ANALYSIS OF NOISE REDUCTION IN ROTOR BLADES OF HELICOPTER USING DIFFERENT MATERIALS

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Abstract : *A helicopter main rotor is the combination of several rotor wings and a control system that generates aerodynamic lift force that supports the weight of helicopter, and the thrust that counteracts aerodynamic drag in forward flight. The helicopter rotor center is powered towards the engine, and the rotor blades connect to the center. Helicopter rotor blade noise is one of the most severe noise sources and it causes disturbance to the passengers. The helicopter rotor blades are generally made of aluminium or titanium alloy and generate noise that causes disturbance. The main aim of this project is to observe the different materials which can produce less noise. In this project the three dimensional model of the rotor blade was created using AUTO CAD software and imported to ANSYS 16.0 WORKBENCH software to analyse the frequency, deformation, stress and strain.*

***Keywords*: Helicopter, Rotor Blade Noise, Noise Reduction, Blade Design and Analysis.**

1. Introduction:

Helicopter noise reduction is a topic of research into designing helicopters which can be operated more quietly, reducing the public-relations problems with night-flying or expanding an airport. In addition, it is useful for military application in which stealth is required: long-range propagation of helicopter noise can alert an enemy to an incoming helicopter in time to re-orient defenses. The lift may be made towards the wings of the plane when they move through the air. There would four strengths acting on the helicopter, they are THRUST, DRAG, LIFT and WEIGHT. Each blade can swivel about a feathering hinge as it spins. Vertical pitch links push the blades up and down, making them swivel as they rotate.

NACA [1], The helicopter rotor blade model is taken from national advisory committee for aeronautics i.e., NACA 23012.

Leishman **[2],** An internationally recognized expert explains the aerodynamic principles of helicopters and other rotating-wing vertical lift aircraft. Besides the history of helicopter flight, basic methods of analysis, and performance and design issues, Leishman covers airfoil flows, unsteady aerodynamics, dynamic stall, and rotor wakes.

Bruhn **[3],** this paper contains the analysis and design of aircraft structures

S. Selva Jeba Darling **[4],** this paper contains the rotor blade analysis for reducing the noise produced due to rotor wings by using composite materials.

www.helistart.com **[5],** this paper describes the airfoil designs, blade twist, drag & lift forces

Hardeep Singh,**[6]** described the detailed study of rotor blade of a helicopter such as types of Rotor systems and blade material specifications

2. HELICOPTER NOISE SOURCES:

2.1 Rotor Noise

The rotor generates different types of noise: Thickness noise is caused by the blade periodically displacing air during each revolution. This sound propagates in the plane of the rotor. Moreover a rotating blade at non-zero angle of attack imposes rotating forces onto the surrounding air, causing blade loading noise. This sound generally propagates in a direction perpendicular to the plane of the rotor. Each main rotor blade also sheds a strong tip vortex whose trajectory travels downstream from the rotor in an approximately epicyclical manner. In descent conditions and sometimes at moderate speeds in level flight, the vortex trail may intersect the paths of subsequent blades. This event causes a blade-vortex interaction (BVI) impulsive noise sometimes referred to as “blade slap”.

2.2 Engine Noise

Most engines are located above the aircraft, so noise is directed upward. Turbine engines are also less noisy than older types of helicopter engines. Most noise from helicopters is generated by the motion of the rotors.

2.3 Thickness Noise

Thickness noise is dependent only on the shape and motion of the blade, and can be thought of as being caused by the displacement of the air by the rotor blades. It is primarily directed in the plane of the rotor.

2.4 Blade-Vortex Interaction Noise

Blade vortex interaction (BVI) occurs when a rotor blade passes within a close proximity of the shed tip vortices from a previous blade. This causes a rapid, impulsive change in the loading on the blade resulting in the generation of highly directional impulsive loading noise. BVI noise can occur on either the advancing or retreating side of the rotor disk and its directivity is characterized by the precise orientation of the interaction.

2.5 Broadband Noise

Another form of loading noise, broadband noise consists of various stochastic noise sources. Turbulence ingestion through the rotor, the rotor wake itself, and blade self-noise are each sources of broadband noise.

2.6 Tail Rotor Noise

While most noise from a helicopter is generated by the main rotor, the tail rotor is a significant source of noise for observers relatively close to the helicopter, where the higher-frequency noise of the tail rotor has not yet been attenuated by the atmosphere. Tail rotor noise is particularly annoying to the human listener due to its higher frequency.

2.7 Contribution of Noise Sources Depending on Flight Condition

The contributions of the individual noise sources to the global helicopter noise spectrum perceived on the ground differ considerably depending not only on the flight condition but also on the observer position. Even though each helicopter configuration might have particular characteristics some general trends can nevertheless be observed. In the take-off case the main rotor is required to provide a maximum thrust level to gain altitude quickly. This results in high anti-torque and engine power requirements. For ducted fans the situation is shifted towards a higher engine noise contribution since the anti-torque noise is partially shielded by the duct, particularly for observers directly under the flight path.

