Design and Static Structural Analysis of Light Helicopter Main Rotor Blade

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***Abstract* - From the beginning aerospace industries are giving more importance to the structures. Because the structure should be of extremely low weight and it's able to withstand the big number of load cases. This paper presents the structural analysis of main rotor blade of a helicopter. To design the rotor blade with the twist angle (0˚, 7˚, 8˚, 9˚) .since the Angle of twist is playing vital role in case of stability and to increases the performance and to compare the properties of composite materials such as carbon/epoxy and glass/epoxy. To simulate the mechanical properties finite element method was used.**

***Keywords – structural analysis, Angle of twist Missiles, composite materials*.**

I. INTRODUCTION TO ADVANCED LIGHT HELICOPTER

Advanced light helicopter (ALH), a light (6.6t class) multirole and multi mission helicopter for army, air force, navy, coastguard and civil operations, for both utility and attack roles by day and night manufactured by Hindustan aeronautics limited Bangalore. Basically ALH is designed with skid and wheel versions as per the requirements of the customers. It has two variants namely civil and military variants; The civil variants helicopter are certified by Directorate general of civil aviation(DGCA) and the Military variant helicopters are certified by center of military airworthiness certification(CEMILAC). The civil variants helicopter are certified by Directorate general of civil aviation(DGCA) and the Military variant helicopters are certified by center of military airworthiness certification(CEMILAC).Certification of the utility military variant was completed in 2002 and that of the civil variant was completed in 2004. The deliveries of production series helicopters commenced from 2001-02 onwards. Military variants are used by INDIAN ARMED FORCES. And civil Dhruv are used for transport, rescue, policing, offshore operations, air-ambulance, and other roles by National Disaster Management Authority (NDMA), India's Home Ministry, Oil and Natural Gas Corporation and Several Indian state governments for police and transportation duties. The development of the Dhruv was first announced in November 1984, and it was subsequently designed with assistance from Messerschmitt Bolkow Blohm (MBB) of Germany. The Dhruv first flew in 1992; however, its development was prolonged due to multiple factors including the Indian Army's requirement for design changes, budget restrictions. The Dhruv DHRUV Entered service in 2002. It is designed to meet the requirement of both military and civil operators.

BLADE TWIST & CONSTRUCTION:

Kinetic energy (important for good auto-rotation performance When a blade rotates, each point on it travels at a different speed. The further away from the root, the higher the velocity. This means that the contribution to lift and drag of every point on the blade differs, with each aspect getting larger when moving closer to the rotor tip. Clearly, the lift distribution over the blade is not constant. This is not a desirable situation, because the contribution diminishes when getting closer to the root. To change this distribution, blades are twisted and, sometimes, also tapered. The twist is such that the angle of attack increases when travelling towards the root, producing Lift. Some important design requirements for blades are high torsional stiffness and a good L/D ratio. Note that the weight of the rotor also has important consequences for both the necessary engine power and stored).

The early designs of rotor blades, which resemble early classic wing design, consisted of long steel tube spars, wooden ribs and some light surface material attached to them. From the 1960s onwards, all metal aluminium alloy blades were introduced. These were constructed from long hollow leading edge D-spar extrusions, allied with some light (probably aluminium) trailing edge constructions. The use of extrusions made blade taper difficult to produce. Honeycomb constructions were added to achieve a stiff and light construction.

These days, composite materials like fiberglass and carbon fiber are used for the fabrication of rotor blades. Stainless steel leading edge spars are also used, and all composite spar designs exist too. The fatigue life properties of composite materials are far better than those of metals. Fiberglass is used for its strength and chemical inertness. Carbon fiber layers, sandwiched at right angles, are used to add stiffness. A sample design might look like the figure below. Generally, composite blades also have some extra added weight (for example, at the blade's tip) in order to achieve desirable inertial characteristics. At the leading edge, an (often metal) erosion shield is used.

II. CONFIGURATION STUDIED

Modelling is done by using CATIA V6 software as per the dimension (considering the design parameters) Length of the rotor blade is 6600mm.& Chord length is 680 mm. In this study the airfoil baseline was chosen as NACA 0012.The air foil coordinates point are generated using CST function.

