Review of Wing Rib Design and Analysis of Aircraft

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Abstract:

Ribs are essential component of Aircraft wing. Ribs are used for maintaining aerofoil contour shape of the wing and reduce stress acting on it. The paper focuses determine stress on wing rib with different designs and select the appropriate design. SOLIDWORKS is used for designing and estimating physical properties of design while ANSYS STATIC STRUCTURAL is used for analysis. Conclusion of the wing rib design is done after study of 5 different rib designs.

Keywords: SOLIDWORKS, ANSYS, Contour, stress, wing rib.

Introduction:

Ribs are the structural element which combine with spars and stringers to form wing. They usually maintain the structure from leading edge to trailing edge of the aircraft wing. It also help wing to maintain cambered shape and reduce load acting on the skin by transmitting it to spars. Ribs reduce the effect of stress acting on wing.

Wing ribs are generally made up with wood or metal. Same kind of material can be used in spars and ribs, expect metal ribs can be used with wooden spar arrangement. The design of the ribs can vary based on the requirement. In our paper we are mainly discussing about stress developed on wing rib design of the wing.

Material and Design selection

As ribs can be made with either wood or metal therefore we have selected Al alloy cast 713 material for our study. Al alloy cast 713 consisting of 0.25% silicon, 0.35% chromium, 0.15% nickel, 1.1% iron, 0.4 to 1% copper, 0.2 to 0.5% magnesium, 0.25% titanium, 7 to 8% zinc, and 0.6% manganese. For design criteria we have studied hole, strip and truss arrangement in ribs.

Design:

The modeling of the rib is done in solidworks

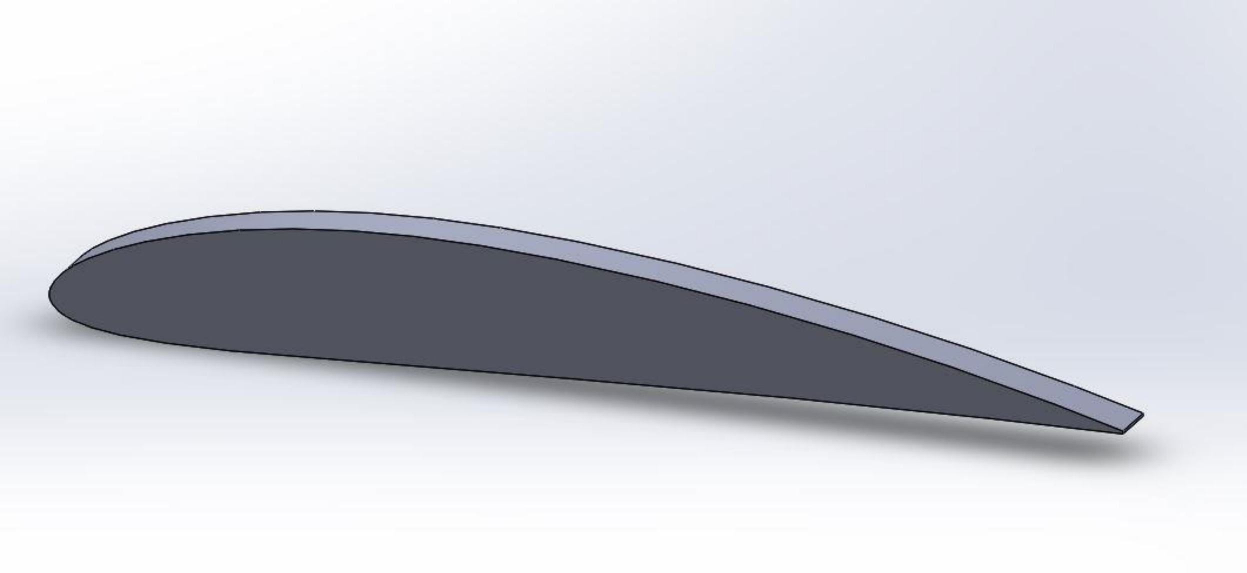

Figure 1: Solid wing rib design

Thickness	50mm
Chord line	1000 mm
mass	11.89 kg
Surface area	0.27 m^2
Center of Mass in meters	(0.42, 0.03, 0)

