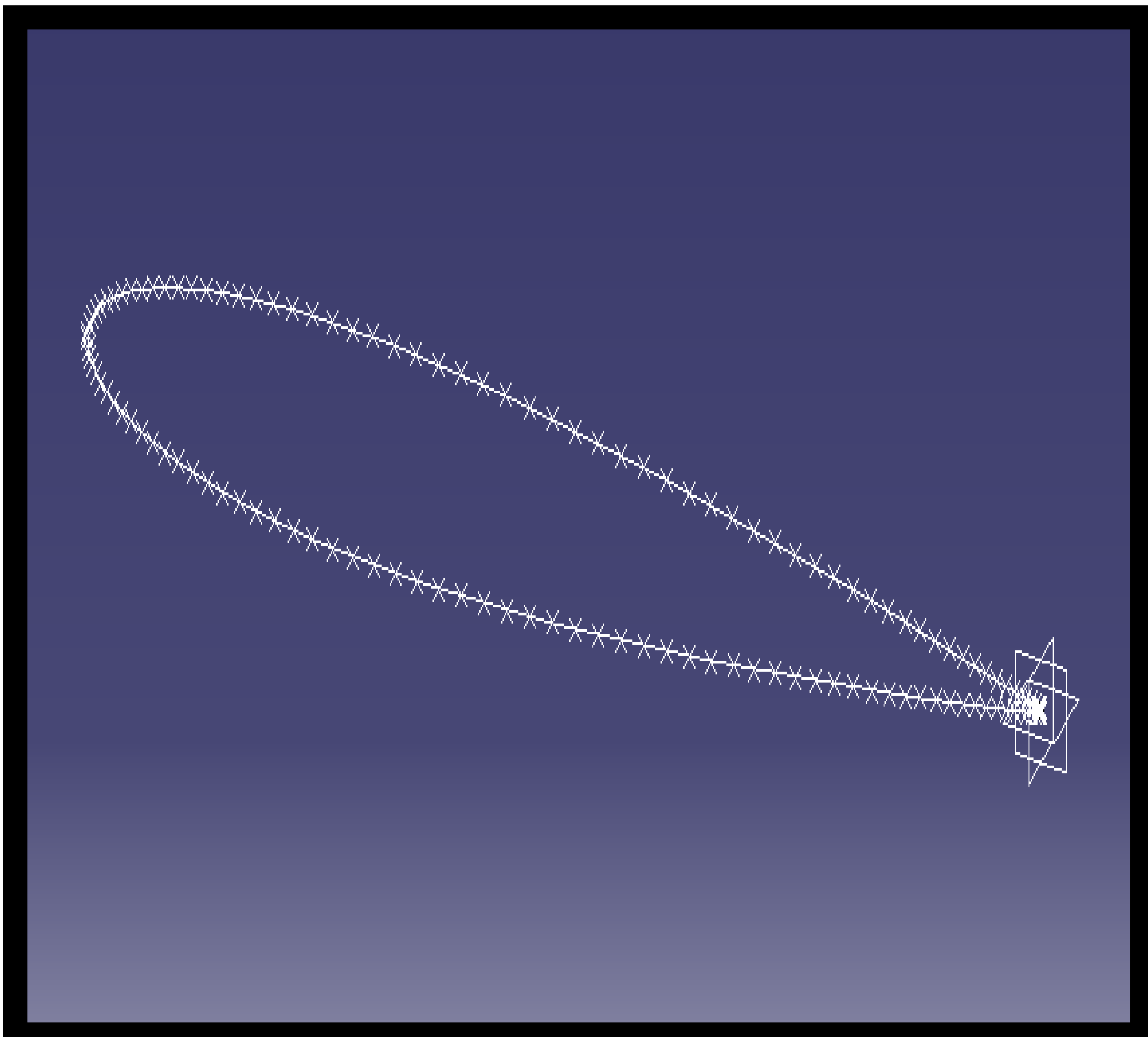


Fig 4 NACA 4412 geometry coordinates

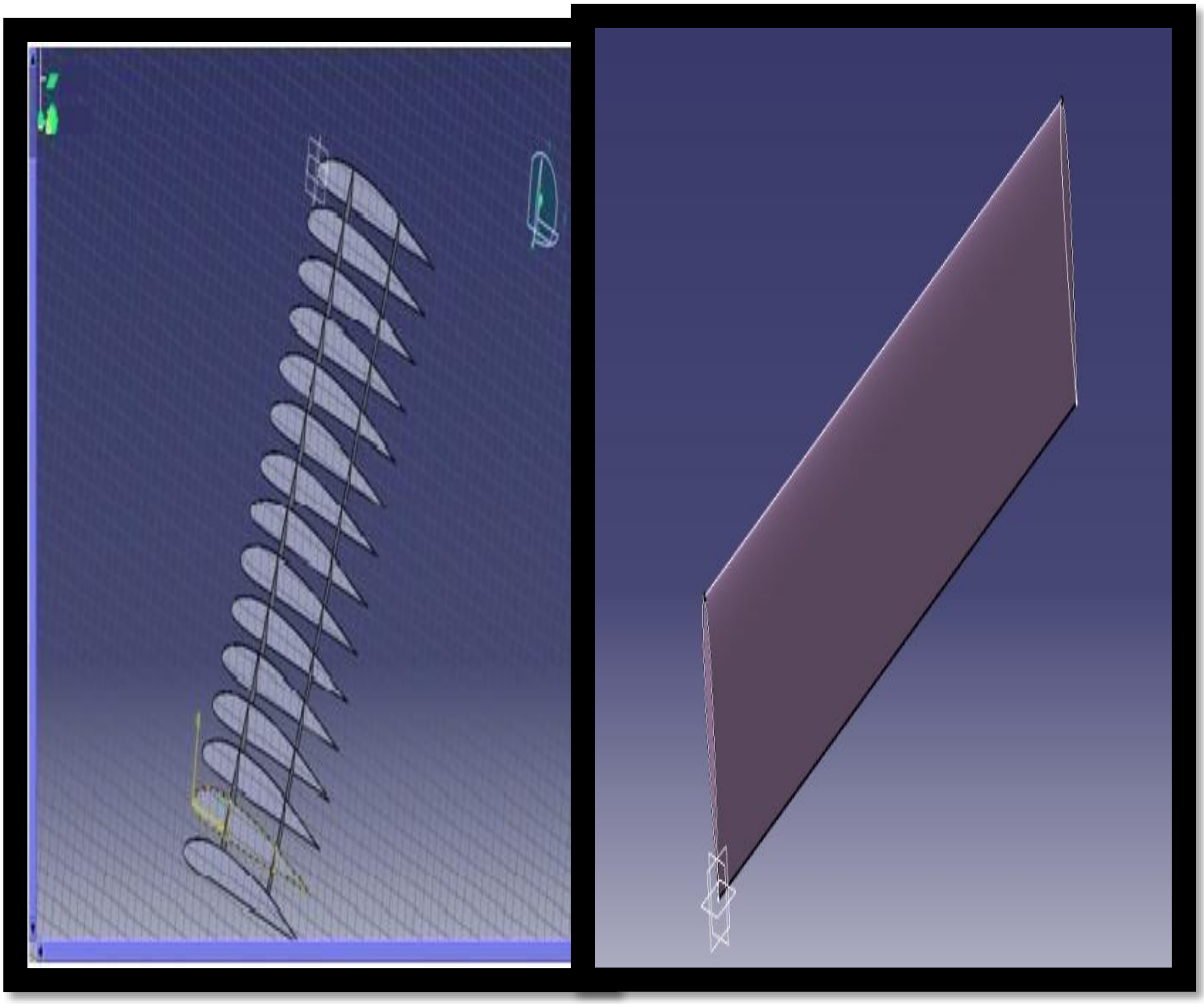


Fig 5 wing spar and ribs in Catia

Fixing the boundary state condition

Figure 3 depicts the loads and boundary conditions, as well as the finite element model. Because it is embedded inside the fuselage, one side of the wing is fixed, leaving the other end free with 6 degrees of rotation. At the center of pressure, a pressure force of 500 Pascal is applied to the lowest surfaces of the wing. The center of pressure is defined as the point at which total pressure is presumed to be acted.

