Design and analysis of Helicopter Rotor Blade

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Abstract:
Rotor blades of helicopters must be stiff and strong enough to maintain structural loads within working limits. The rotating cycles change the aerodynamic and structural stresses created by the blade revolution. In this project, you will discover the structural stresses of the blades as well as the vibration frequencies studied using the Ansys programme, taking into consideration environmental consequences. This material was tested utilising Kevlar 49, carbon-epoxy, and advanced carbon fibre composite materials and found to be a lightweight, high-strength, and long-lasting material. catia v5 software was used to create the design.

Keywords: aerodynamics forces, helicopter blades, ansys, structural analysis, vibration analysis.

1. INTRODUCTION:

Helicopters are available in a range of sizes and shapes, based on their intended use and payload requirements. However, the majority of them have similar portions and sections. The helicopter rotor or rotor frame is one of the most significant components (Fig. 1). Its goal is to build lifting helicopters and payloads, as well as to reduce the drag generated during forwards flight. The rotor frame's primary sections are the pole, centre, and sharp edge. The rod is linked to the gearbox via a hollow in the metal shaft of the tube. The connecting rotor edges are focused on the top pole. Sharp rotor edges are critical components of the rotor structure and are attached to the centre at various angles. There are three types of rotor framework: stiff, semi-rigid, and completely voiced. This sequence is determined by the rotor edges' connection to the centre and their speed in relation to the pole.

Fig. 1: Helicopter rotor system

1.2 TYPES OF ROTOR SYSTEMS:

1.2.1 Rigid:

The flexible rotor frame is sometimes known as a hinged rotor frame since it has no pivot points and the edges are smartly joined in the centre (Fig. 2). Over the boundaries of the adjustable region, there will be mid-pull and fold movement. The totally essential rotor frame is substantially more stiff than this sort of rotor frame.

DOI: 10.9756/INT-JECSE/V14I3.1205

Fig. 2: Rigid rotor system

1.2.2 Semi-rigid:

Currently, a swaying or fluttering pivot is used to link the two sharp edges in the opposite direction. As a consequence, the sharp edge illuminates in the other direction (Fig. 3). On the pull, there is also a wing pivot for pitching the rotor blade.

Fig 3: Semi-rigid rotor system

1.3 Rotor Blade Design

1.3.1 Airfoil, lift and drag:

The lift / drag ratio of a rotor construction is perhaps the most critical characteristic, which should be greater than predicted.

This ratio is determined by the plan profile, and before we go into some of the alternatives, let's start with the delectable ratio. It's a thick air filler that's roughly the length of the placenta's rated length. The outer chamber is roughly a quarter of the way from the driving edge on large L / D type cutting edges, which have a tiny ratio of around 15%. The standard L/D ratio for helicopter rims is 30:1.

Rotor blade airfoils come in a variety of shapes and sizes (pictured below). Large chunks of them were in balance for a long period. Higher L / D ratios are predicted in the event of uneven fluctuations. These forms of cutting blades arose while producing rational alloys because of their greater internal strength. They have the ability to withstand high internal loads while remaining light in weight.

Symmetrical aerofoil

Asymmetrical aerofoil

1.4 Forces Acting on the Aircraft:

Four soft forces trail the helicopter as it takes off from the ground: thrust, drag, lift, and weight. Flight is essential to understanding how these forces are exerted via violence and flight control. The following is a list of them:

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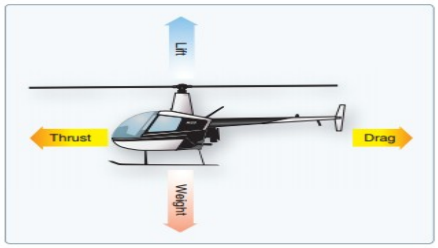
Thrust is the forwards thrust generated by the engine, propeller, or rotor. It either limits or surpasses the resistance's intensity. It usually operates in comparison to the longitudinal centre. However, as will be discussed later, this is not a broad context.

• Rear - Pulling back owing to wing, rotor, centre, and other expanding items obstructing air flow. Relatives and race pushers struggle against the wind.

• Weight - The total weight of an aircraft, a group of aircraft, fuel, and cargo or property. The shop pushes the aircraft into the abyss in the face of this gravitational attraction. Through the aircraft point of gravity (CG) convergence, it rejects and operates vertical lift.

• Lift is a property determined by weight, dynamic action on airfoils working out of the air, and inverse to the trajectory at the convergence point.