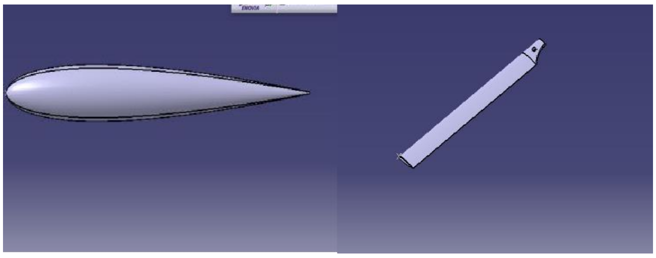

Figure 1 - zero degree pitch

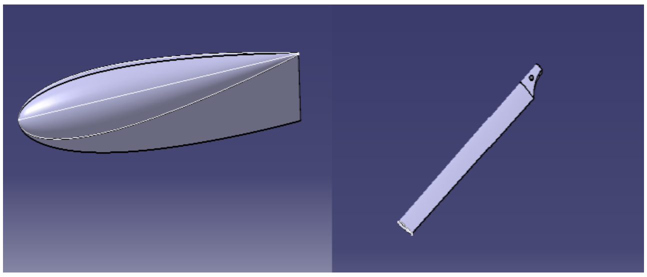

Figure 2 - seven degree pitch

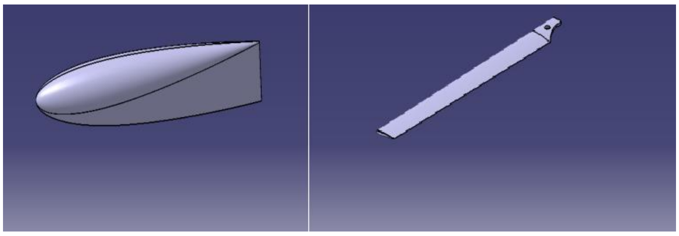

Figure 3 - eight degree pitch

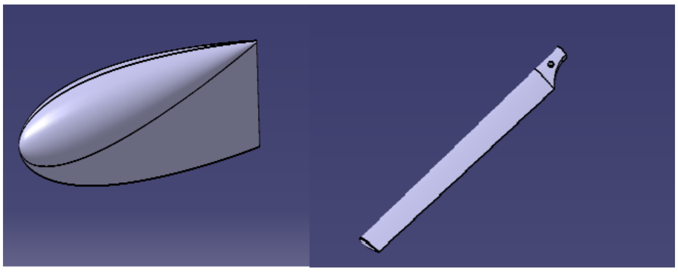

Figure 4 - nine degree pitch

III. MESH

The mesh has been generated by using HYPERMESH software for better accuracy. The element used is tetra mesh. Number of nodes and elements for this product are nodes: 226 elements: 13001.