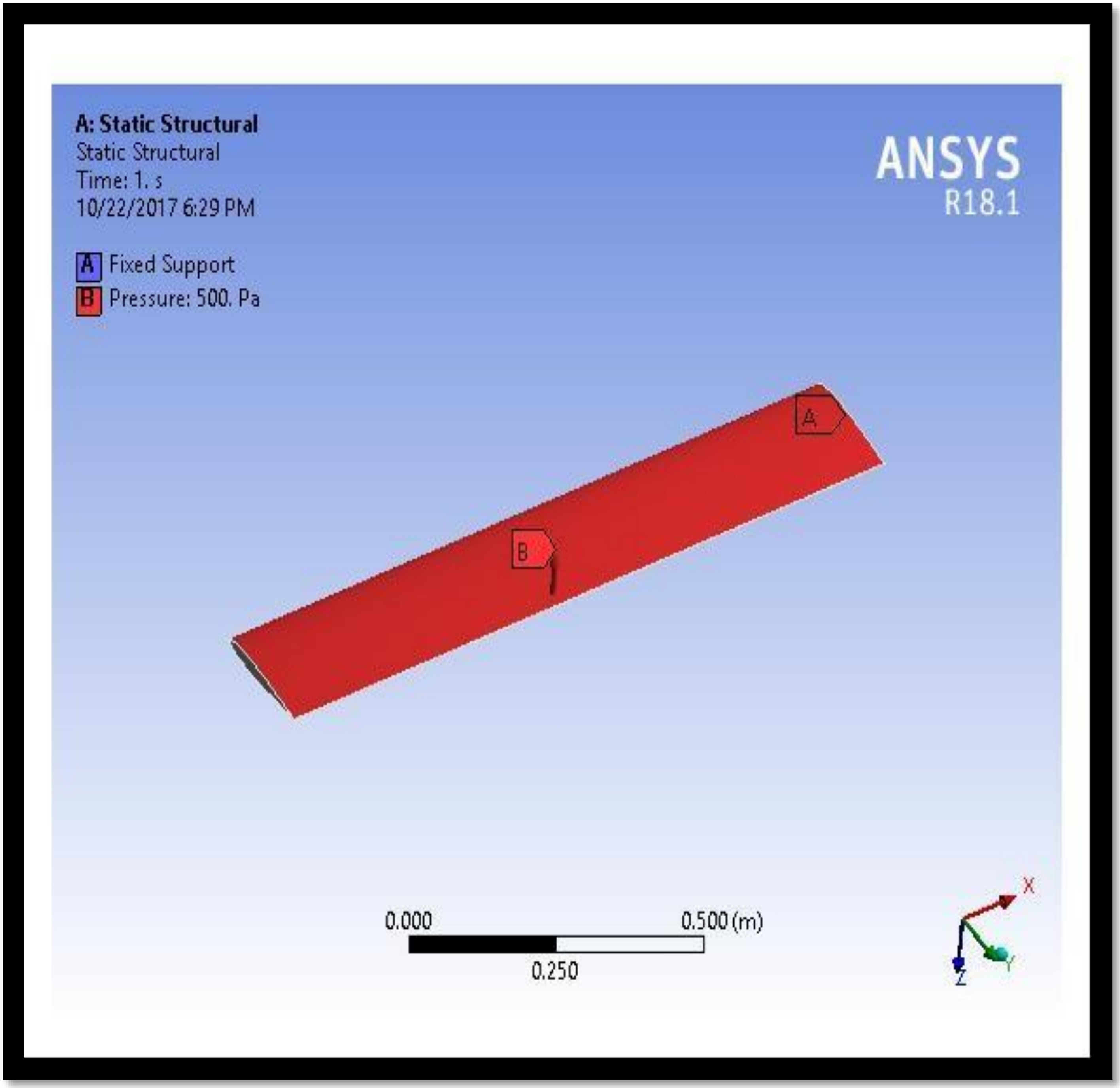
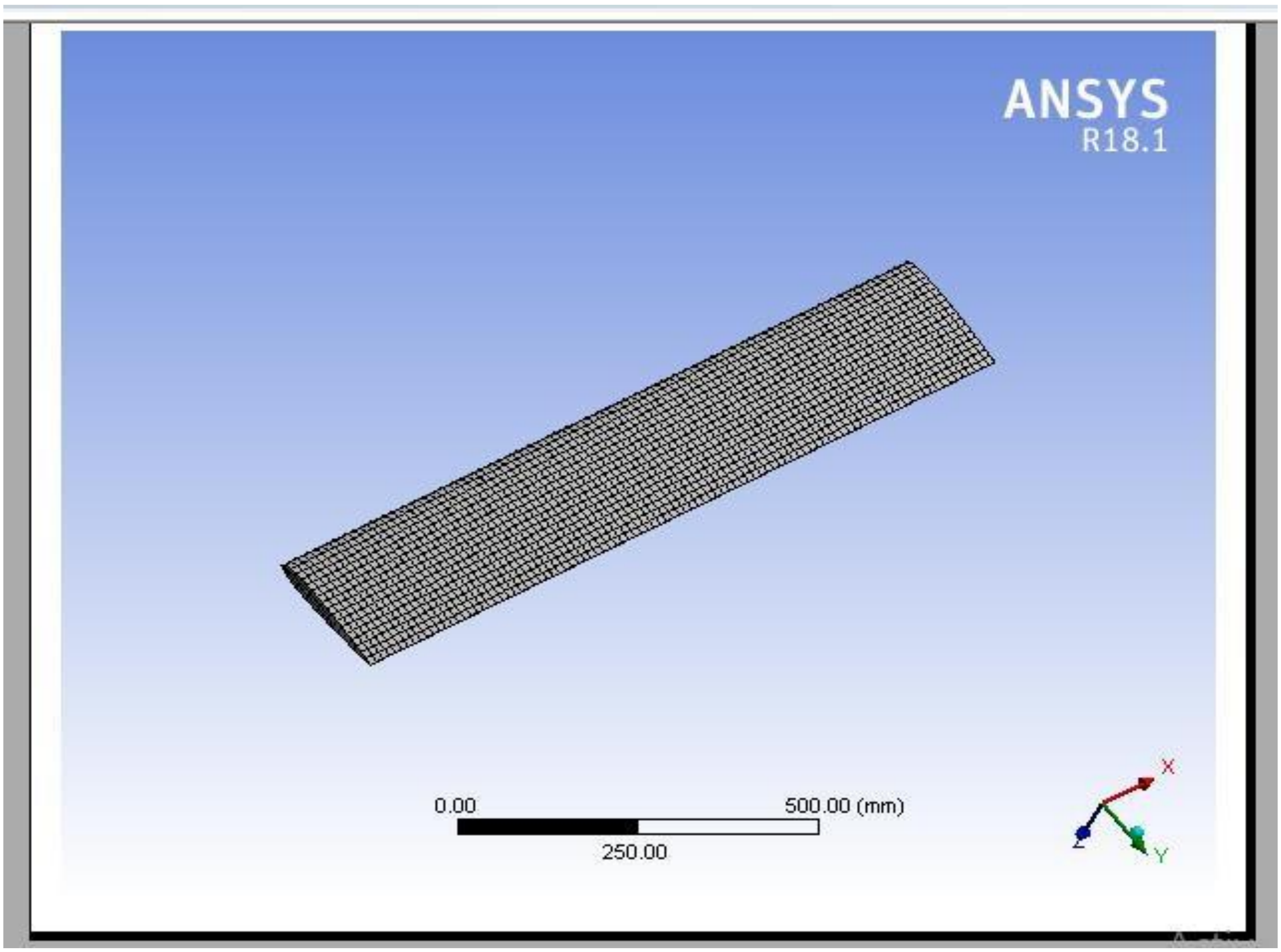


Fig 6 – ANSYS Model with boundary condition with load

3. Meshing of the model

I choose a very fine grain mesh for my analysis to get accurate analysis in ANSYS R18.