Four forces acting on a helicopter in forward flight.

2. Literature review:

China made the most detailed allusions to the vertical plane. BC Since about 400 BC, Chinese teens have been playing with bamboo toys. Swinging the rod linked to the rotor cuts the bamboo copter. When the twist breaks and the toy flies away... "Ace Who Grows Effortlessly" [1] by J. Gordon Leishman has several concepts that are supposed to have existed in Rottercraft in Bapuji'sdopist book in the fourth century AD. Anchored.

Gustav de PontondOncourt [2], a French inventor who displayed miniature, steam-powered models, invented the name "chopper" in 1861. Despite the fact that the new metal is indicated as a hypothetical application of aluminium, the model never develops from the ground up. D'Arto lived long enough to symbolise the vertical plane he envisioned, thanks to his etymological commitments. Inventors have known about the power of steam for a long time.

In 1906, two French brothers, Joseph Needham [3], started researching various helicopter routes for the Luftwaffe. These investigations led to the development of Gyroplane No. 1 in 1907. However, the data has certain flaws: between August 14 and September 29, 1907, Gyroplane No. 1 hoisted its pilot 0.6 metres into the air. The No. 1 Autogyro is the most vulnerable and fundamental individual in any aeroplane. As a result, the Zeroplane # 1 aircraft are essentially autonomous aerial helicopters, but not free or cruel planes. Two planar main rotor groups are installed one after the other on the connected rotor, with the rear rotor somewhat higher than the front rotor.

Anderson, John D. [4] At helicopter speeds, a mechanism known as pitch mindset changes and differential mass pitch reduces the dual rotors. The rear rotor builds up the whole pitch, expands the tail, and lowers the entire pitch to make the front rotor nose-sink for additional and quicker pitch. The front rotor widens the nozzle by extending the whole pitch while lowering (or going rearward), and the complete pitch reduces to minimise the total rotor. The rotor features right-rear rotor tilts in front of the clockwise rotation, and front rotor tilts and rear rotor tilts in the left rotation; Ya control is created by opposing cyclic contributions from each rotor.

Alexandre Savin, [5] Coaxial rotors are a pair of revolving rotors that are positioned one on top of the other on a rod with the same pivot point. The lift contradiction is eliminated by the bit coaxial rotor of the wiggle chamber, which balances the elevator offered to the other section where each of the rotor development parts on the forwards flight comes in. Blade regression is slowed. Coaxial rotors, on the other hand, are affected by additional design issues. Because both rotor frames need connection and self-plate, the mechanical unpredictability is increased.

3. DESIGN:

CATIA offers a solution for mould configuration, styling, surface work process, and rendering to construct, configure, and approve complicated, inventive designs from mechanical structure to Class A surface using ICEM surface innovations. CATIA supports all phases of item production, whether they are started from scratch or from 2D blueprints. CATIA can identify and utilise STEP location data by reading and providing them.

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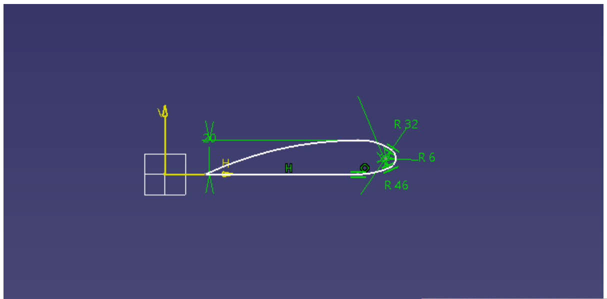
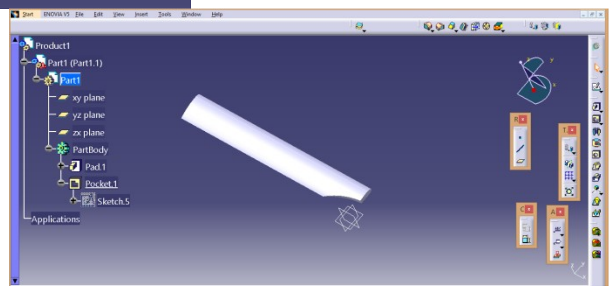


