ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

E-Mail :
editor.ijasem@gmail.com
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www.ijasem.org

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

Vol 18, Issue 2, 2024

MODELLING AND ANALYSIS OF FLIGHT WING USING ANSYS AND CATIA

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ABSTRACT

An aircraft is a machine that is able to fly by gaining support from the air. It counters the force of gravity by using either static lift or by using the dynamic lift of an airfoil, or in a few cases the downward thrust from jet engines.

A wing is a type of fin that produces lift, while moving through air or some other fluid. As such, wings have streamlined cross-sections that are subject to aerodynamic forces and act as an airfoils. A wing's aerodynamic efficiency is expressed as its lift-to-drag ratio.

In this project wing structure of the ultra light aircraft was developed by using cad tool (CATIA) and analyzed with CAE TOOL (ANSYS WORKBENCH)

Our aim of the project is to reduce the stresses on the wing structure to increase its strength to weight ratio. To do this 2wing structures were developed (NACA 0012 &0016) analyzing with existing material (al-7075) and with CFRP (Carbon Reinforced Polymer) kevlar. From the results we can say which wing structure and which combination of material would be better for ultra light aircraft model

1. INTRODUCTION

Aircraft

An airplane is a machine that can fly with support from the air. It exerts a gravitational pull by using a static lift or by using the dynamic lift of the airfoil, or in some cases downward thrust from jet engines.

Human activity around an aircraft is called aviation. Crude aircraft are flown by an onboard pilot, while unmanned aerial vehicles can be remotely controlled or self-controlled by onboard computers. Aircraft can be classified by various criteria such as

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lift type, aircraft propulsion, consumption and so on.

Fixed-wing aircraft

A fixed-wing aircraft is an airplane-like aircraft capable of flying using the wings that produce lift due to the vehicle's forward airspeed and wing shape. Fixed-wing aircraft are different from rotary-wing aircraft in that the wings form a rotor mounted on a spinning shaft and form ornithoppers, in which the wings flap like a bird.

Wing

A wing is a type of fin that produces lift when moving through air or other fluid. Also, the wings have streamlined cross-sections that are subject to aerodynamic forces and act as airfoils. The aerodynamic capacity of the wing is expressed as its lift-to-drag ratio. At a given speed and angle of attack the size of the wing generated is one to two orders of magnitude greater than the total drag on the wing. A high lift-to-drag ratio requires a considerably smaller thrust to drive the wings through the air at an adequate lift.

Lifting structures used in water contain a variety of flakes, including hydrofoils. Hydrodynamics is a governing science rather than aerodynamics. Applications of underwater flakes take place on hydroplanes, sailboats and submarines.

2. LITERATURE REVIEW

T.V. Baughn and P.F. Packman [1] in 1986, led a limited component examination to decide the underlying trustworthiness of a high-wing link upheld ultralight airplane. A straightforward, even, half-structure full scale model was dissected and exposed to even out flight stacking and two-wheel-landing stacking conditions. Flexural and bowing firmness for the upheld and unsupported wing still up in the air. A fundamental harm resistance examination was led in which chose link components and wing pressure swaggers were taken out, the reallocated loads determined, and conceivable airplane flight designs analyzed. The model can produce every link load, uprooting of each underlying hub (for each stacking condition), create dislodging plots, and find possible exceptionally focused areas.

Baughn, T. what's more, Johnson, D. [2] around the same time of 1986, proposed a

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plan change from high-wing link upheld to swagger upheld airplane. One of the most well-known plans is the high wing link upheld ultralight. On account of its basic shape and strategy for development proprietors like to change the design and streamlined surfaces to endeavor to work on the exhibition of the airplane. One of the more normal change demands is for the transformation from a link upheld to a swagger upheld airplane. The target of the adjustment is to diminish the drag and work on the exhibition of the ultralight. The reason for their review is to decide the primary presentation of the link upheld airplane and contrast it with the underlying exhibition of a swagger upheld rendition of a similar airplane and to give a gauge of the adjustment of drag related with the transformation from link upheld to swagger upheld.

Girish S. Kulkarni [3] in 1987, with the assistance of all the plan rules given by Baughn, T alongside considering basic condition in un-sped up flight, done a Finite component strategy based foundational layout to break down the way of behaving of a plane under Aerodynamic stacking.

3.MATERIAL SELECTION

AL-7075-T6:

Aluminum alloy 7075 is an aluminum alloy, the basic alloying element of zinc. It is strong, comparable in strength to many steels, and has good fatigue strength and average machining efficiency, but is less resistant to corrosion than many other alloys. Its relatively high cost limits its use to applications that are not suitable for cheap alloys. The composition of the 7075 aluminum alloy is approximately 5.6–6.1% zinc, 2.1–2.5% magnesium, 1.2–1.6% copper and less than half a percent of silicon, iron, manganese, titanium, chromium and other metals. It is produced in many formats, some of them 7075-0, 7075-T6, 7075-T651

Carbon fiber reinforced polymer

Carbon fiber uphold polymer, carbon fiber developed plastic or carbon fiber development thermoplastic (CFRP, CRP, CFRTP or even conventional carbon fiber or carbon), is a very rich and lightweight fiber-up plastic containing carbon fibers. 'Fiber' spelling is common in British Commonwealth countries.