FINITE ELEMENT ANALYSIS OF DIFFERENT MATERIAL

(1) EPOXY-CARBON UD

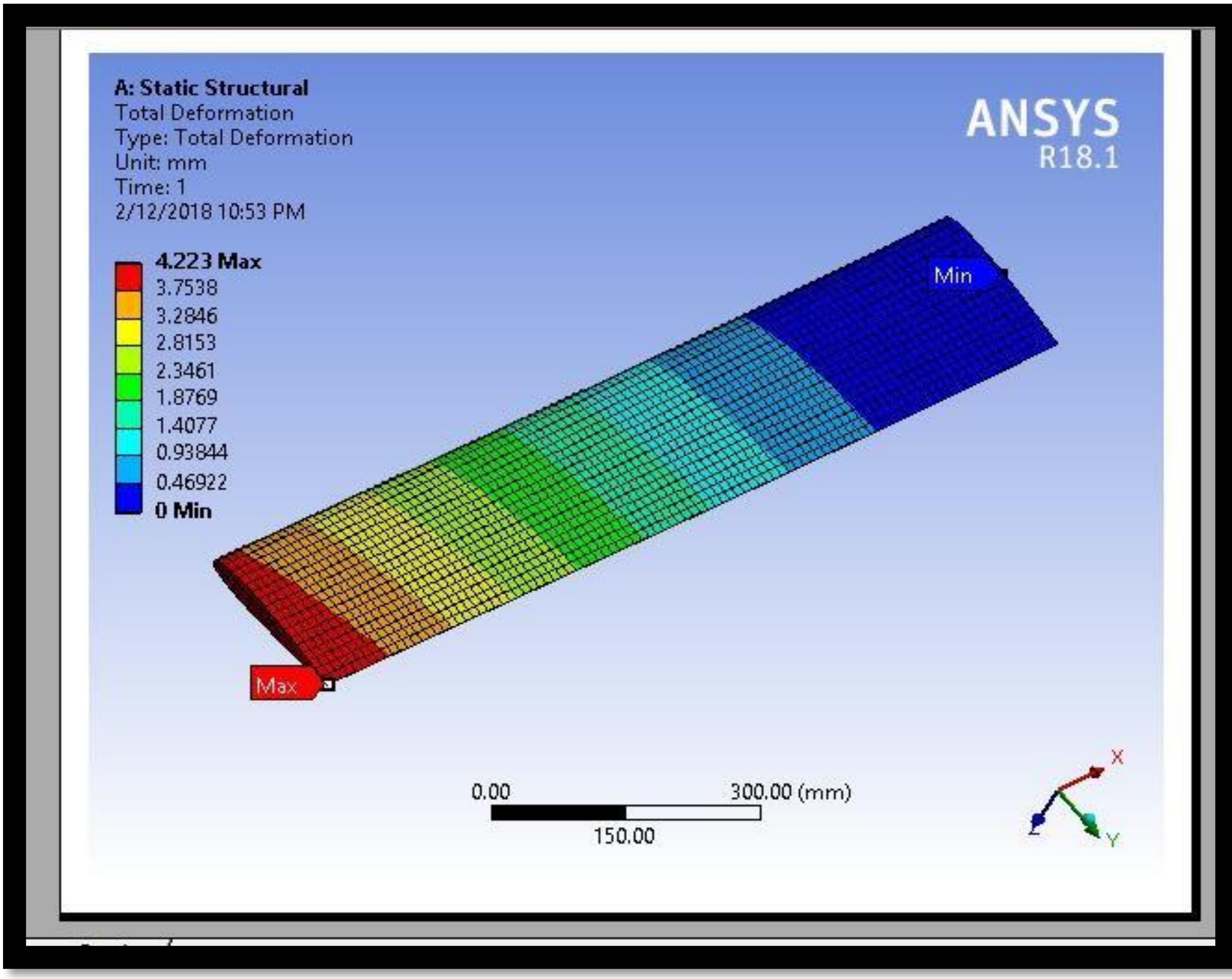


Fig 7 Total deformation of Epoxy-Carbon UD

2 EPOXY- S- GLASS

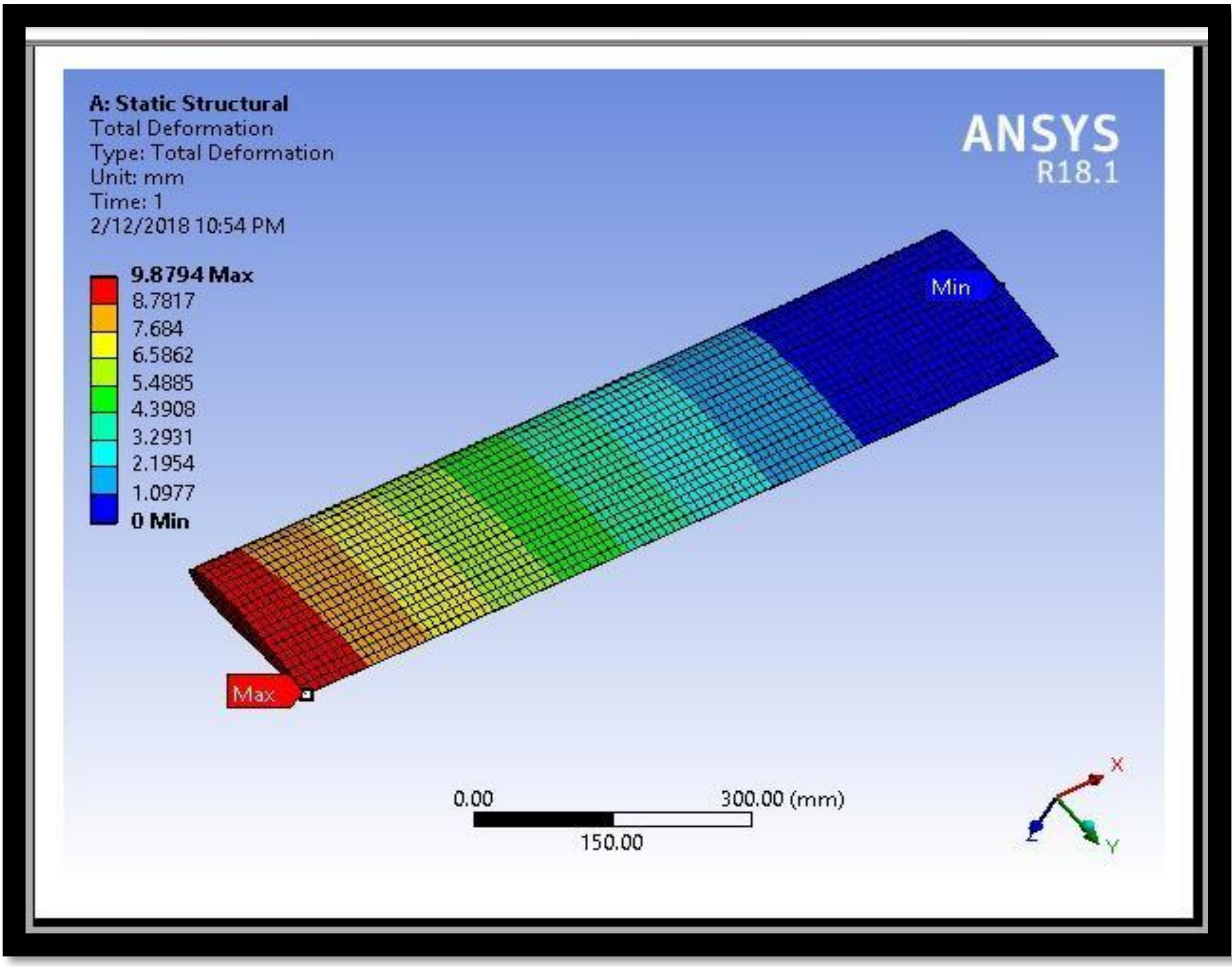