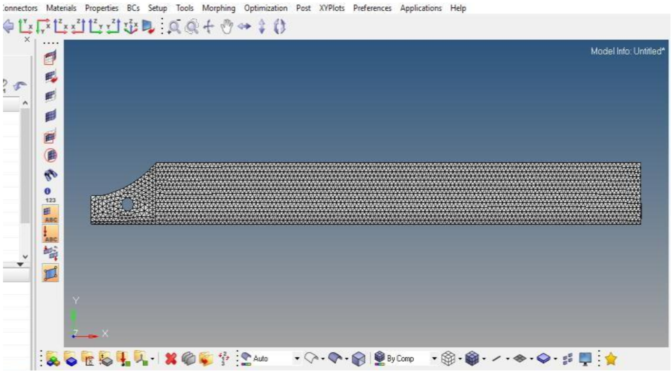

Figure 5 - zero degree pitch

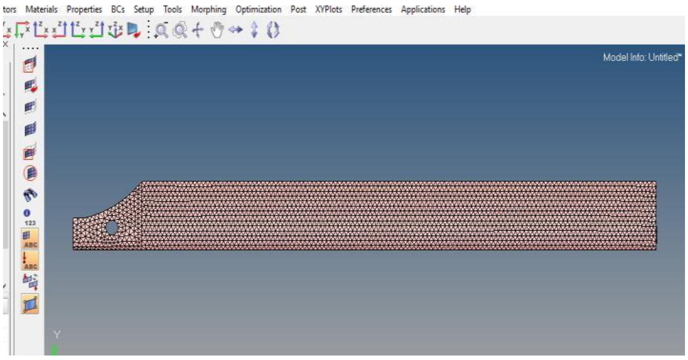

Figure 6 - seven degree pitch

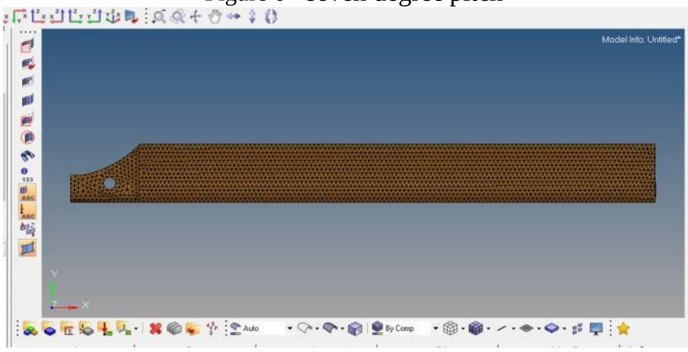

Figure 7 - eight degree pitch

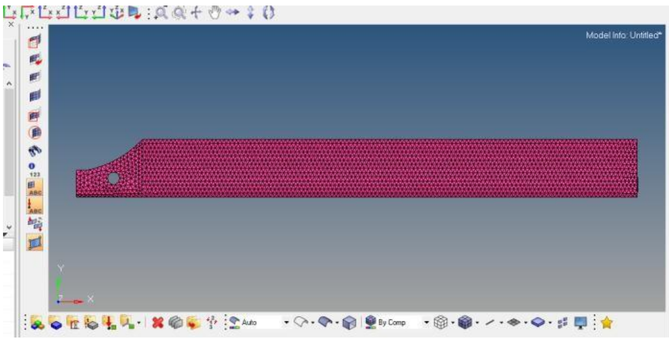

Figure 8 - nine degree pitch

IV. ANALYSIS:

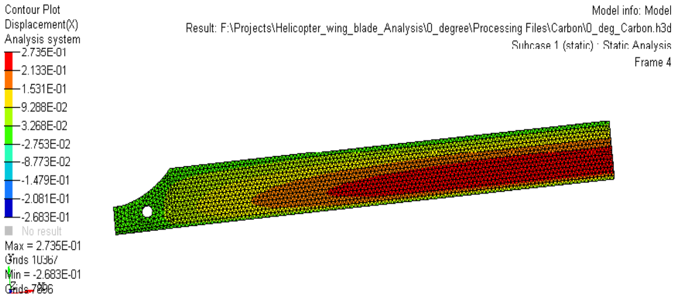

Figure 9 -Displacement at x direction (carbon epoxy at 0º)

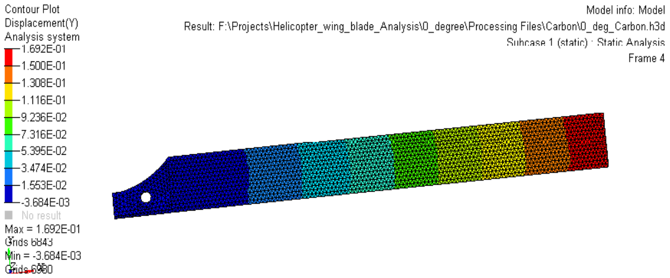

Figure 10 -Displacement at y direction (carbon epoxy at 0º)

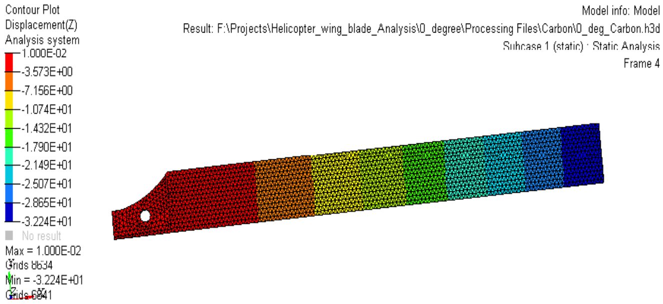

Figure 11 -Displacement at z direction (carbon epoxy at 0º)

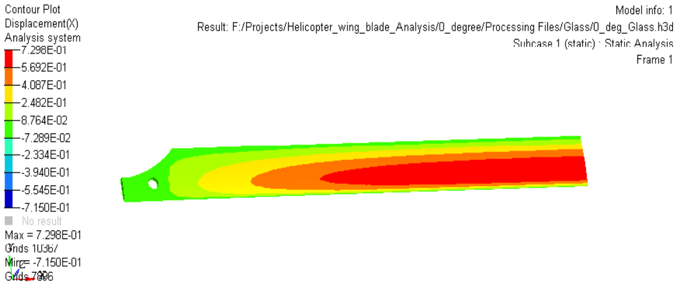

Figure 12 -Displacement at x direction (glass epoxy at 0º)

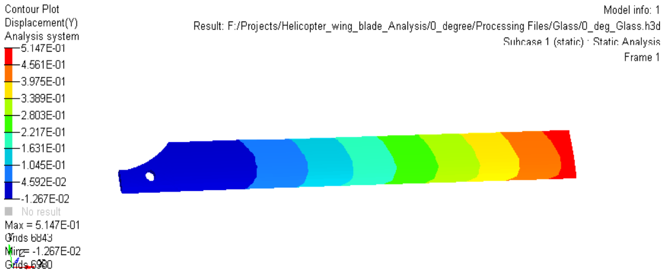

Figure 13 -Displacement at y direction (glass epoxy at 0º)