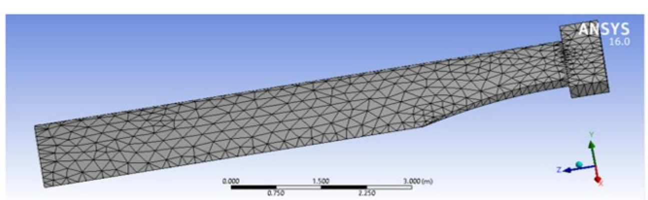


4 Ansys:
The approach of establishing characteristic frequencies and mode configurations is known as modular analysis.

The structure oscillates under "fit" discharge conditions.
In one of its resonant frequencies,
The scalar variable of the mode form is vibration state.
The next vibration is a "quiet" vibration for "quiet" input circumstances.
Mode forms are superimposed one on top of the other.
Determines the auxiliary components' vibration properties (normal frequencies and mode states).
• The study of temporal or symphonic music begins with natural frequencies and mode forms.
Material data:
Carbon Fiber Composite Materials:

Density	1.6 kg m^-3
Coefficient of Thermal Expansion	2.15 C^-1
Thermal Conductivity	78.8 W m^-1 C^-1
Specific Heat	1.13 J kg^-1 C^-1

MESH:



Total Deformation

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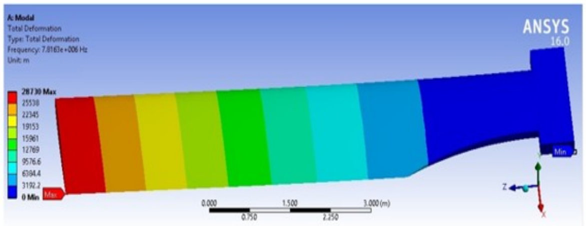

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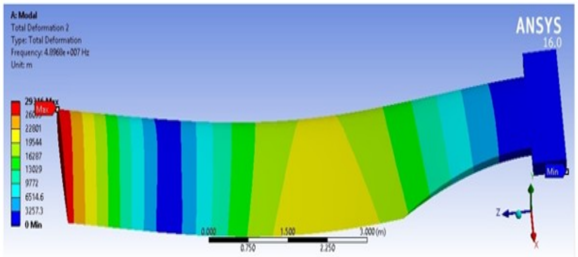

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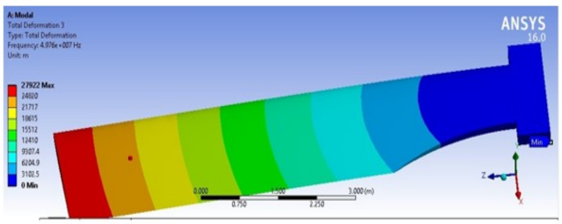

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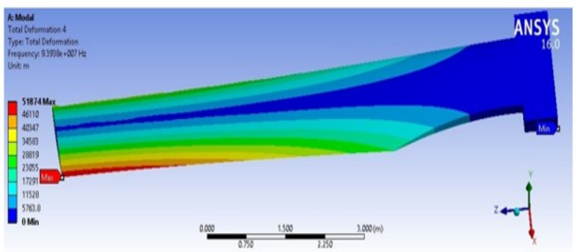

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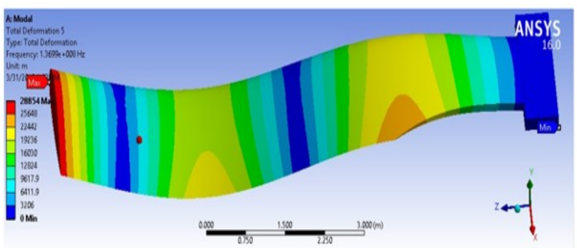

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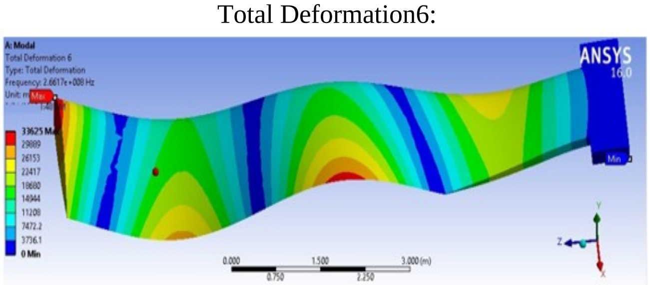

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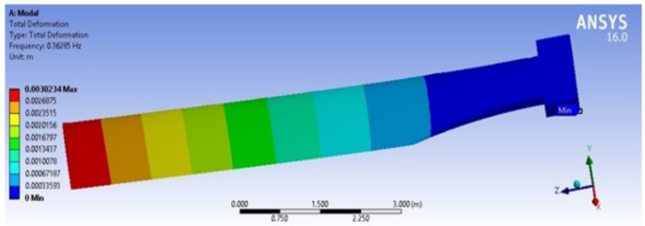
Materials:
kevaler 49:

Density	1.45e+005 kg m^-3

Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
1.35e+011	0.36	1.6071e+011	4.9632e+010

Total Deformation



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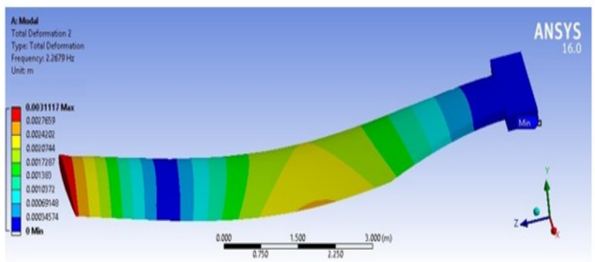

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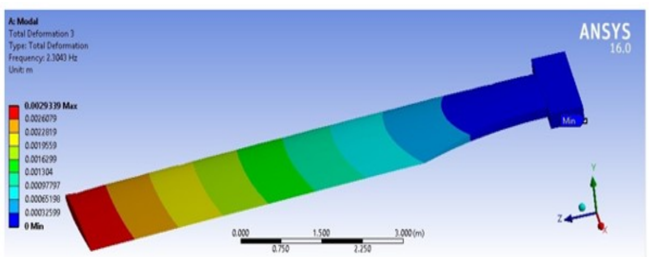

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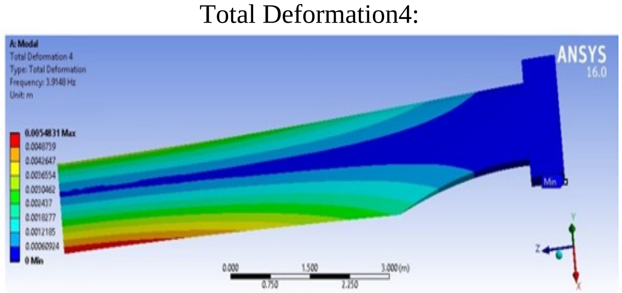

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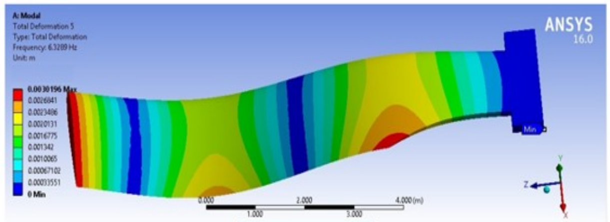

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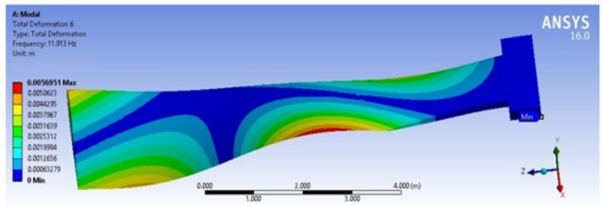
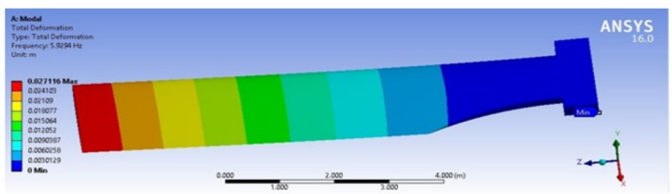


<u>Material Data</u>

o <u>carbon epoxy</u>

Density	1800 kg m^-3		
Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
4.5e+011	0.3	3.75e+011	1.7308e+011

Total Deformation



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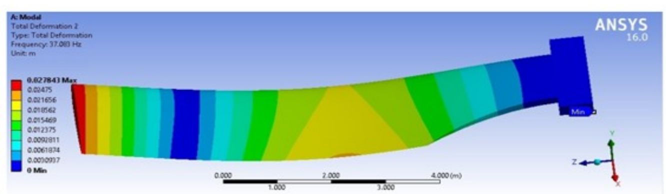

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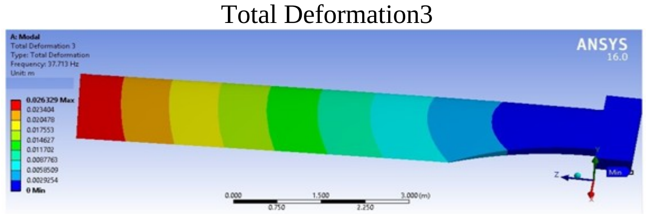