Fig 8 Total Deformation of Epoxy S-Glass

(3) Aluminum 2024

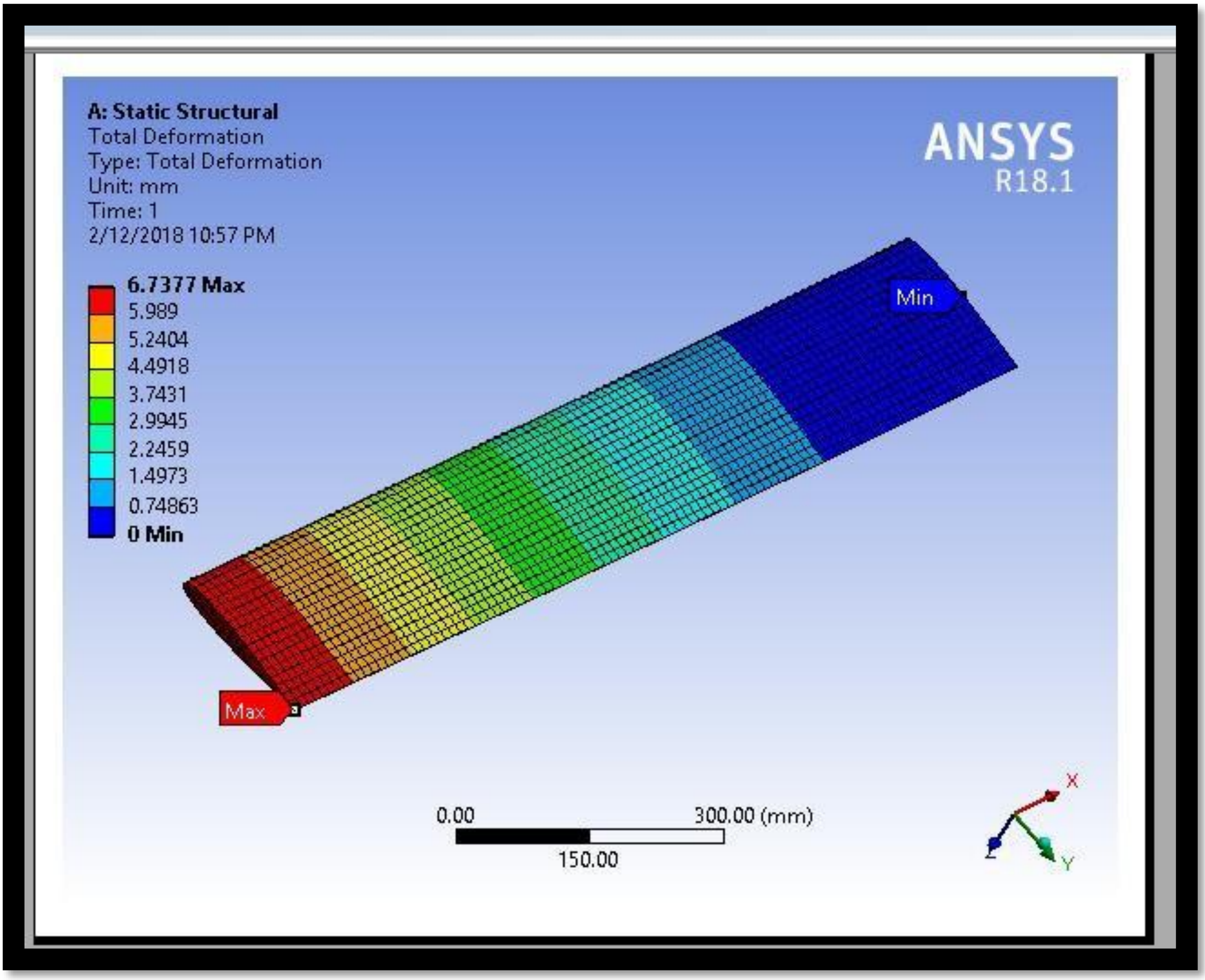


Fig 9 Total deformation using Aluminum 2024T3

4. (EPOX- CARBON WOVEN)