CFRPs can be expensive to convey yet are by and large used any spot high fortitude to-weight extent and unyielding nature are

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required, similar to flying, vehicle, underlying planning, sports items and a rising number of other client and specific applications.

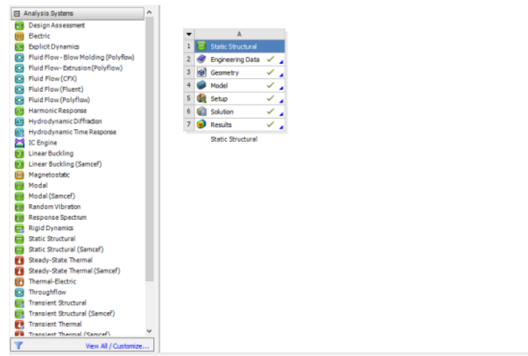
Kevlar

Kevlar is the enlisted brand name for a para-aramid produced fiber, associated with other aramids like Nomex and Technora. Made by Stephanie Kwolek at DuPont in 1965, this high-strength material was first fiscally used during the 1970s as a replacement for steel in hustling tires. Routinely it is transformed into ropes or surface sheets that can be used likewise or as a fixing in composite material parts.

At this moment, Kevlar has various applications, going from bicycle tires and hustling sails to body support, because of its high inflexibility to-weight extent; by this activity it is on numerous occasions more grounded than steel. Moreover used to make current drumheads persevere through high impact. Right when used as a woven material, it is sensible for getting lines and other lowered applications

FINITE ELEMENT ANALYSIS OF WING RIBS AND STRINGERS

ANSYS PROCESS



	Cfrp90	Kevlar	Al-7075-t6
Young's modules(pa)	44.9e9	83e9	71.7E^9
Poison ratio	0.10	0.29	0.33
Density(kg/m^3)	1760	1440	2810
Yield strength(Mpa)	474	650	503

Above mentioned materials need to be entered in engineering data, and after entering material properties now import wing that developed in CATIA and the imported model, is shown in below image. After importing object then assign material properties to wing spars and ribs, here first al-7075 material consider is existing material for both wing spars and ribs, after completing analysis in it then change the materials of ribs and stringers into composite materials. Each time al-7075 material is replaced with composite material, and comparing results of each case.

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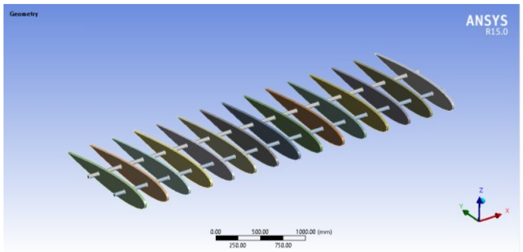
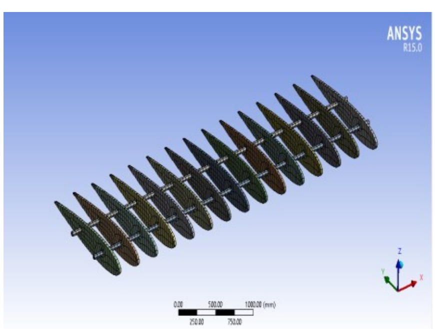


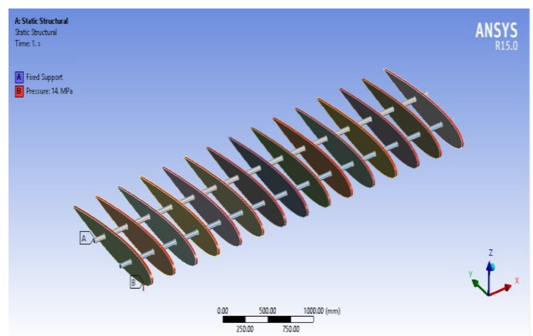
Meshing

In real world when loads applied on any object, it will transfer throughout object with the help of atoms and molecules, but in software, it is not possible to create those atoms and molecules, so that here meshing option create elements and nodes, and these elements and nodes will act as atoms and molecules. Here hexa meshing were used. In addition, this meshing is created default based on their shape and structure. Here element size is consider as 1mm.



Loads and Boundary Conditions

After completing materials assignment and meshing process, now need to apply boundary conditions on it, here object is consider as cantilever beam, so that object is fixed at one end, and the load will be applied on top of the area, here maximum pressure value which wing can withstand calculated based safety factor values, here pressure values applied multiple times and checking factor of safety values,



When factor of safety is near to 1.5 or above one is consider as maximum limit of the object/material, in this process al-7075 material with NACA 0016 wing can withstand maximum pressure on it 14Mpa only.

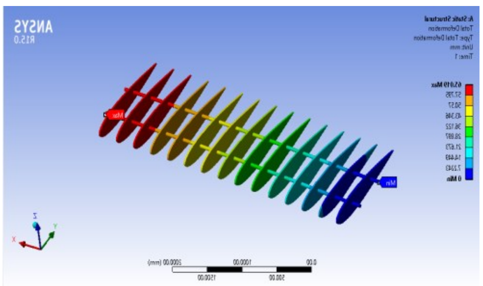
After applying load on it now calculating results like deformation, stress, strain, safety factor values.