The moment of inertia is given by (kilogram*square meter)

I_{xx} =0.02	I_{xy}=0.16	I_{xz}=0
I_{yx}=0.16	I_{yy}=2.76	I_{yz}=0
I_{zx}=0	I_{zy}=0	I_{zz}=2.78

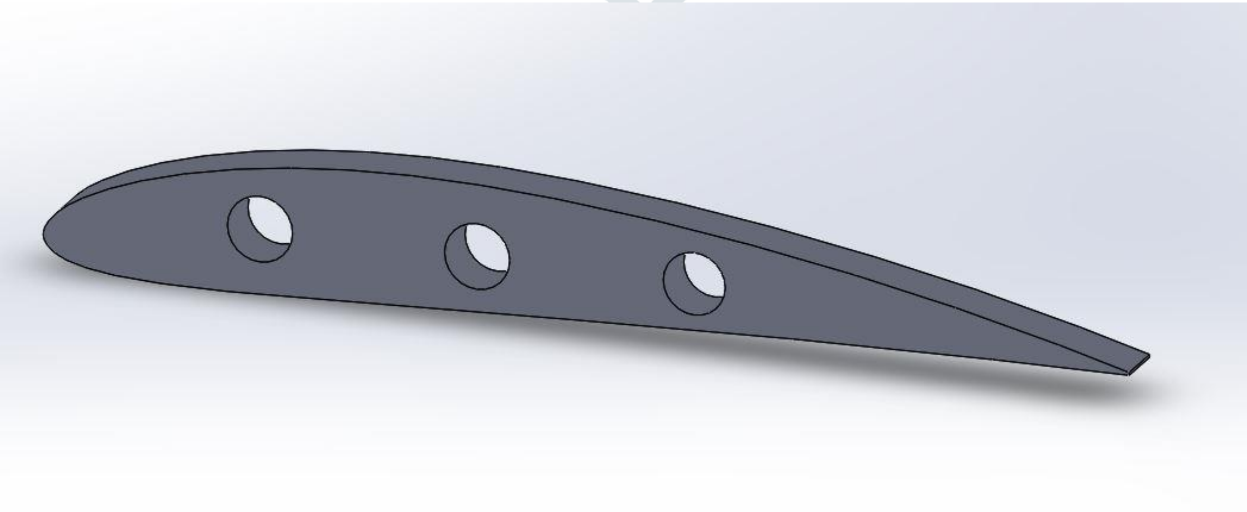

Figure 2: Wing rib design with 3 holes

Hole diameter	60mm
Distance between each holes	200mm
mass	10.71 kg
Surface area	0.28 m^2
Center of mass (in meter)	(0.42,0.03,0)

The moment of inertia is given by (kilogram*square meter)

I_{xx} =0.02	I_{xy}=0.14	I_{xz}=0
I_{yx}=0.14	I_{yy}=2.54	I_{yz}=0
I_{zx}=0	I_{zy}=0	I_{zz}=2.56

Figure 3: Wing rib design with 2 holes

Dimensions for 2 holes rib

Hole diameter	60mm
Distance between each holes	200mm
mass	11.08 kg
Surface area	0.28 m^2
Center of mass (in meter)	(0.43,0.03,0)

The moment of inertia is given by (kilogram*square meter)

I_{xx} =0.02	I_{xy}=0.15	I_{xz}=0
I_{yx}=0.15	I_{yy}=2.68	I_{yz}=0
I_{zx}=0	I_{zy}=0	I_{zz}=2.7