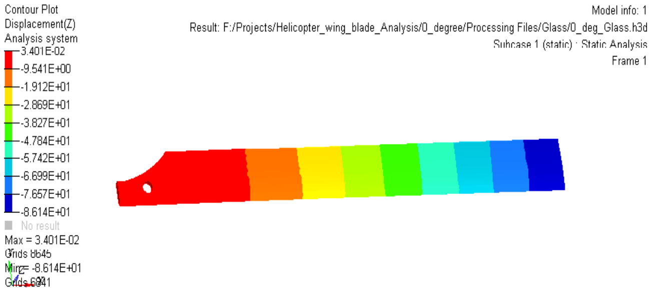

Figure 14 -Displacement at z direction (glass epoxy at 0º)

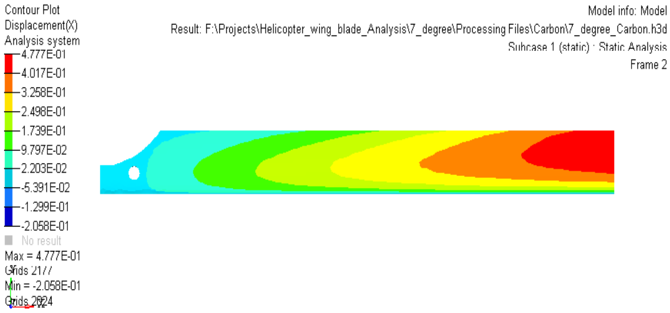

Figure 15 -Displacement at x direction (carbon/epoxy at 7º)

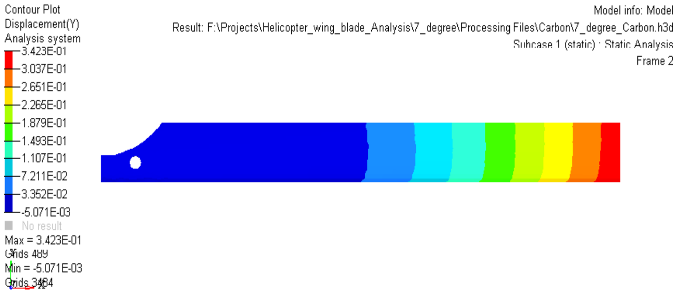

Figure 16 -Displacement at y direction (carbon/epoxy at 7º)

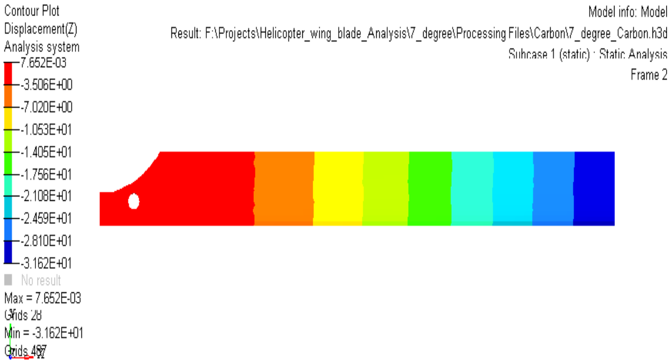

Figure 17 -Displacement at z direction (carbon/epoxy at 7º)

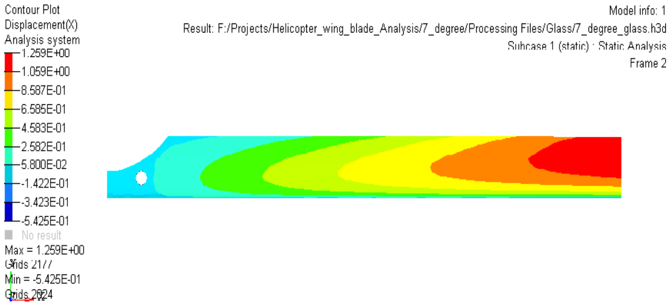

Figure 18 -Displacement at x direction (glass /epoxy at 7º)

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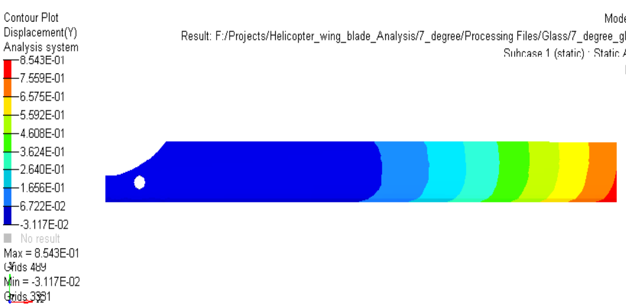