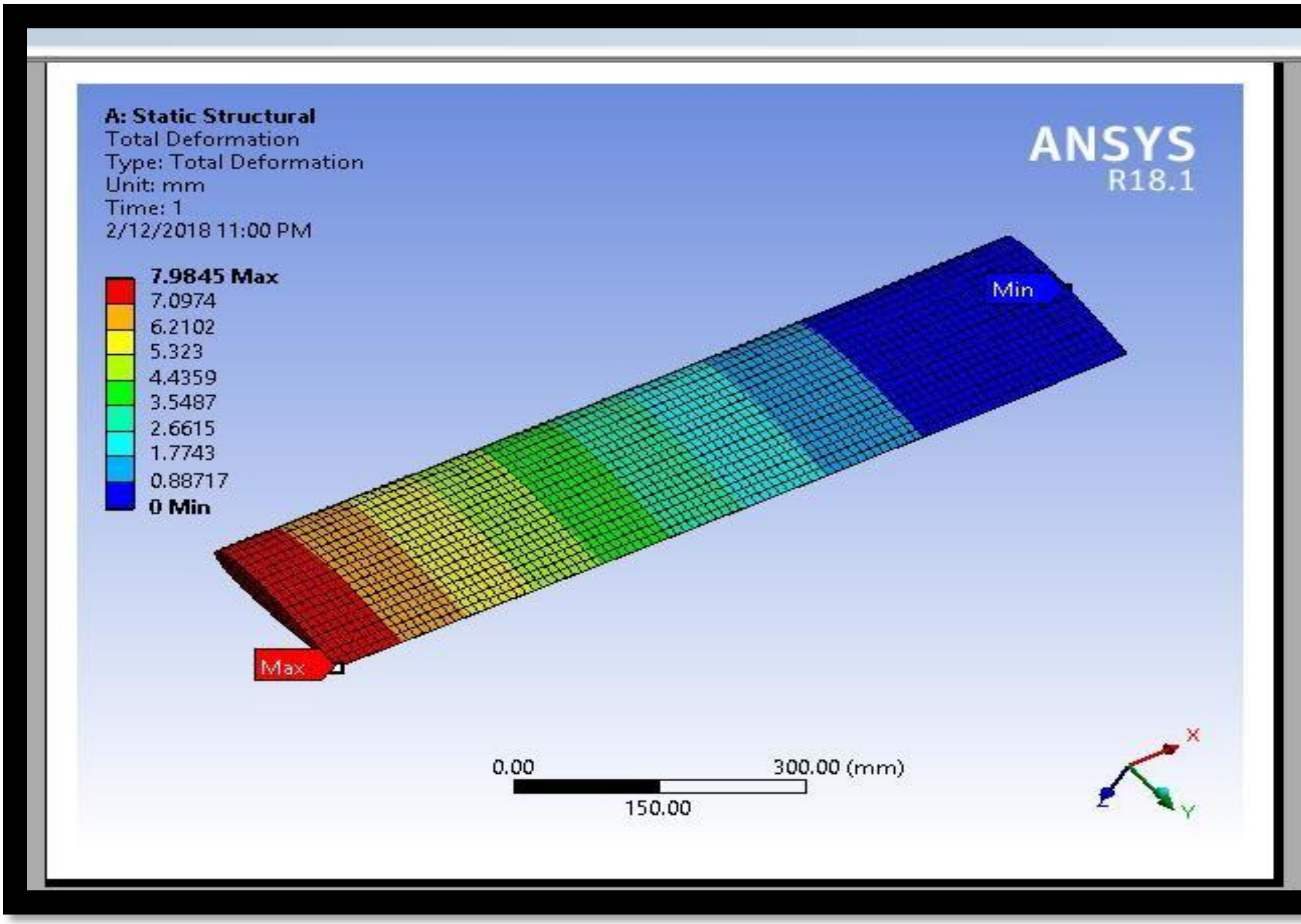


Fig 10. Total Deformation of Epoxy-Carbon Woven

7. RESULT ANALYSIS AND DISCUSSION

As we go through different ANSYS software and check different composite materials and find Their total deformation, equivalent stress, and equivalent strain in static condition We can see that Epoxy- carbon UD least total deformation and less stress. so, in static conditions, Epoxy-Carbon UD is the best material for static wing design

There are different reasons for less deflection in composite material

- **High strength and high stiffness**
- **Composite material reinforcement can be controlled up to particles level and they can resist load in every possible direction**
- **In composite design, we can form structure eliminating joints**

The use of composite in Aircraft machine are getting new height due to some advantages The use of composite material in commercial transport aircraft is attractive because reduced airframe weight enables better fuel economy and therefore lowers operating costs. Composite enabled 20 percent saving in weight along with lower Operating cost and production cost and with a lower production time and improved damage tolerance.

In ANSYS software we get slight inaccurate results due to mesh size we can achieve precise calculation by getting the finest quality of mesh but in the academic version of software we can’t get this type of mesh so we generally get medium size mesh

Table 5. Static Structural (FEA) Analysis Results

Materials	Total deformation (mm)	Equivalent stress (Mpa)	Equivalent strain
Epoxy-carbon UD	4.223	16.225	0.00016508
Aluminum 2024 T3	6.7377	16.034	0.00022722
Epoxy-carbon Woven	7.9845	15.7085	0.00030372
Epoxy E-glass	10.942	15.9431	0.00044116

In my second analysis, I changed boundary condition from static to motion analysis And gives different velocities to at different points and finds deflection, stress, and strain Again, in this condition, we find that Epoxy carbon UD has less deflection and less stress in motion analysis so we can choose Epoxy carbon UD as our material

There are some basic steps involved in Ansys Dynamic analysis of wing structure

- **Firstly, we have to transfer geometry from Catia to the Ansys workbench or in the Ansys modeler**

- **Then in the Ansys modeler, we have to change some geometry to get error-free geometry**
- **Then after we need to select material in a material section like in the case of this wing structure, we are having composite material with different patterns it's a very complicated task to complete.**
- **After that, we will add some constraints to structure like fixed condition and force application direction and all different things as our calculation demand.**
- **After that, we will choose mesh size to get the accurate result as what we need following our study.**