Results

NACA 0016 wing structure

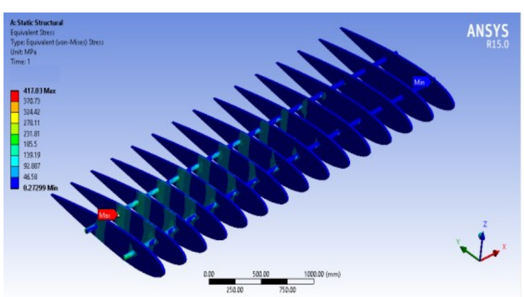
Material: al-7075

Deformation



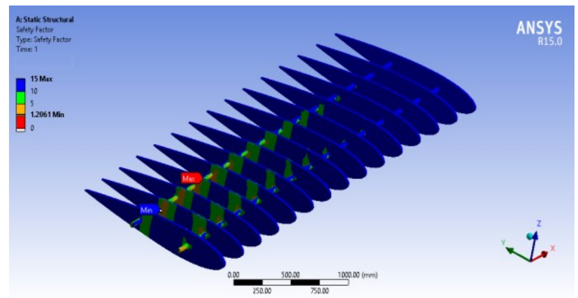
Above image, represent the NACA 0016 wing deformation results when it has al-7075 material for both ribs and spars, and it has maximum deformation of 65.019mm and minimum deformation value of 0mm.

Stress



Above image, represent the NACA 0016 wing stress results when it has al-7075 material for both ribs and spars, and it has maximum stress of 417.03Mpa and minimum stress value of 0.27299Mpa.

Safety factor



From the above results here we got maximum stress value is 417.03Mpa and safety factor value is 1.2061 and generally we cannot eliminate complete stresses on the body but we can reduce it by changing design and material properties values. Here we took al-7075 material for both ribs and stringers. To decrease the stress and increase the strength to weight ratio here we changing materials, i.e we took another two materials those are CFRP and KEVLAR materials

Applying same amount of boundary conditions on it and calculated results

Results

Ribs: al-7075

Stringers: CFRP

Deformation

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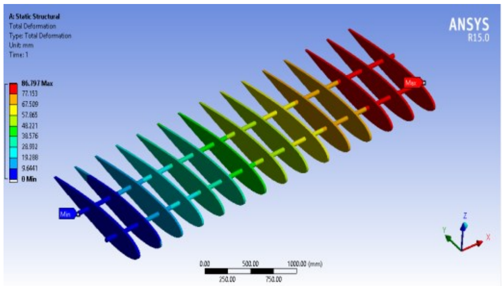
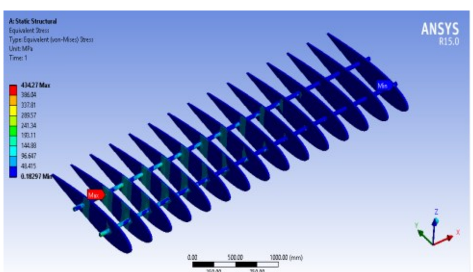


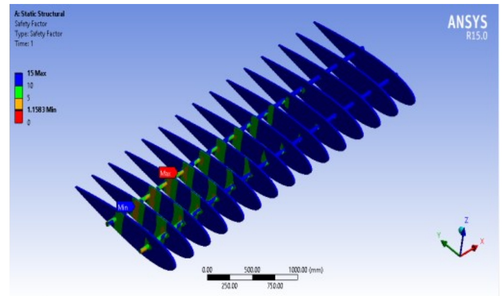
Above image, represent the NACA 0016 wing deformation results when it has al-7075 material for ribs and CFRP material for spars, and it has maximum deformation of 86.797mm and minimum deformation value of 0mm.

Stress



Above image, represent the NACA 0016 wing stress results when it has al-7075 material for ribs and CFRP material for spars, and it has maximum stress of 434.27Mpa and minimum stress value 0.18297Mpa.

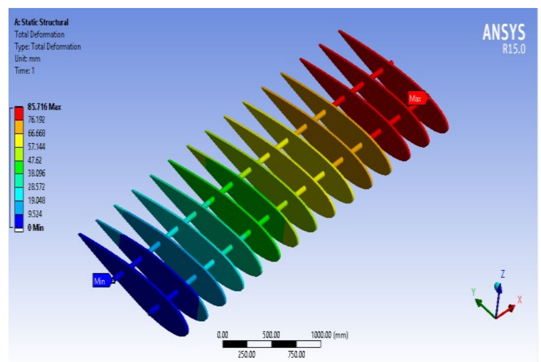
Safety factor



Ribs: CFRP

Stringers: al-7075

Deformation



Above image, represent the NACA 0016 wing deformation results when it has al-7075 material for stringers and CFRP material for ribs, and it has maximum deformation of 85.716mm and minimum deformation value of 0mm.