Figure 19 -Displacement at y direction (glass /epoxy at 7°)

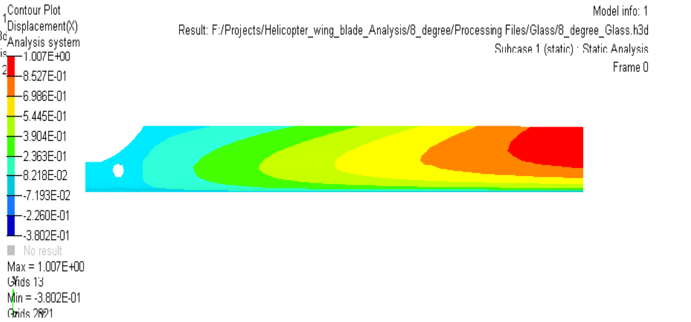

Figure 24 -Displacement at x direction (glass/epoxy at 8°)

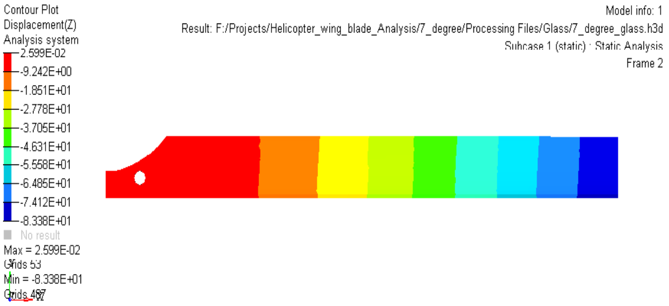

Figure 20 -Displacement at Z direction (glass /epoxy at 7°)

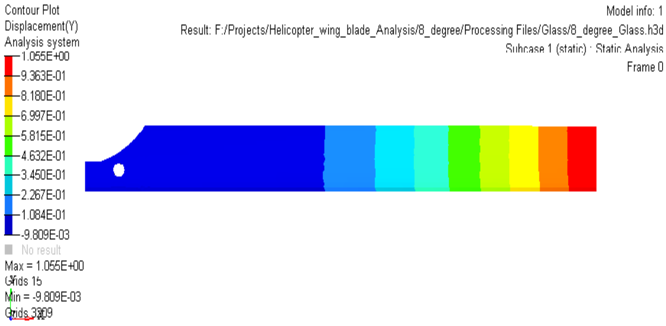

Figure 25 -Displacement at y direction (glass/epoxy at 8°)

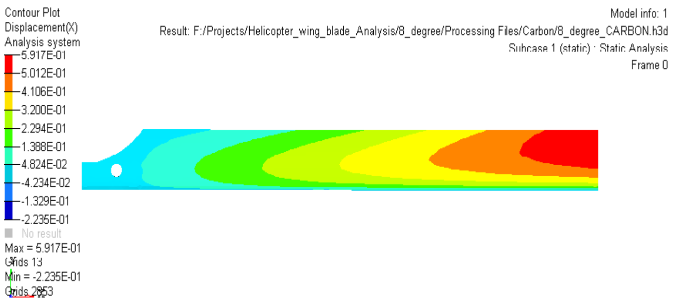

Figure 21 -Displacement at x direction (carbon /epoxy at 8°)

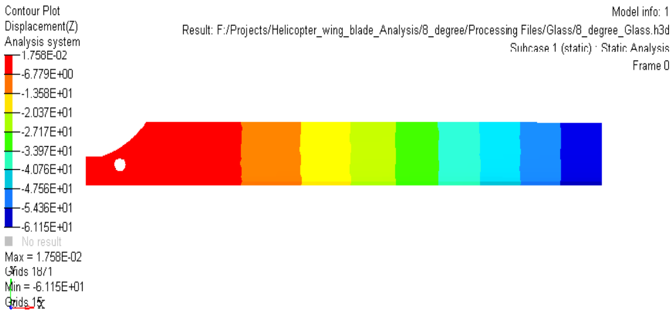

Figure 26 -Displacement at z direction (glass/epoxy at 8°)

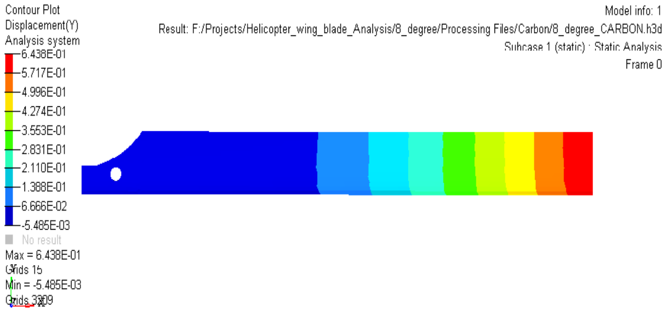

Figure 22 -Displacement at y direction (carbon /epoxy at 8°)