Materials	velocity(km/hr.)	Total deformation(mm)	stress(Mpa)	strain
Epoxy carbon UD	200 400 600 800 1000	4.1013 4.1106 4.1501 4.2540 4.4651	17.382 48.259 102.69 179.16 277.62	0.00018043 0.00048840 0.00010383 0.00181151 0.00280721
Aluminum 2024	200 400 600 800 1000	6.6401 6.7380 7.0510 124.94 462.41	25.051 84.141 183.79 321.76 502.04	0.00035280 0.00118511 0.00258862 0.00453193 0.00707101
Epoxy- carbon woven	200 400 600 800 1000	8.2013 8.2590 8.3816 8.6483 9.1602	17.080 46.266 98.275 171.33 265.43	0.00033361 0.00089541 0.00190540 0.00331470 0.00513490
Epoxy-e glass	200 400 600 800 1200	10.847 10.927 11.175 11.749 12.866	20.068 62.048 133.82 234.77 364.70	0.00054441 0.00168010 0.00362340 0.00635650 0.00987450

Deformation vs speed.

This graph shows a relationship between deformation vs speed as we plot all material reading in the same graph to get comparative analysis to get the clearer concept about which material fails at what speed as compared to others
color has been shown to clear identification of each material as AL 2020 is in green color we can quite easily see that aluminum get the highest deformation at particular speed As we can see clearly in this graph that Al 2024 is having steeper slope as compare to other material so we have to go for other option for out material choice and other material like Epoxy carbon UD, Epoxy carbon woven and Epoxy-E- Glass is having a constant slope and they are more resistant to deflection in a high-speed application.

Reason for graph slope variation under different loads.

the composite material graph is more off constant with a slight increase in slope, Since the composites are non-homogeneous, the resulting properties will be the combination of the properties of the constituent materials. The different types of loading may call on different components of the composite to take the load. This implied that the material properties of composite materials may be different in tension and compression as well as in bending.

But in the case of the aluminum graph, there is a drastic increase in deformation due to the necking phenomenon at the maximum load the deformation of most metal specimens becomes localized in the form of an abrupt reduction in cross-section along a small length in the gage section. Plastic deformation becomes concentrated in the reduced cross-section after the maximum load. The non-uniform deformation is called necking

- So initially aluminum has moreover the same deflection so the curve follows less variation because the material is in the elastic limit as per the stress-strain curve it regains all its deflection.
- But after some elastic point, there will be some plastic or permanent deformation which cannot be regained.
- But after the ultimate load point, there will be a necking phenomenon, and the change in cross-section will be severe so the curve will be steeper.