Stress

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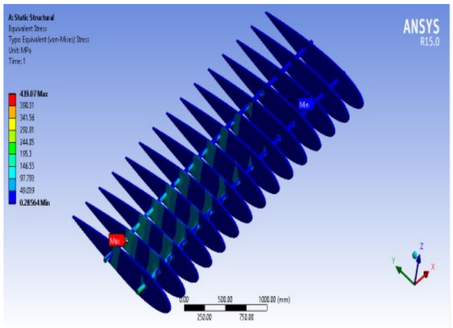
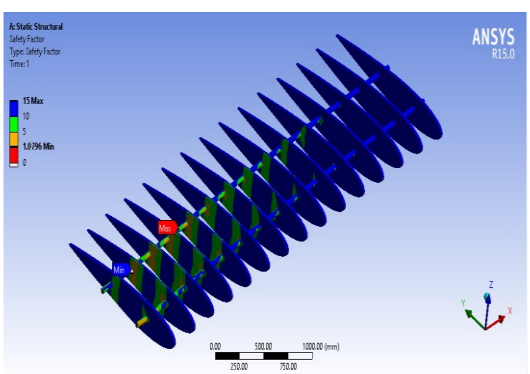


Above image, represent the NACA 0016 wing stress results when it has al-7075 material for stringers and CFRP material for ribs, and it has maximum stress of 439.07Mpa and minimum stress value of 0.28564Mpa.

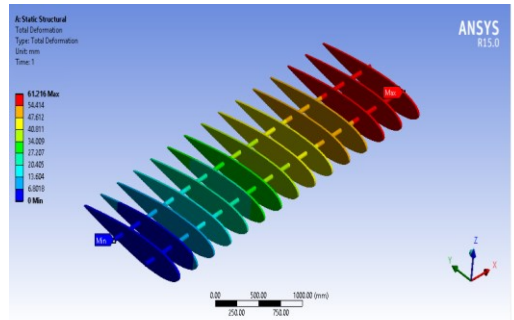
Safety factor



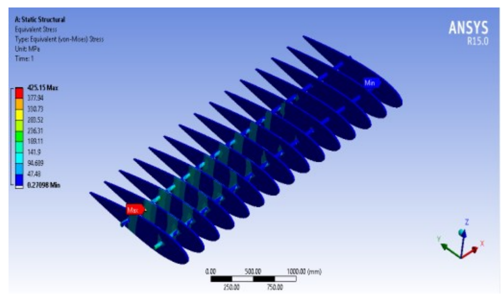
Ribs: Kevlar

Stringers: al-7075

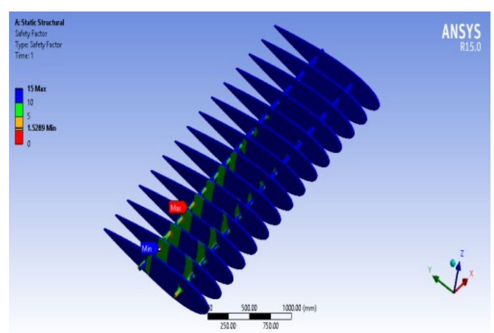
Deformation



Stress



Safety factor



Ribs: al-7075

Stringers: Kevlar

Deformation

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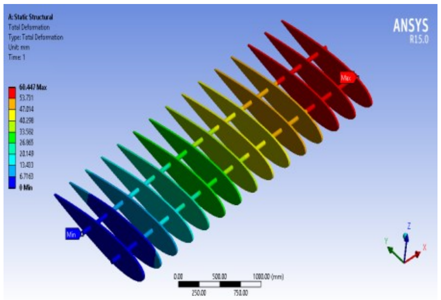
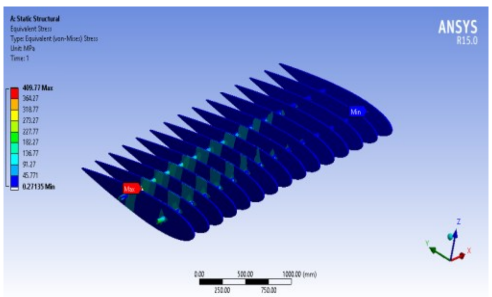
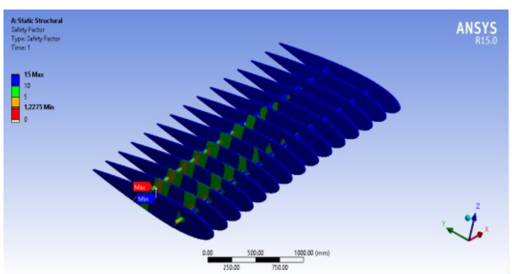