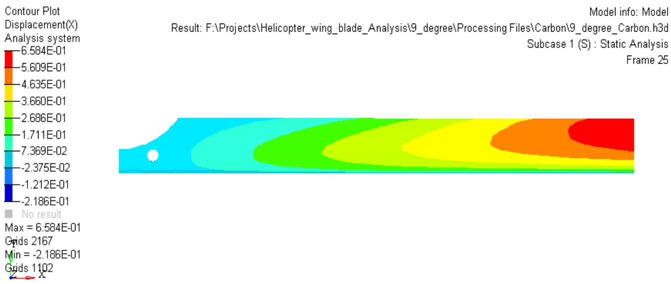

Figure 27 -Displacement at x direction (carbon /epoxy at 9°)

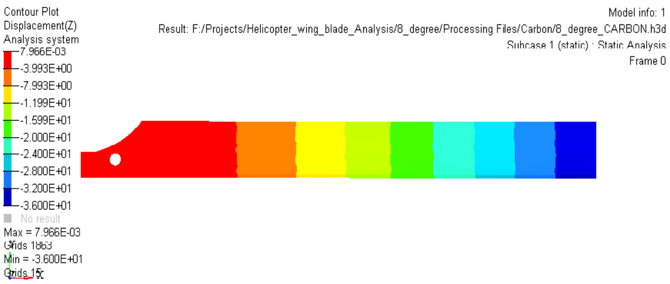

Figure 23 -Displacement at z direction (carbon /epoxy at 8°)

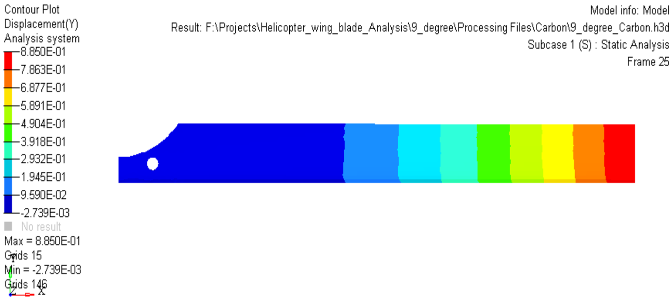

Figure 28 -Displacement at Y direction (carbon /epoxy at 9°)

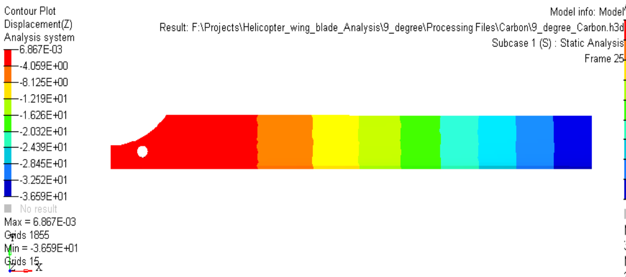

Figure 29 -Displacement at z direction (carbon /epoxy at 9º)

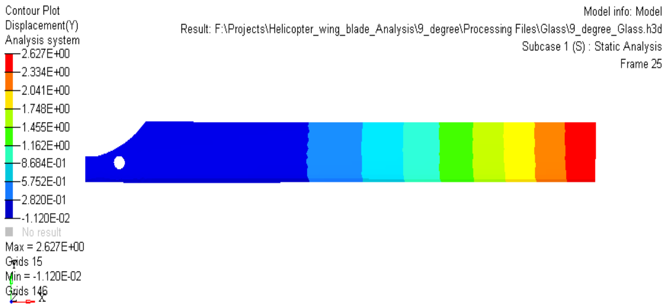

Figure 30 -Displacement at x direction (glass/epoxy at 9º)

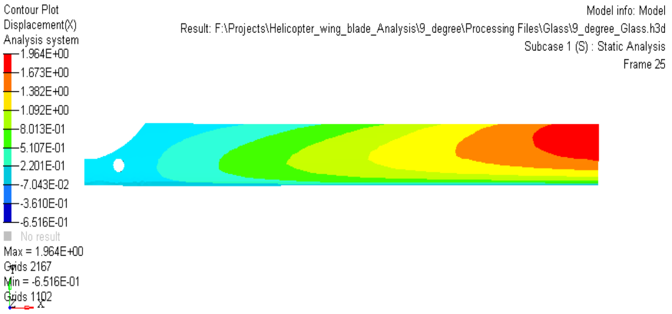

Figure 31 -Displacement at y direction (glass/epoxy at 9º)