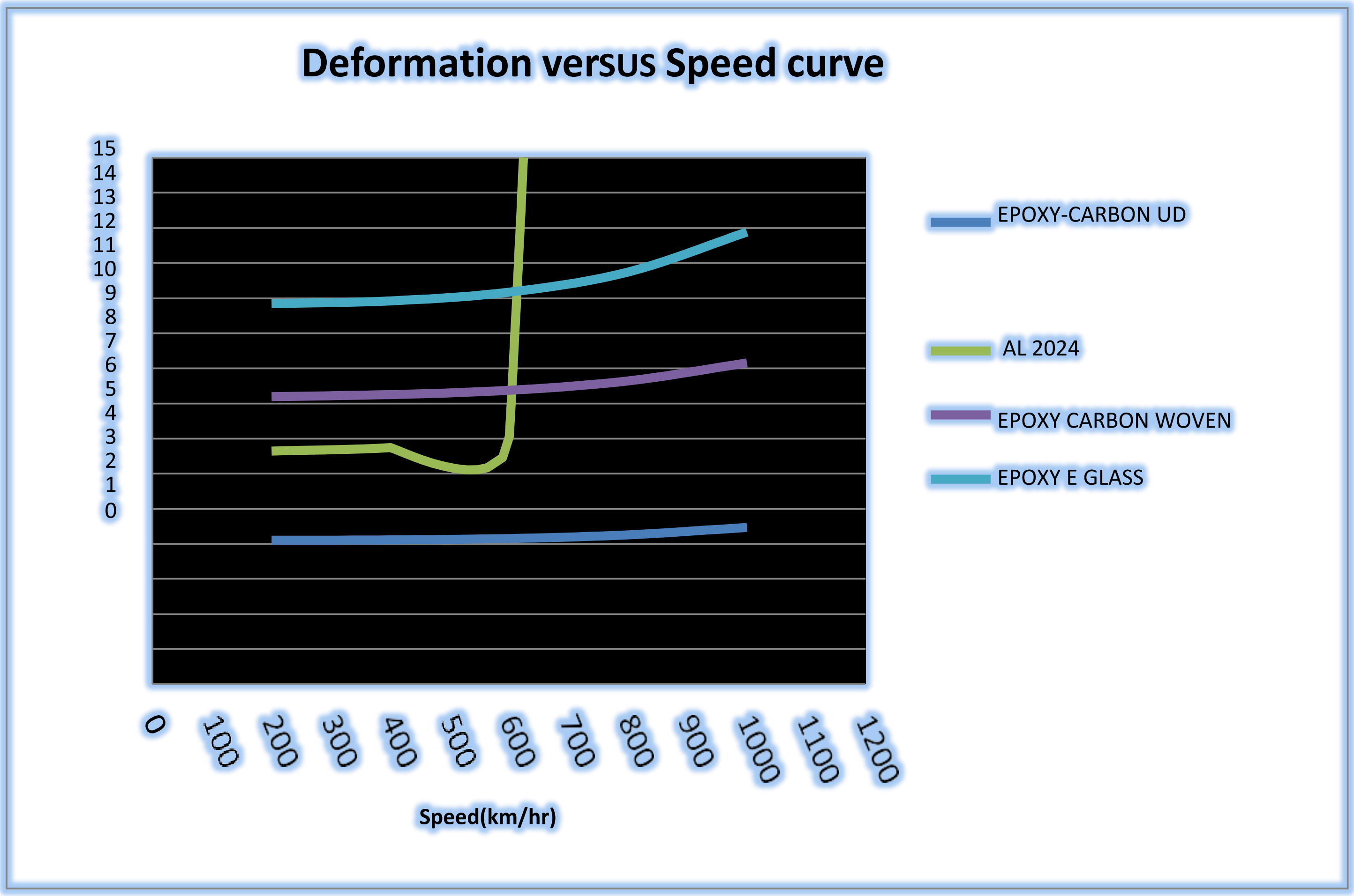


Figure 11. Deformation vs Speed curve for different composites materials

Stress vs load

This graph shows a relationship between stress vs speed as we plot all material reading in the same graph to get comparative analysis to get the clearer concept about which material fails at what speed as compared to others reason for this behavior of curve are same as before mentioned above.

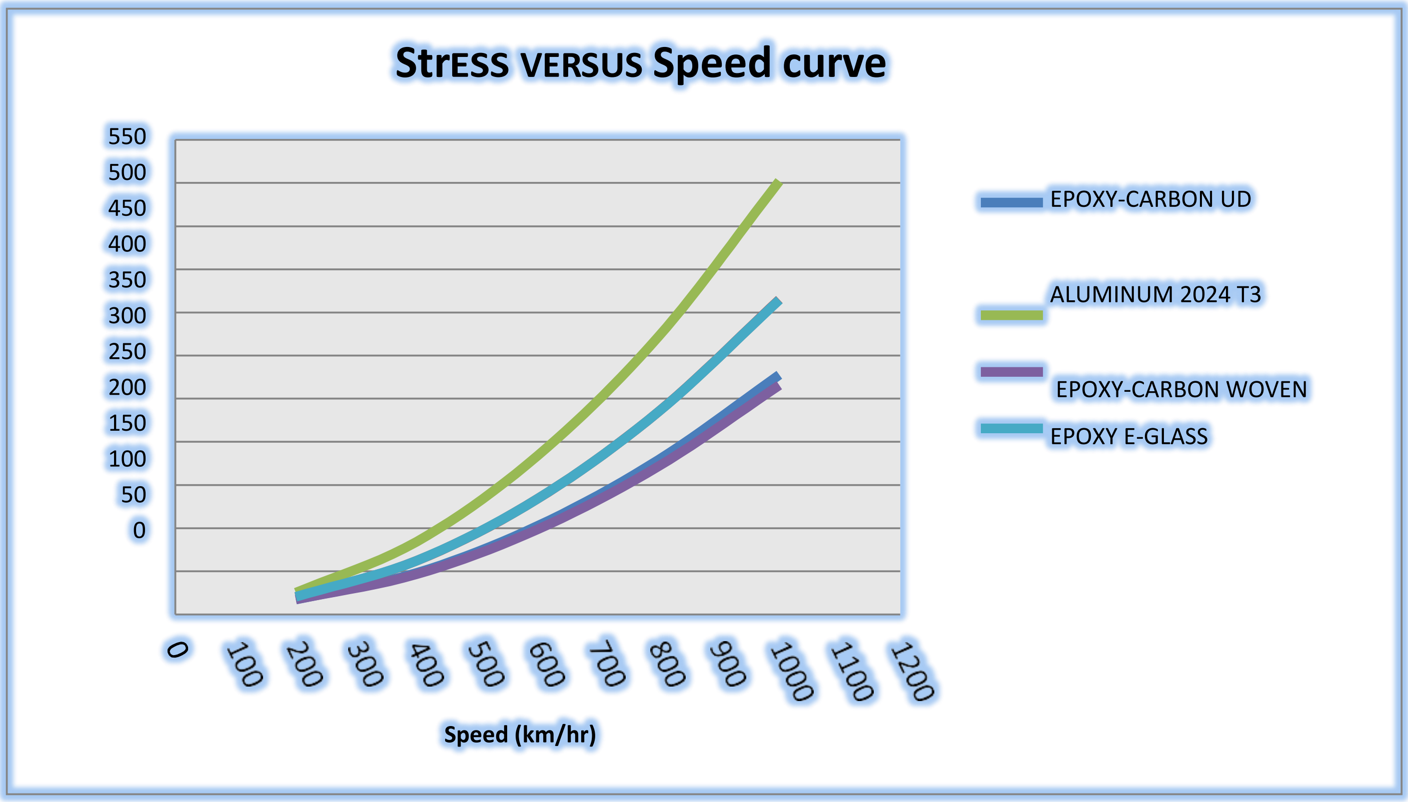


Figure 12. Stress vs velocity curve for different composite materials

8. Conclusion

During my computational studies of an aircraft wing, I obtained various stress, strain, and deformation and their relationships at various speeds, which are plotted in different graphs.

The comparison of results shows that Epoxy-Carbon Uni-Directional has improved structural properties than other materials present at this moment. When equated to Aluminum 2024(T3) and other materials, it has very little deformation, larger in length, and is lighter in weight. As a result, it comes out that Epoxy- Carbon UD is the best material for aircraft wings.

Different materials are tested with different states conditions shortly to find more suitable advanced materials as we know nanomaterial are also coming through and there is also research going on laboratory-made material in which proprieties can be injected according to our need with good aerodynamic and structural features, the number of load-carrying members can be changed, and analysis are performed, but as far as my analysis is concerned, epoxy-carbon UD has mechanical properties at higher speeds.

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