Stress



Safety factor

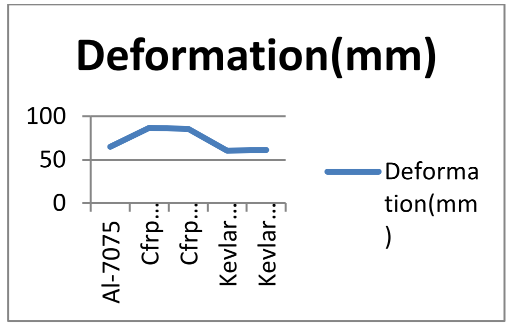


Tables

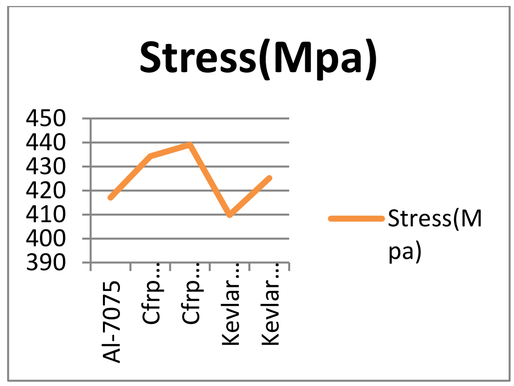
	Deformation(mm)	Stress(Mpa)	Safety factor
Al-7075	65.019	417.03	1.2061
Cfrp (stringers) &al-7075 (ribs)	86.797	434.27	1.1583
Cfrp (ribs) &al-7075 (stringers)	85.716	439.07	1.0796
Kevlar (stringers)&al-7075 (ribs)	60.447	409.77	1.2275
Kevlar (ribs) &al-7075 (stringers)	61.216	425.15	1.5289

Graphs

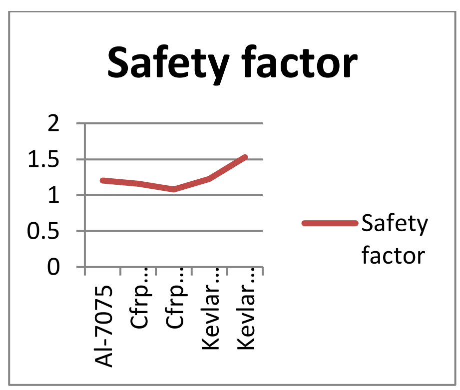
Deformation



Stress



Safety factor



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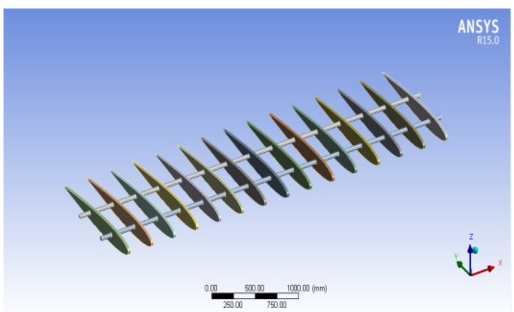
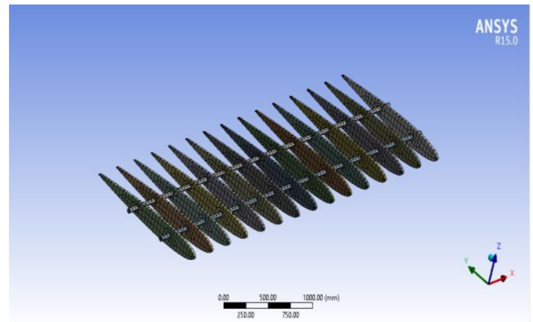
ANALYSIS PROCESS FOR NACA 0012 MODEL

After importing object then assign material properties to wing spars and ribs, here first al-7075 material consider is existing material for both wing spars and ribs, after completing analysis in it then change the materials of ribs and stringers into composite materials. Each time al-7075 material is replaced with composite material, and comparing results of each case.



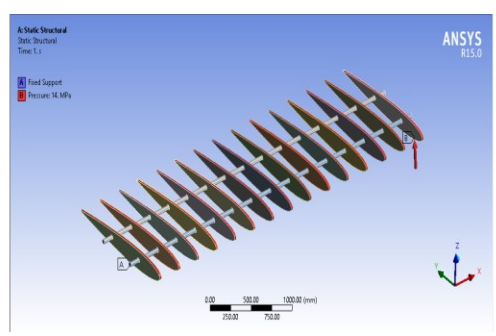
Meshing

In real world when loads applied on any object, it will transfer throughout object with the help of atoms and molecules, but in software, it is not possible to create those atoms and molecules, so that here meshing option create elements and nodes, and these elements and nodes will act as atoms and molecules. Here hexa meshing were used. In addition, this meshing is created default based on their shape and structure. Here element size is consider as 1mm.



Loads and Boundary Conditions

After completing materials assignment and meshing process, now need to apply boundary conditions on it, here object is consider as cantilever beam, so that object is fixed at one end, and the load will be applied on top of the area, here maximum pressure value which wing can withstand calculated based safety factor values, here pressure values applied multiple times and checking factor of safety values,



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When factor of safety is near to 1.5 or above one is consider as maximum limit of the object/material, in this process al-7075 material with NACA 0012 wing can withstand maximum pressure on it 14Mpa only.