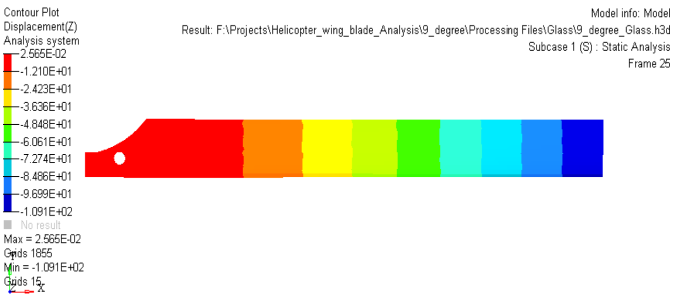

Figure 32 -Displacement at y direction (glass/epoxy at 9º)

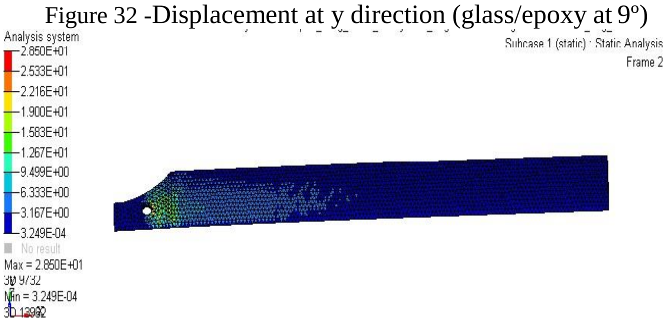

Figure 33 -Von misses stress at 0º (carbon epoxy)

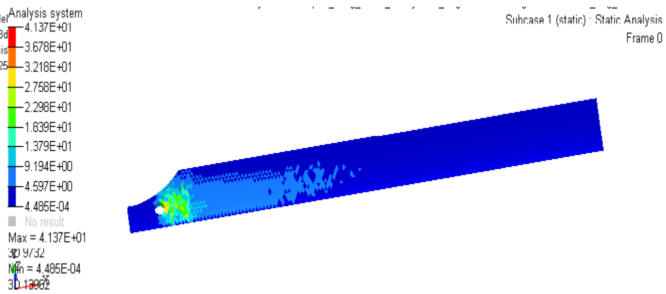

Figure 34 - Von misses stress at 0º (glass epoxy)

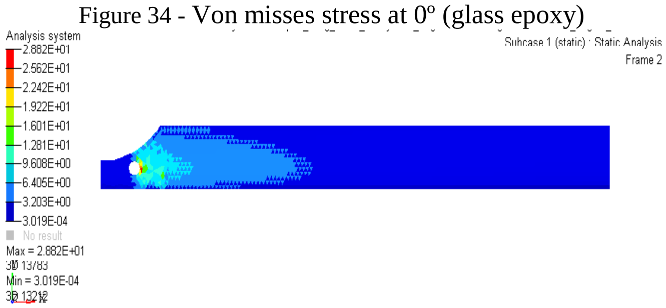

Figure 35 -Von misses stress at 7º (carbon epoxy)

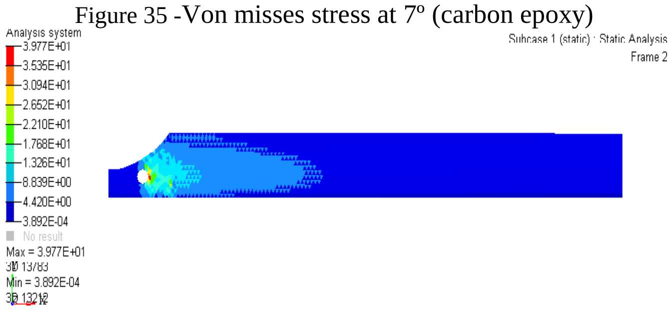

Figure 36 - Von misses stress at 7º (glass epoxy)

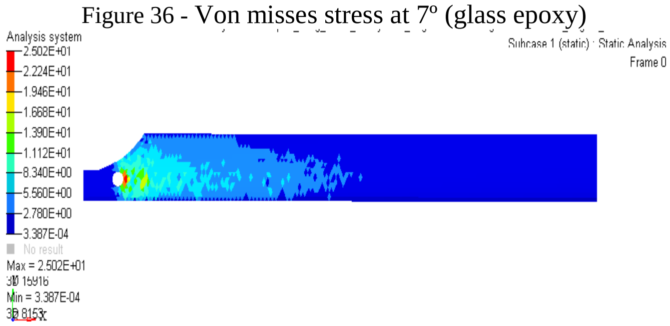

Figure 37 -Von misses stress at 8º (carbon epoxy)