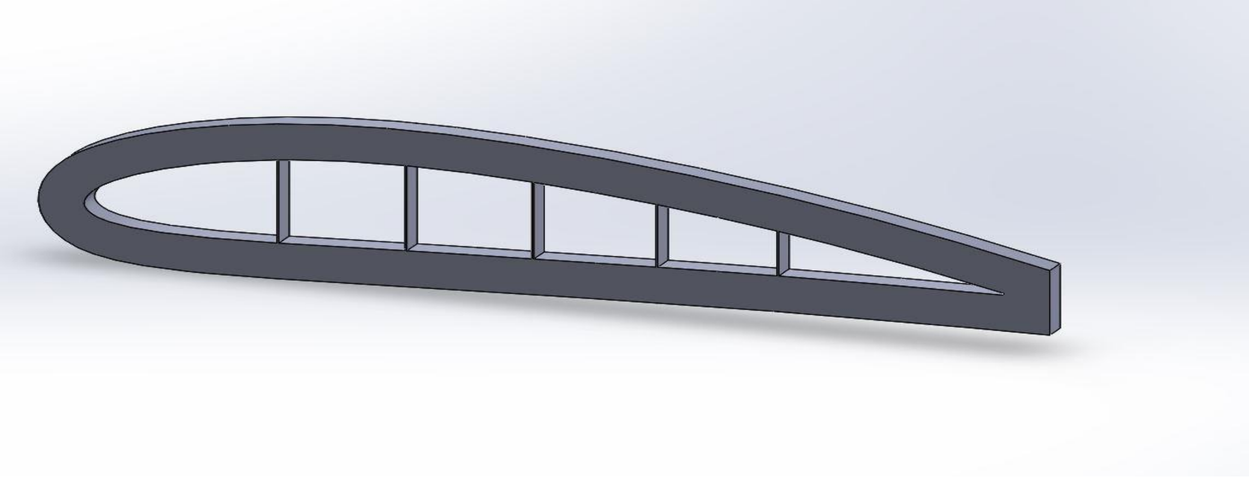

Figure 4: Wing rib design with vertical strips

Airfoil Thickness	50mm
Vertical truss thickness	2mm
mass	9.68 kg
Surface area	0.39
Center of mass(meter)	(0.5,0.03,0)

The moment of inertia is given by (kilogram*square meter)

I_{xx} =0.05	I_{xy}=0.11	I_{xz}=0
I_{yx}=0.11	I_{yy}=3.37	I_{yz}=0
I_{zx}=0	I_{zy}=0	I_{zz}=3.42

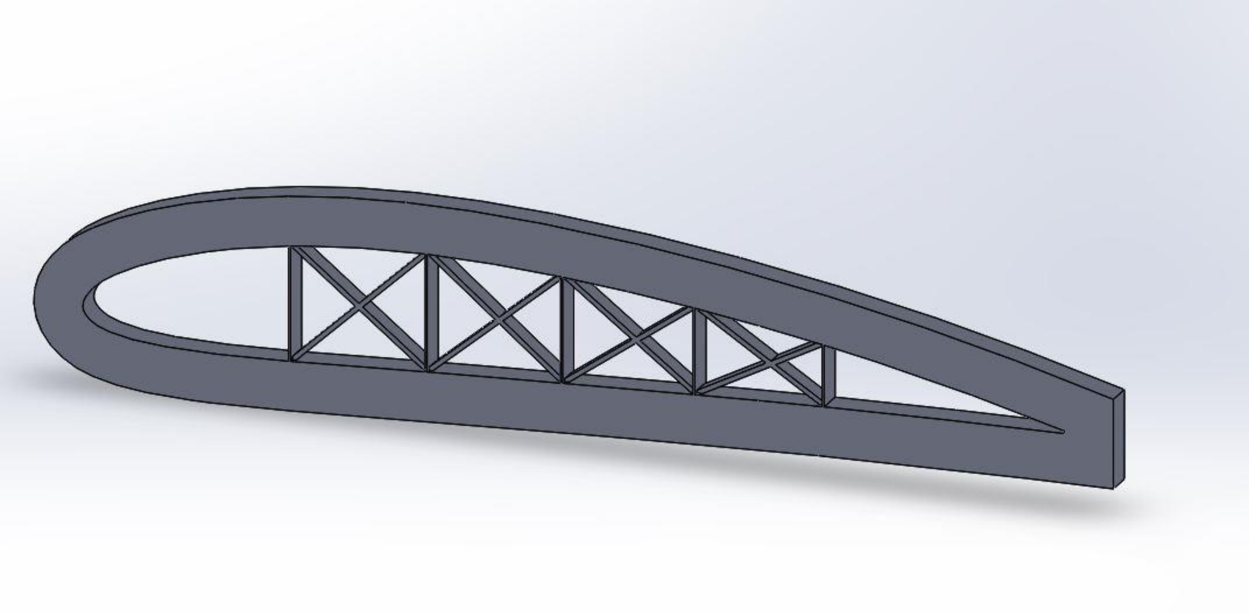

Figure 5: Wing rib design with criss cross

thickness	50mm
Vertical truss thickness	2mm
Inclined trusss thickness	5mm
mass	10.6 kg
Center of mass (meter)	(0.5,0.03,0)