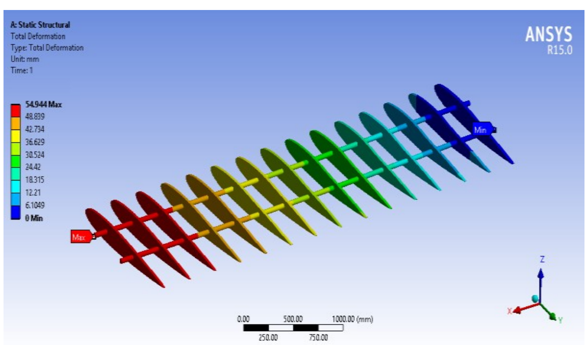
After applying load on it now calculating results like deformation, stress, strain, safety factor values.

Results

NACA 0012 wing structure

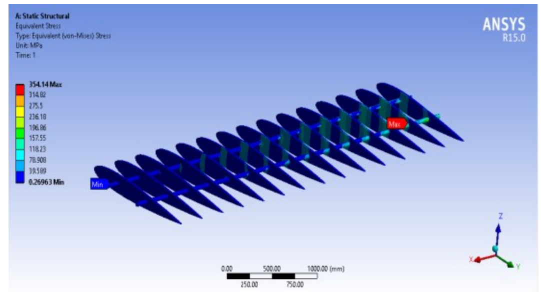
Material: al-7075

Deformation



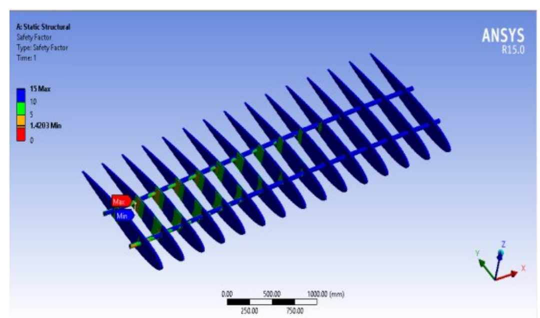
Above image, represent the NACA 0012 wing deformation results when it has al-7075 material for both ribs and spars, and it has maximum deformation of 54.944mm and minimum deformation value of 0mm.

Stress



Above image, represent the NACA 0012 wing stress results when it has al-7075 material for both ribs and spars, and it has maximum stress of 354.14Mpa and minimum stress value of 0.26963Mpa.

Safety factor



From the above results here we got maximum stress value is 354.14Mpa and safety factor value is 1.4203 and generally we cannot eliminate complete stresses on the body but we can reduce it by changing design and material properties values. Here

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we took al-7075 material for both ribs and stringers. To decrease the stress and increase the strength to weight ratio here we changing materials, i.e we took another two materials those are CFRP and KEVLAR materials

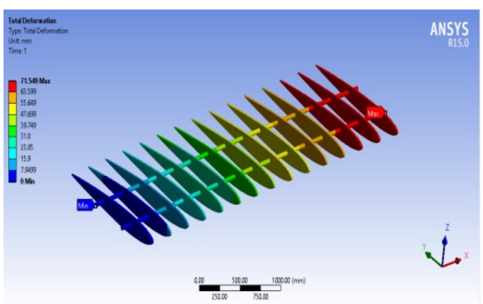
Applying same amount of boundary conditions on it and calculated results

Results

Ribs: al-7075

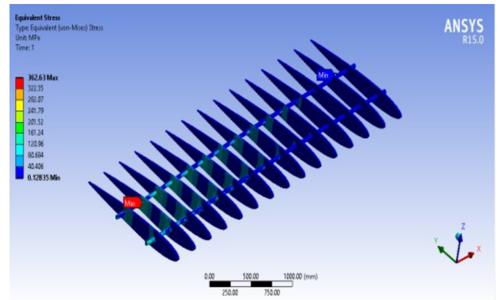
Stringers: CFRP

Deformation



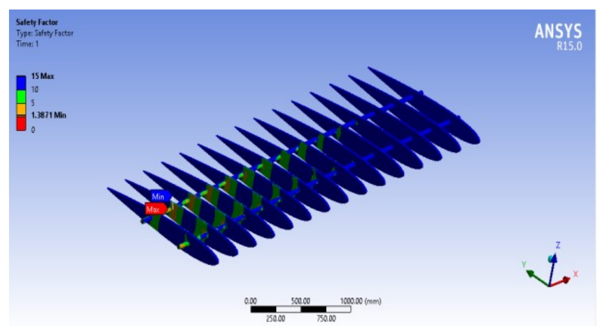
Above image, represent the NACA 0012 wing deformation results when it has al-7075 material for ribs and CFRP material for spars, and it has maximum deformation of 71.549mm and minimum deformation value of 0mm.

Stress



Above image, represent the NACA 0016 wing stress results when it has al-7075 material for ribs and CFRP material for spars, and it has maximum stress of 362.63Mpa and minimum stress value 0.12835Mpa.