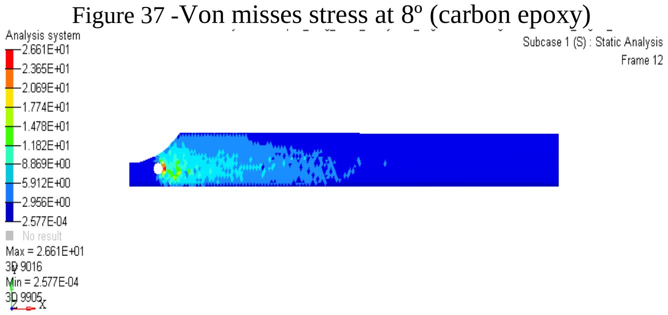

Figure 38 - Von misses stress at 8º (glass epoxy)

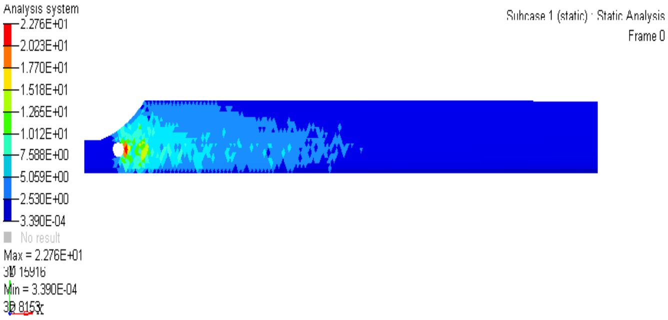

Figure 39 -Von misses stress at 9º (carbon epoxy)

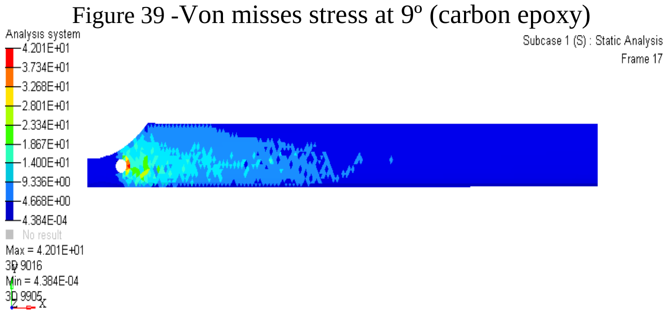

Figure 40 - Von misses stress at 9º (glass epoxy)

V.CONCLUSION

We studied the systems which are used in light helicopter. This helicopter can be used for ambulance role, civil Purpose, skid variants, wheeled variants, disaster relief operations, Offshore Operations, armed role, coast guard role, high altitude operations, Maritime Operations, policing duties and Sarong display team of IAF.In this project we carried out structural analysis and material analysis by considering angle of twist of the rotor blade as well as properties of composite materials. In structural analysis we designed rotor blade for four different angle of twist (0º, 7º, 8º, 9º) by CATIA software and the analysis carried out by hyper mesh software. As per simulation analysis we conclude that Carbon Epoxy is providing better results than glass epoxy.

VI.REFERENCES

1. Prof.Amarnath.v.hegne and Prof.preethi hegne, July-august 2013,"Design and power transmission of advance light helicopter".
2. Hardeep Singh and Jag sahil saini ,Gurukul vidyapeeth institute of engineering and technology, September 2014, "Detailed study of rotor blades of helicopter"
3. Jag sahil saini, Gurukul vidyapeeth institute of engineering and technology. June 2015 "Analysis of rotor blade of helicopter" Michael Roemer, Matthew Montana, Scott Novak, and Mitchell brush, spring 2016.
4. Michael Roemer, Matthew Montana, Scott Novak, and Mitchell brush, spring 2016 "The development and analysis of helicopter rotor blades".
5. "Effect of tail- fin span on stability and control charicteristics of an canard- controlled missile at supersonic mach number" by a. B. Blair, jr., jerry m. Allen, and gloria hernandez langley research center in june 1983.
6. B.Suresha and Chandra Mohan, department of mechanical engineering, PSG college of technology, Coimbatore, September 2016 "Friction and Wear Characteristics of Carbon Epoxy and Glass Epoxy Roving Fiber Composites"
7. Pravallika reddy, Department of aeronautical engineering, MLR institute of technology and management, Hyderabad, September – December 2015 "Static structural analysis of a helicopter rotor blade"