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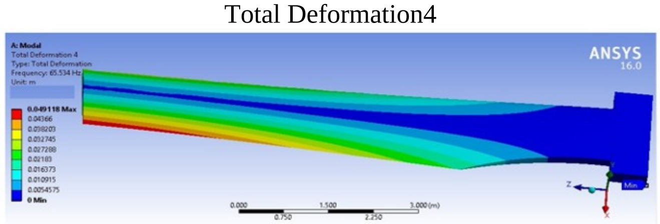

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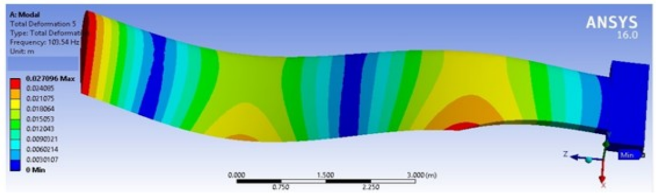

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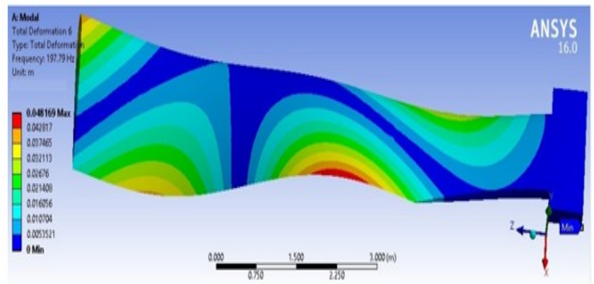

Results:

Object Name	*Total Deformation*	*Total Deformation 2*	*Total Deformation 3*	*Total Deformation 4*	*Total Deformation 5*	*Total Deformation 6*
State	Solved					
Results						
Minimum	0. m					
Maximum	28730 m	29316 m	27922 m	51874 m	28854 m	33625 m
Information						
Frequency	7.8163e+006 Hz	4.8968e+007 Hz	4.976e+007 Hz	9.3938e+007 Hz	1.3699e+008 Hz	2.6617e+008 Hz

Object Name	*Total Deformation*	*Total Deformation 2*	*Total Deformation 3*	*Total Deformation 4*	*Total Deformation 5*	*Total Deformation 6*
State	Solved					
Results						
Minimum	0. m					
Maximum	3.0234e-003 m	3.1117e-003 m	2.9339e-003 m	5.4831e-003 m	3.0196e-003 m	5.6951e-003 m
Information						
Frequency	0.36285 Hz	2.2679 Hz	2.3043 Hz	3.9148 Hz	6.3289 Hz	11.913 Hz

Object Name	*Total Deformation*	*Total Deformation 2*	*Total Deformation 3*	*Total Deformation 4*	*Total Deformation 5*	*Total Deformation 6*
State	Solved					
Results						
Minimum	0. m					
Maximum	2.7116e-002 m	2.7843e-002 m	2.6329e-002 m	4.9118e-002 m	2.7096e-002 m	4.8169e-002 m
Information						
Frequency	5.9294 Hz	37.083 Hz	37.713 Hz	65.534 Hz	103.54 Hz	197.79 Hz

Conclusion

The rotor blade of a helicopter must be replaced with a sharp three material in this article. With CATIA V5, the building process was evaluated and several key factors were found. Helicopter rotor blades are made of carbon-epoxy, Cavalier 49, carbon fibre composite, multi-level alloys with high modulus and strength. The inherent frequencies of helicopter rotor blades are investigated using a sample analysis. On carbon fibre epoxy power rotor blades, Cavalier 49, carbon fibre composite material, the influence of boundary conditions and the stacking sequence of composite layers is examined. On the blade and blade, we noticed the maximum load the helicopter could endure. When compared to the current materials, the weight of the composite materials was dramatically reduced.

The frequency and MRS values of carbon fibre are greater than the other two materials. The largest elastic stress and the least amount of deformation are found in carbon epoxy materials. Cavalor 49 is more effective than carbon epoxy and carbon fibre.

FUTURE SCOPE

Various additional merging resources may be investigated, as well as the helicopter rotor blades for various flocks, i.e. for symmetrical placements. The rotor blades may be evaluated using model analyzers for additional investigation. On the same problem, a regression analysis may be performed. Analysis of a single geometry model Rotor blades have a natural frequency.

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DOI: 10.9756/INT-JECSE/V14I3.1205