Safety factor



Ribs: CFRP

Stringers: al-7075

Deformation

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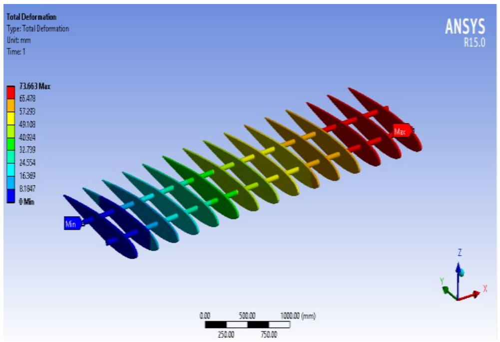
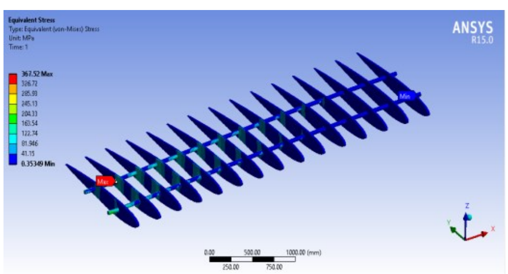


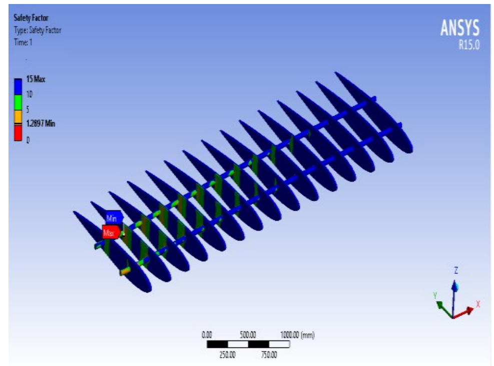
Above image, represent the NACA 0012 wing deformation results when it has al-7075 material for stringers and CFRP material for ribs, and it has maximum deformation of 73.663mm and minimum deformation value of 0mm.

Stress



Above image, represent the NACA 0016 wing stress results when it has al-7075 material for stringers and CFRP material for ribs, and it has maximum stress of 367.52Mpa and minimum stress value of 0.35349Mpa.

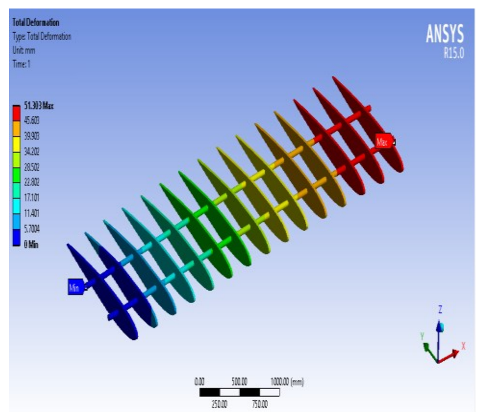
Safety factor



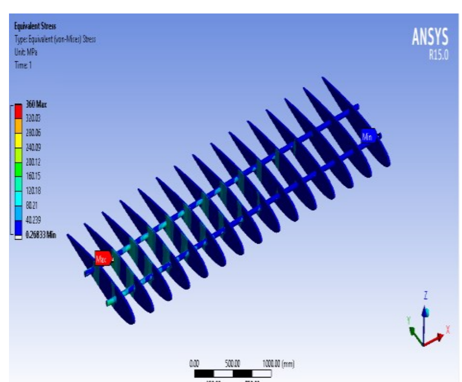
Ribs: Kevlar

Stringers: al-7075

Deformation



Stress



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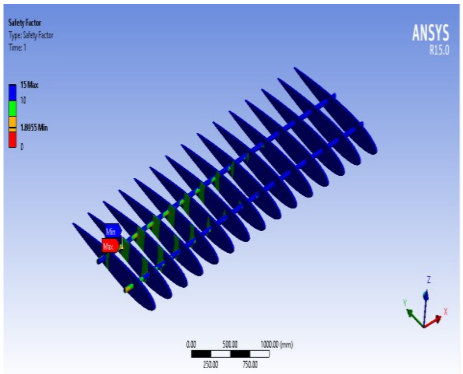
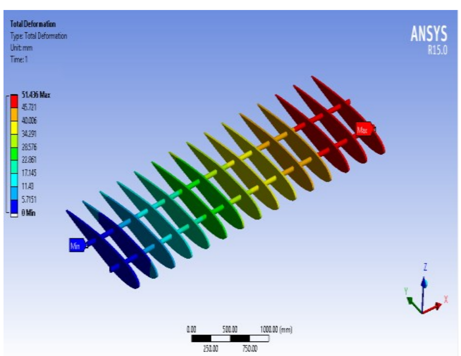
Safety factor