3. PROBLEM DEFINITION AND METHODOLOGY:

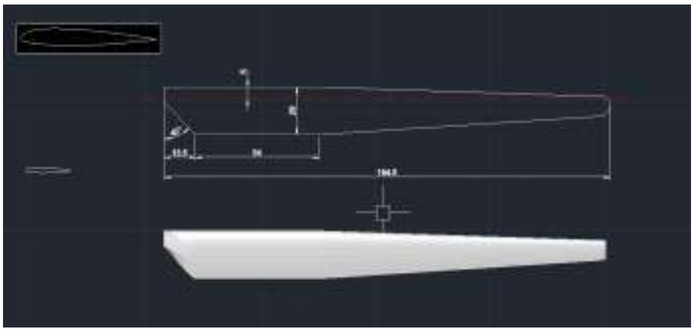
A helicopter main rotor generates primarily low frequency noise and, in certain operating regimes, high amplitude low-to-mid-frequency noise modulated at the blade passage frequency. So to avoid the higher noise levels, we used different materials and analyse their frequencies, which are producing less noise levels. In this project the three dimensional model of the rotor blade was created using AUTO CAD software and imported to ANSYS 16.0 workbench software to analyse the frequency, deformation, stress and strain.

4. SELECTION OF AIRFOIL:

In this project, NACA 23012 airfoil was used for 3D model design. NACA 23012 airfoil model is the cross section of helicopter rotor blade. It is the recently developed airfoil and is commonly used these days So we used this airfoil for designing the CAD model.

5. DESIGN OF HELICOPTER ROTOR BLADE:

The helicopter rotor blade is designed using the standard dimensions that is taken from the NACA 23012 i.e., National Advisory Committee For Aeronautics.



6. SELECTION OF MATERIALS:

6.1 Structural Steel:

Structural steel is a category of steel construction material that is produced with a particular cross section or shape, and some specified values of strength and chemical composition. Structural steel composition, strength, size, shape, and storage are controlled in most advanced countries. The word structural steel includes a broad variety of low carbon and manganese steels that are used in great numbers for civil and marine engineering applications. Structural steels are manufactured in section and plate shapes and are normally used in bridges, buildings, ships, and pipelines. On heating, the steel expands and becomes softer, and finally the structural integrity is lost. If sufficient energy is provided, steel may also melt.

6.2 Aluminium:

Aluminium is remarkable for its low density and its ability to resist corrosion through the phenomenon of passivation. Aluminium and its alloys are vital to the aerospace industry and important in transportation and building industries, such as building facades and window.

6.3 Titanium Alloy:

Titanium alloys are alloys that contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness (even at extreme temperatures).They are light in weight, have extraordinary corrosion resistance and the ability to withstand extreme temperatures. However, the high cost of this material and processing limit their use to military applications, aircraft, spacecraft, bicycles, medical devices, jewelry, highly stressed components such as connecting rods on expensive sports cars and some premium sports equipment and consumer electronics.

6.4 Glass Fibre Epoxy:

An individual structural glass fiber is both stiff and strong in tension and compression that is, along its axis. Although it might be assumed that the fiber is weak in compression, it is actually only the long aspect ratio of the fiber which makes it seem so i.e., because a typical fiber is long and narrow, it buckles easily On the other hand, the glass fiber is weak in shear that is, across its axis.

6.5 Carbon Fibre Epoxy:

Carbon fibre reinforced composites have exceptional mechanical properties. These strong, stiff and lightweight materials are an ideal choice for applications where lightweight & superior performance are important, such as components for aircraft, automotive, rail and high quality consumer products. Composite materials are produced by combining a reinforcing fibre with a resin matrix system such as epoxy. This combination of fibre and resin provides characteristics superior to either of the materials alone and are increasingly being used as replacements for relatively heavy metallic materials. In a composite material, the fibre carries the majority of the load and is the major contributor to the composite material properties.

7. DRAG FORCE CALCULATION:

The force of drag on an object when it is moving in a fluid (either a gas or a liquid). You feel the drag force when you move your hand through water. You might also feel it if you move your hand during a strong wind. The faster you move your hand, the harder it is to move. You feel a smaller drag force when you tilt your hand so only the side goes through the air you have decreased the area of your hand that faces the direction of motion. Like friction, the drag force always opposes the motion of an object. Unlike simple friction, the drag force is proportional to some function of the velocity of the object in that fluid. The relationship is mathematically represented as:

Drag force = ▯ C_d ρ A v^2

Here,

Drag coefficient (C_d) =0.0077

Density of fluid i.e., air (ρ) = 1.2754 kg/m^3

Area of rotor blade (A) = 76.789m^2

Velocity (V) = 100m/s

Therefore,

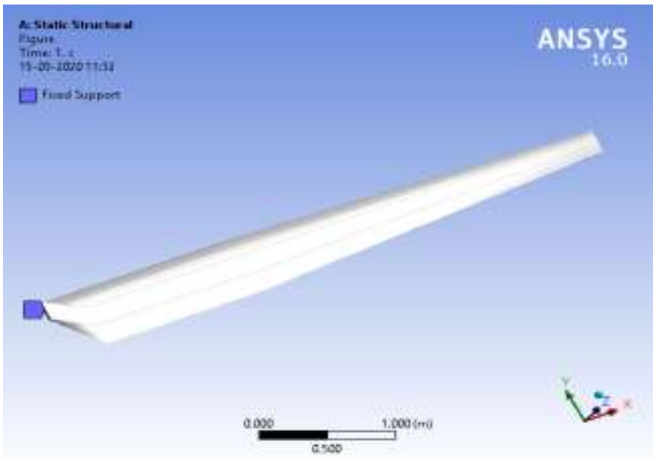
Drag force, $\mathbf{f_d}$ = ▯ ▯0.0077▯1.2754▯76.789 ▯100 ^{2}

$\mathbf{f_d}$ = 3770.56 **N**

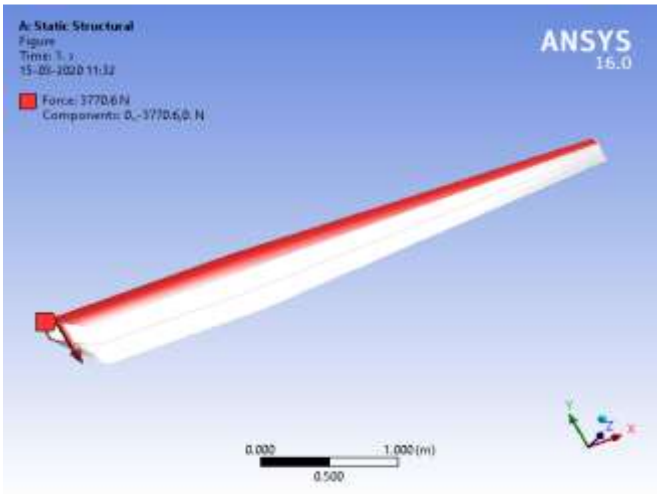
8. ANALYSIS OF THE ROTOR BLADE USING ANSYS 16.0 :

Ansys Mechanical Enterprise is the flagship mechanical engineering software solution that uses finite element analysis (FEA) for structural analysis using the Ansys Mechanical interface. It covers an enormous range of applications and comes complete with everything you need from geometry preparation to optimization and all the steps in between. With Mechanical Enterprise you can model advanced materials, complex environmental loadings and industry-specific requirements in areas such as offshore hydrodynamics and layered composite materials.

Forces acting on rotor blade:



Fixed Support

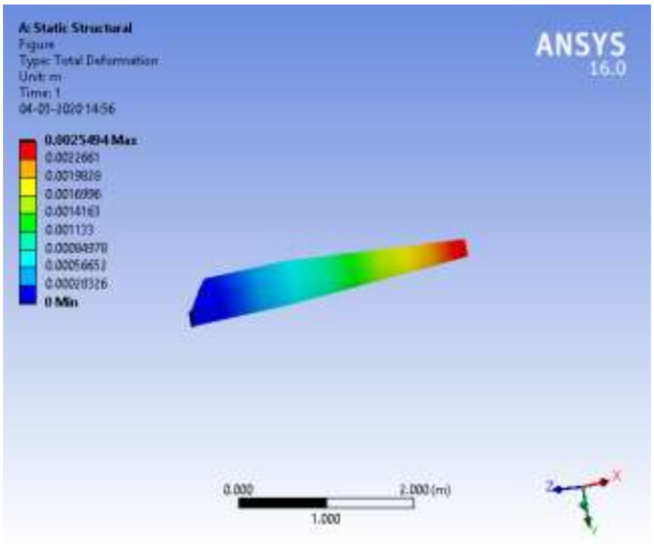


Drag Force

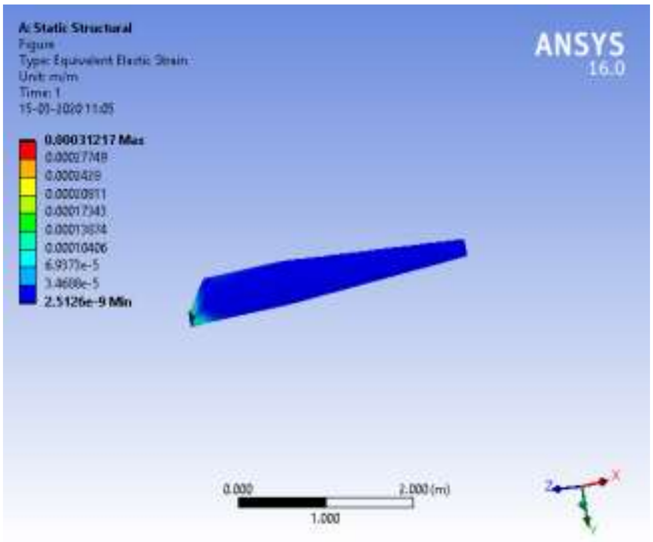
8.1 STATIC STRUCTURAL ANALYSIS:

Structural analysis is the determination of the effects of loads on physical structures and their components. Structures subject to this type of analysis include all that must withstand loads, such as buildings, bridges, aircraft and ships. Structural analysis employs the fields of applied mechanics, materials science and applied mathematics to compute a structure's deformations, internal forces, stresses, support reactions, accelerations, and stability. The results of the analysis are used to verify a structure's fitness for use.

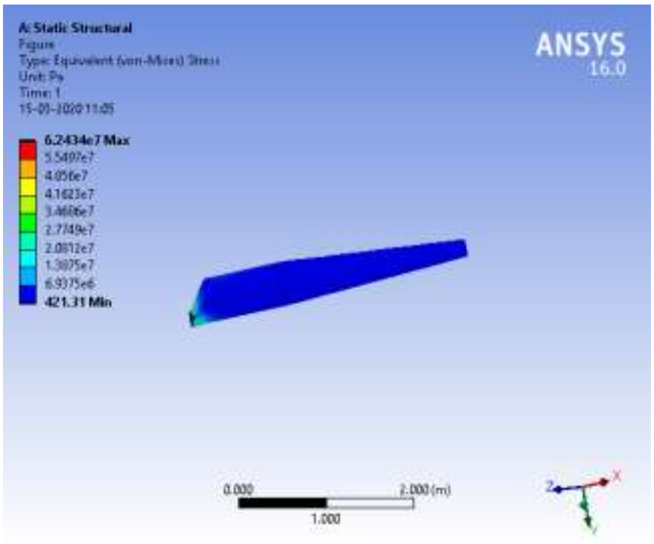
For Structural Steel:



Total Deformation

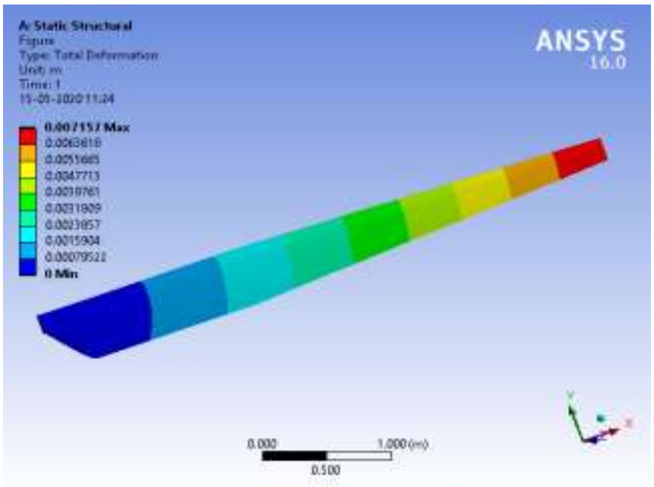


Elastic Strain

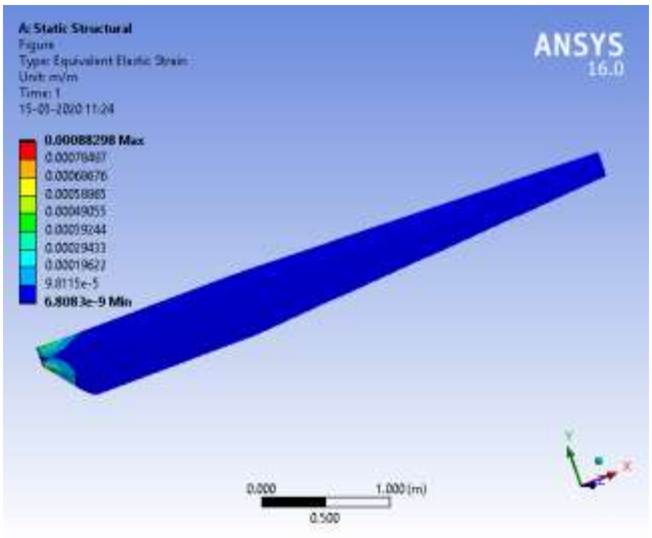


Equivalent Stress

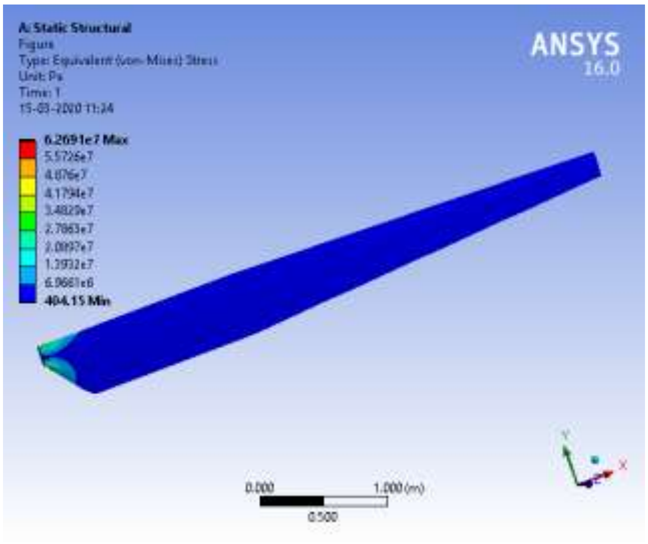
For Aluminium Alloy:



Total Deformation

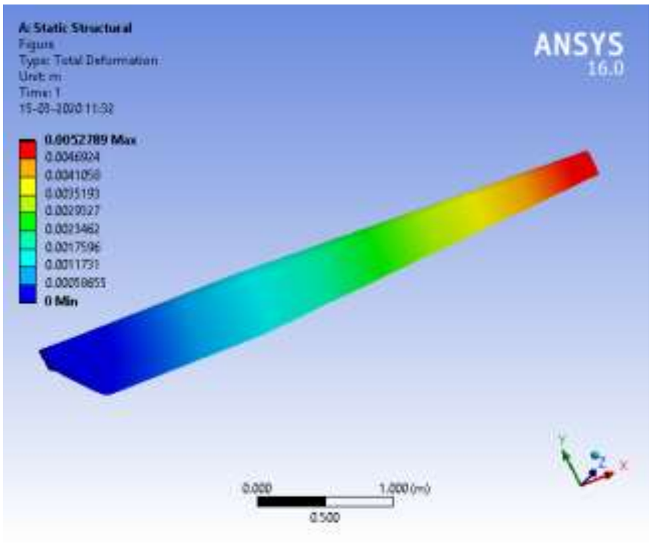


Elastic Strain

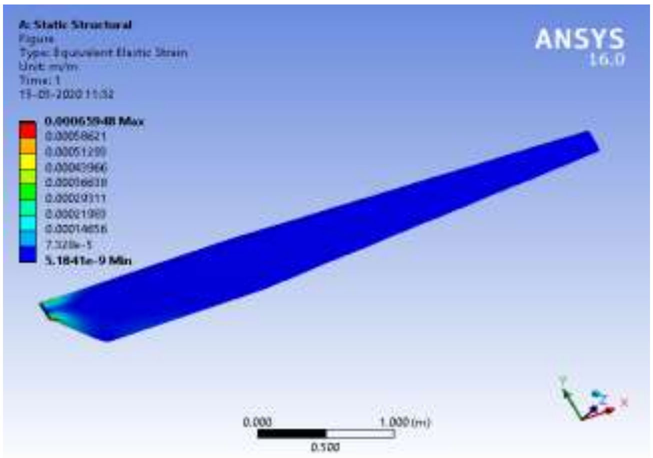


Equivalent Stress

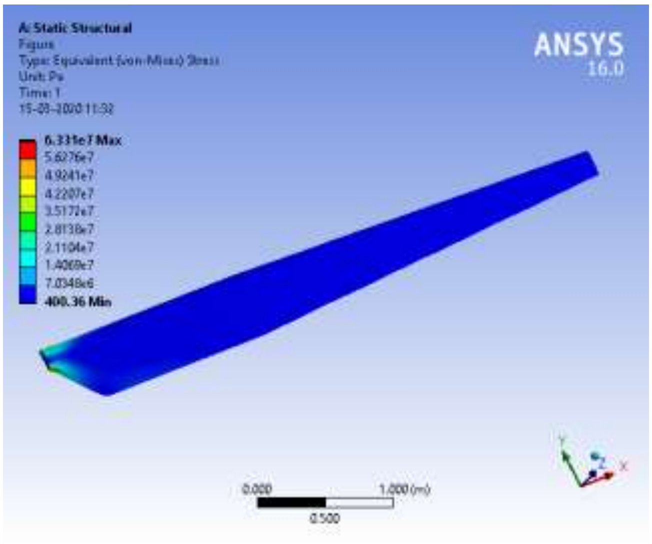
For Titanium Alloy:



Total Deformation

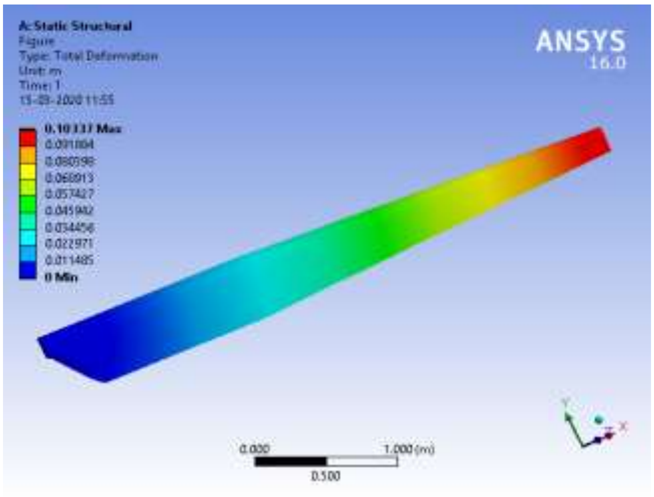


Elastic Strain

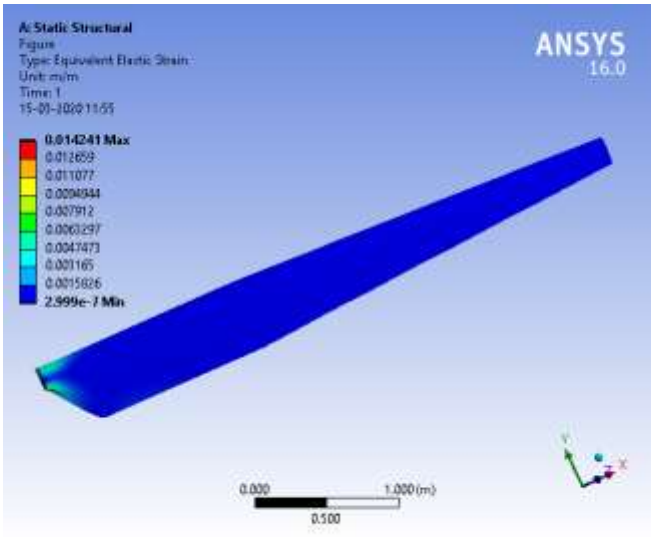


Equivalent Stress

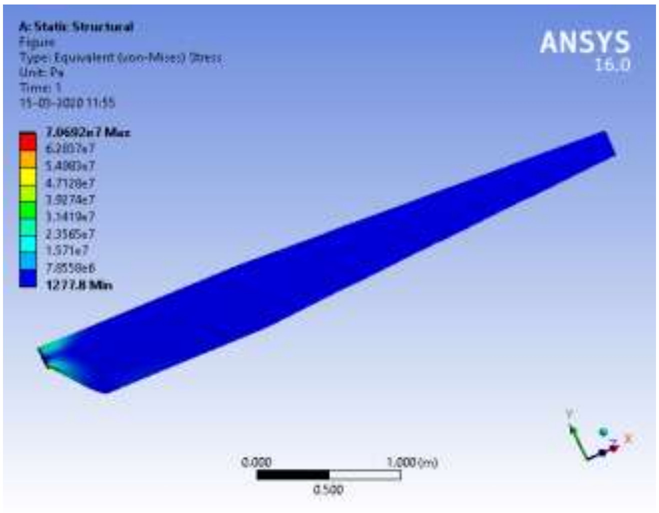
For Glass Fibre Epoxy:



Total Deformation

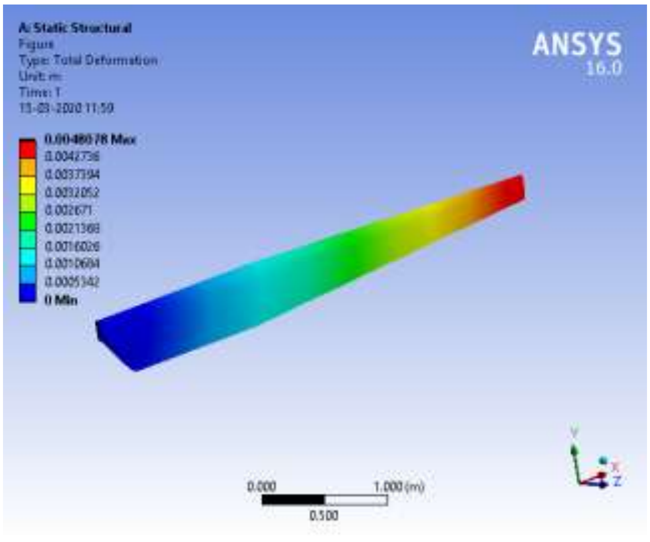


Elastic Strain

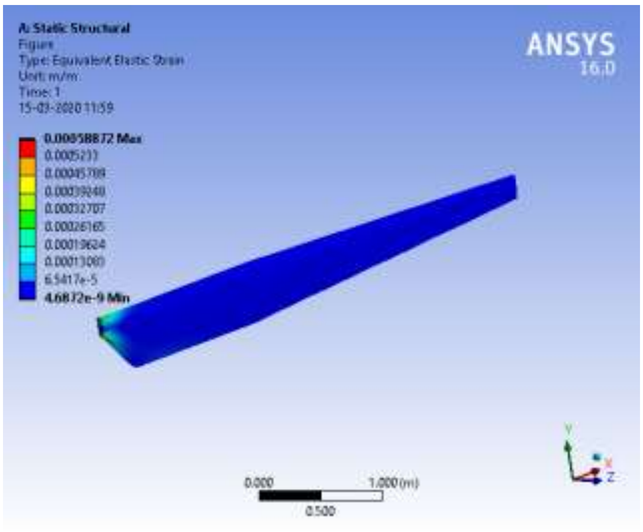


Equivalent Stress

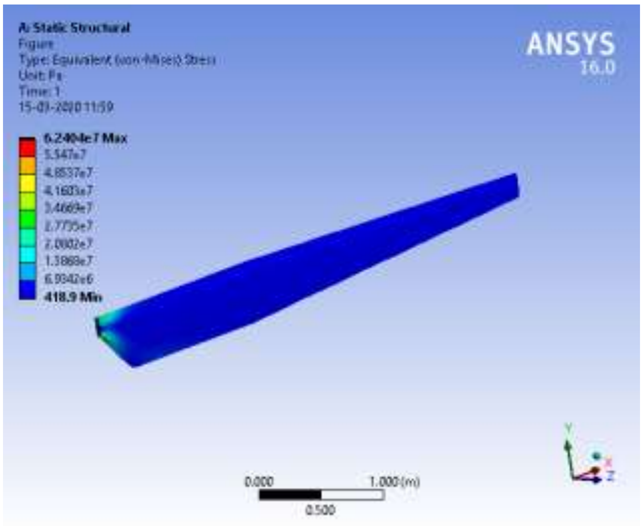
For Carbon Fibre Epoxy:



Total Deformation



Elastic Strain



Equivalent Stress

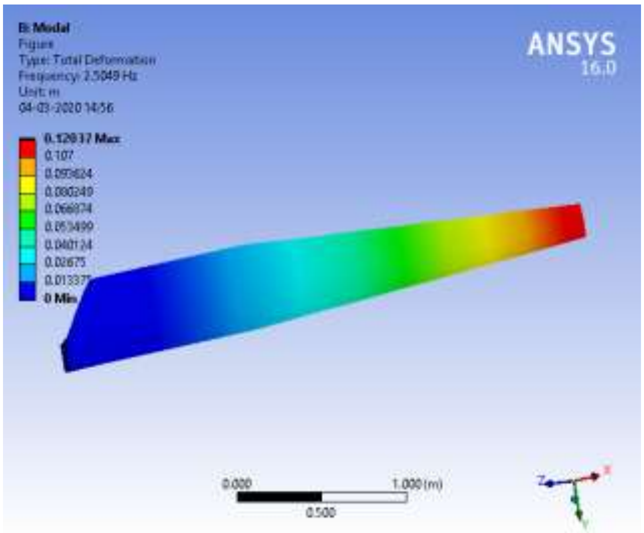
Comparison of Results For Static Structural Analysis:

Material	Total Deformation (m)	Stress (N/m^2)	Strain
Structural Steel	0.0025494	6.2434e7	0.00031217
Aluminium Alloy	0.007157	6.2691e7	0.00088298
Titanium Alloy	0.0052789	6.331e7	0.00065948
Glass Fibre Epoxy	0.10337	7.0692e7	0.014241
Carbon Fibre Epoxy	0.0048078	6.2404e7	0.00058872

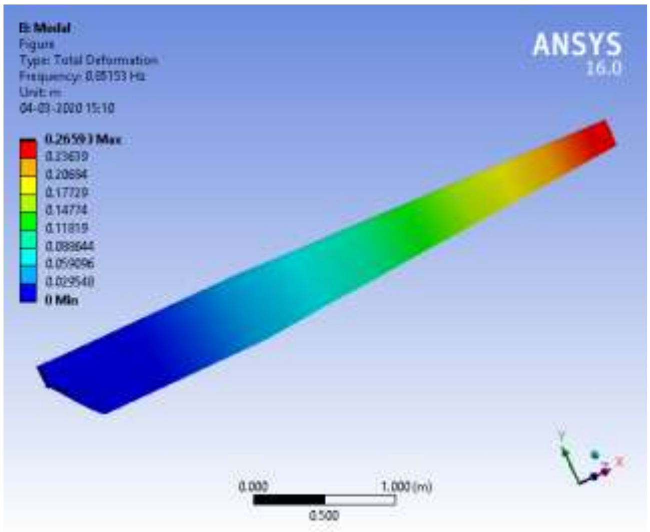
8.2 MODEL ANALYSIS:

Model analysis allows us to predict the key characteristics of proposed designs. However, unless we have extensive experience and expertise with a given type of problem, in practice we rarely get the design right the first time around. More often than not, we need to explore multiple design alternatives and configurations before making any hard commitments. The result is an iterative and incremental process, in which it is crucial to be able to predict the consequences of design choices rapidly and accurately.