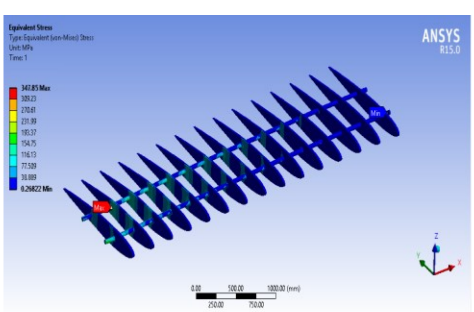
Ribs: al-7075

Stringers: Kevlar

Deformation



Stress



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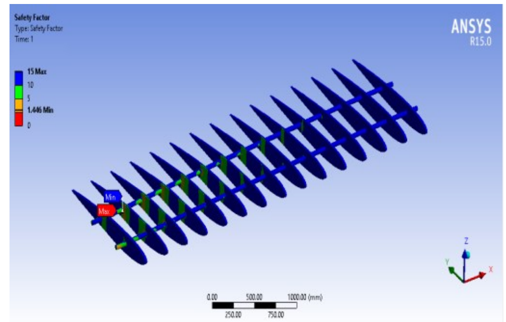
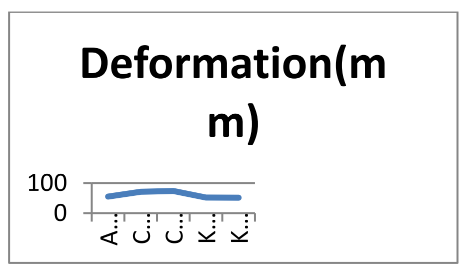


Tables

	Deformation(mm)	Stress(Mpa)	Safety factor
Al-7075	54.944	354.14	1.4203
Cfrp (stringers) &al-7075 (ribs)	71.549	362.63	1.3871
Cfrp (ribs) &al-7075 (stringers)	73.663	367.52	1.2897
Kevlar (stringers)&al-7075 (ribs)	51.436	347.85	1.446
Kevlar (ribs) &al-7075 (stringers)	51.303	360	1.8055

Graphs

Deformation



Stress

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

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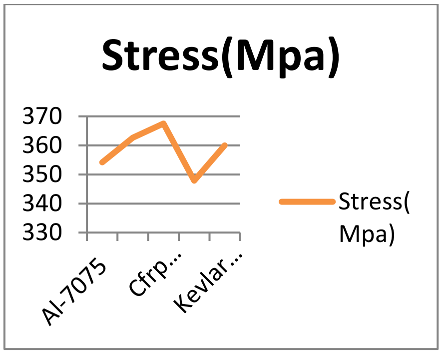
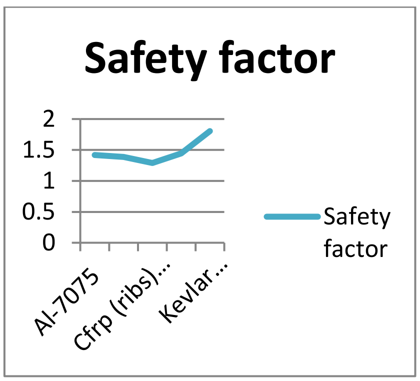
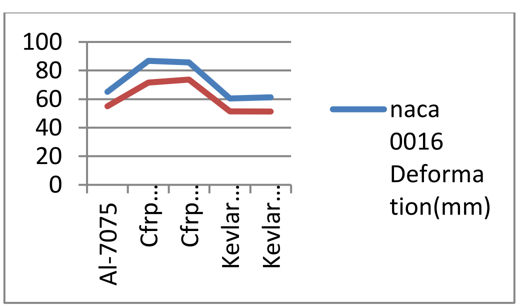


Safety factor

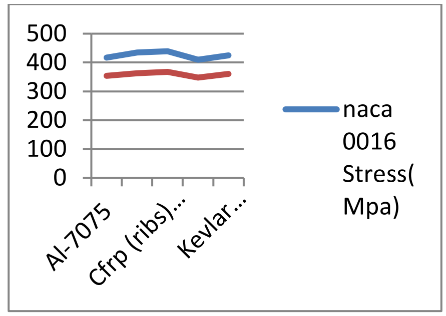


COMPARISON BETWEEN TWO WING STRUCTURES

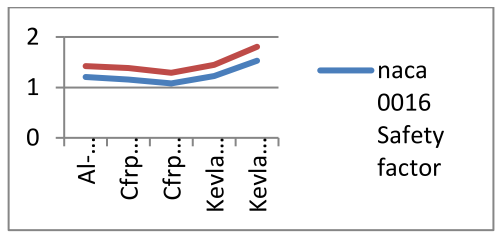
Deformation



Stress



Safety factor



4. CONCLUSION

In this project ultra light aircraft wing structure was developed by using CAD TOOL (solid works) and analyzed with CAE TOOL (ANSYS WORK BENCH) , in this project we took different wing structuresthose are NACA 0012 and NACA 0016 and calculated their maximum strength values.

Here we consider al-7075 material as existing material for both structures and applied 14Mpa pressure on ribs and calculated results like deformation, stress, safety factor values. In this case NACA 0016 has huge stress (417.03Mpa) compared with NACA 0012 (354.14Mpa) structure. It means by using NACA 0012 wing structure we can reduce 63Mpa amount of stress it means the strength will increases.

To get more efficient wing structure here we using composite materials also those are CFRP and KEVLAR. In this process first we apply CFRP to stringers and ribs (al-7075) then next CFRP (ribs) &al-7075 (stringers), and we repeat same process for Kevlar &al-7075 materials for both structures

From the results of NACA 0012 wing structure it has high strength to weight ratio in all static loading conditions, finally we can conclude that NACA 0012 wing structure with ribs (Kevlar) stringers (al-7075) materials will increase the strength of the wing structure compare to existing material.

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