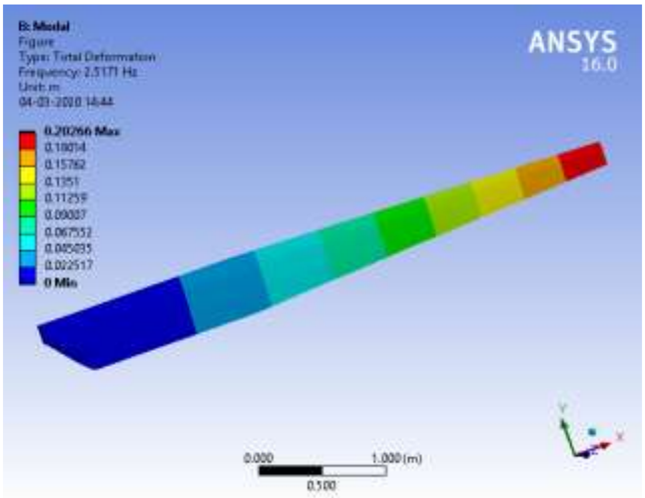
For Structural Steel:



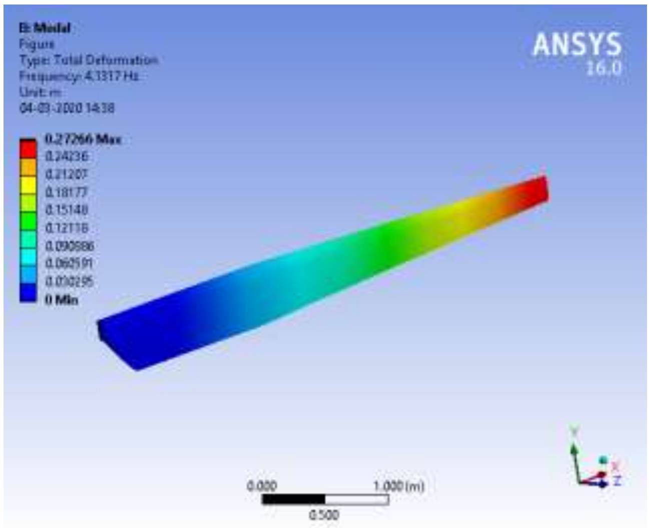
For Glass Fibre Epoxy:



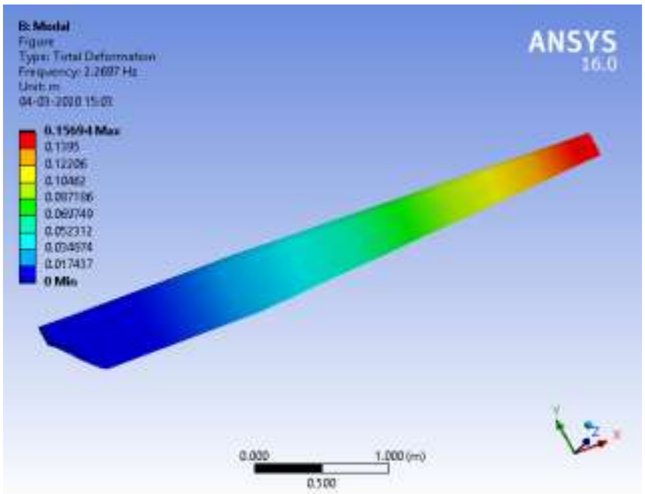
For Aluminium Alloy:



For Carbon Fibre Epoxy:



For Titanium Alloy:



Comparison Of Results For Model Analysis:

Material	Frequency (Hz)	Deformation (m)
Structural Steel	2.5049	0.12037
Aluminium Alloy	2.5171	0.20266
Titanium Alloy	2.2697	0.15694
Glass Fibre Epoxy	0.85153	0.26593
Carbon Fibre Epoxy	4.1317	0.27266

9. CONCLUSION

In this project, both the static structural and model analysis for helicopter rotor blade is done for finding the results of frequency, stress, strain and deformation. In this paper model analysis of the rotor blade is done to suggest the better material, which can produce less noise compared to other materials. In this aspect the carbon fibre epoxy performs better in terms of producing less noise levels (because of higher frequencies). Also the carbon fibre epoxy withstands better stress and strain.

ACKNOWLEDGEMENTS

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