The moment of inertia is given by (Kg.m^2)

I_{xx} =0.05	I_{xy}=0.12	I_{xz}=0
I_{yx}=0.12	I_{yy}=3.46	I_{yz}=0
I_{zx}=0	I_{zy}=0	I_{zz}=3.52

Meshing:

Meshing is a crucial step for analysis of any structure or body ,the process of discretization of any body or domain into small domain for solving the governing equation used for analysis of a given system for our analysis an unstructured mesh with triangular topology is used for discretization and the software used is Ansys meshing the details of the mesh is tabulated below

No. of elements	31656
No. of nodes	51751
Element size	1.4876e-2
Mesh topology	triangular

Analysis:

The analysis is done in ansys workbench 2019 R2 the pressure applied is 100pa

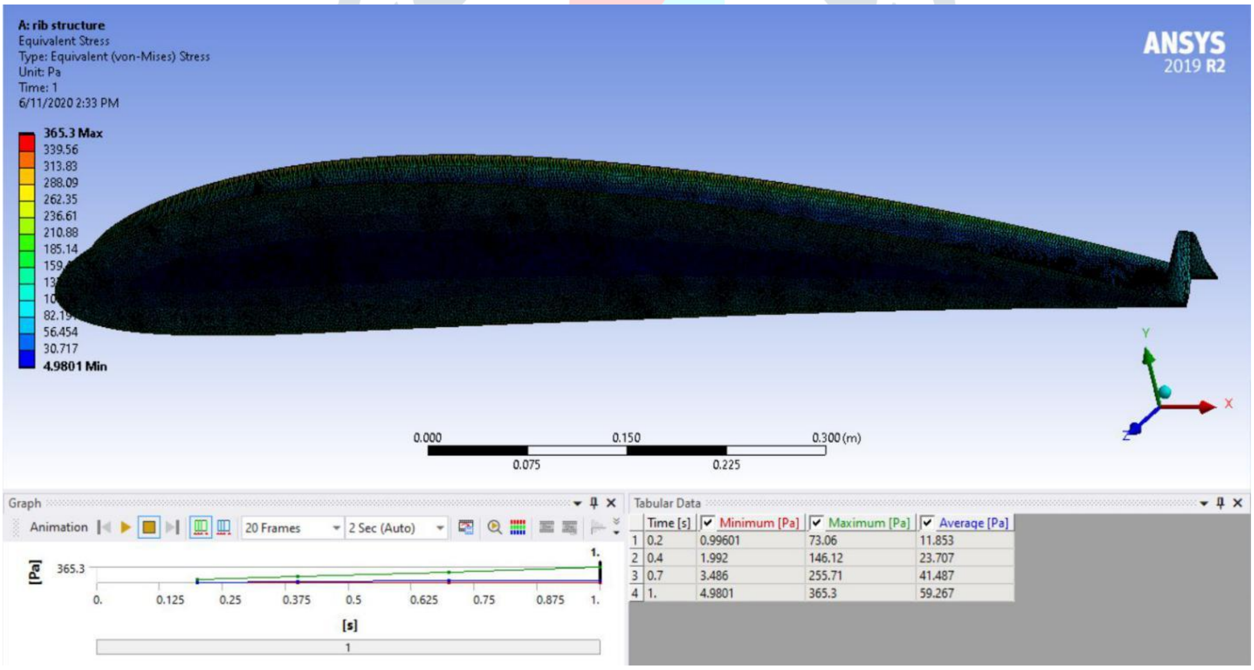

Figure 6: Analysis of solid wing rib design

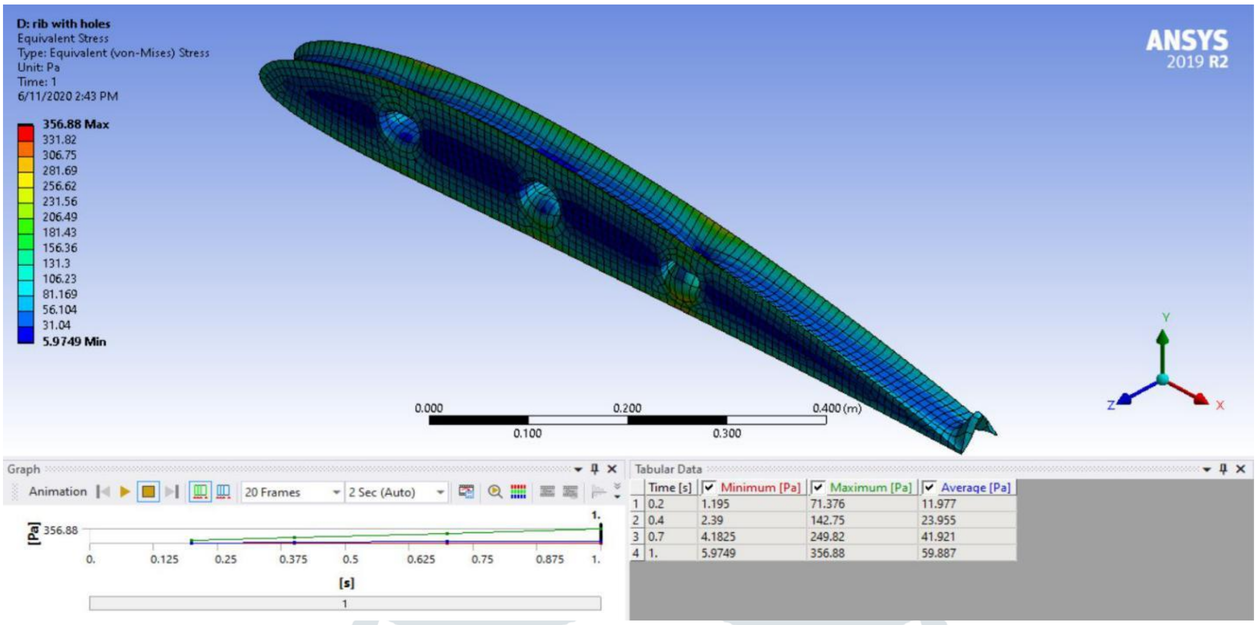

Figure 7: Analysis of Wing rib design with 3 holes

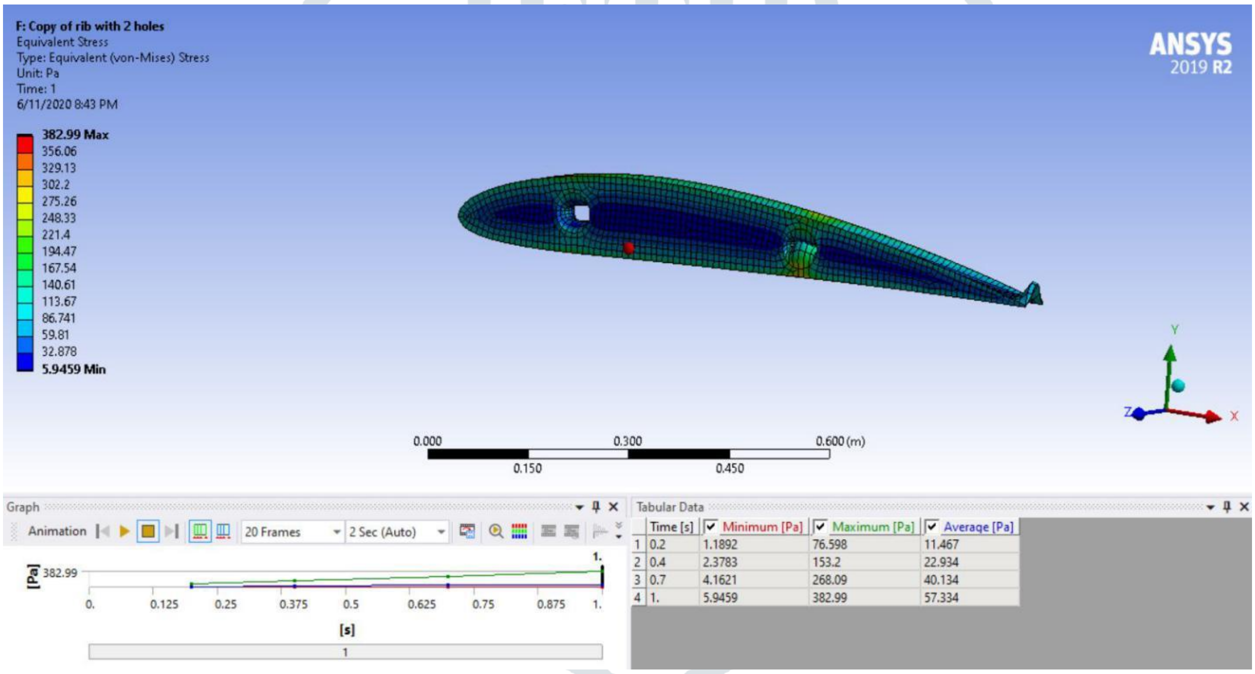

Figure 8: Analysis of Wing rib design with 2 holes

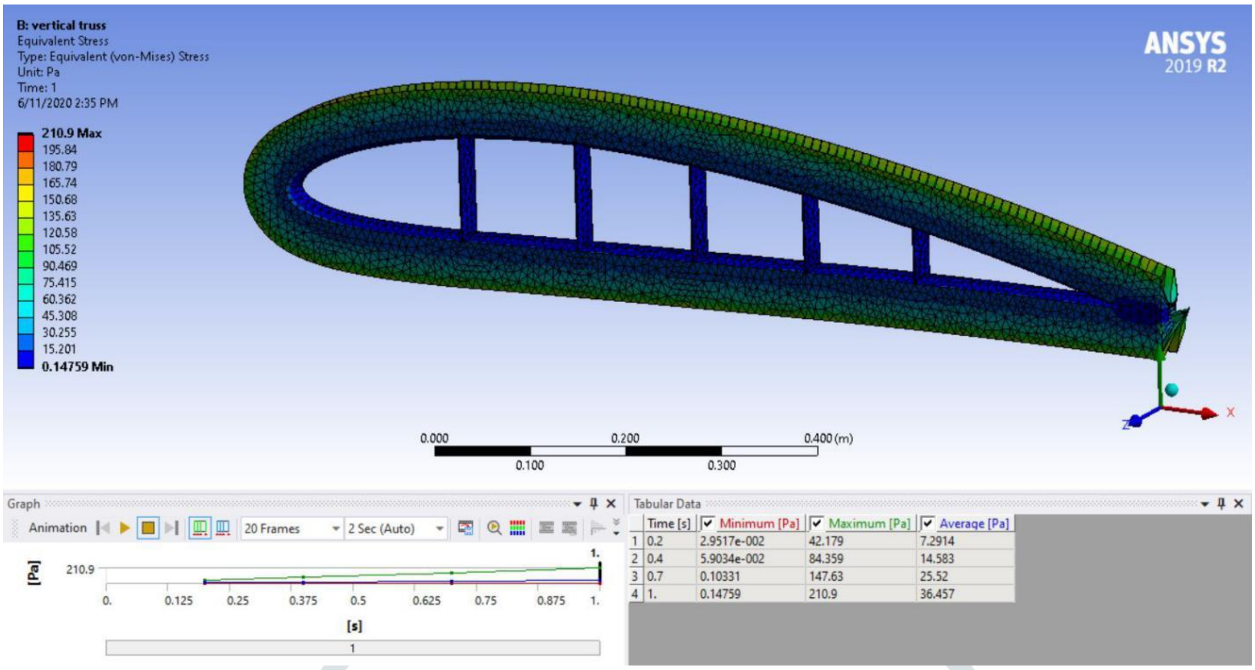

Figure 9: Analysis of Wing rib design with vertical strips

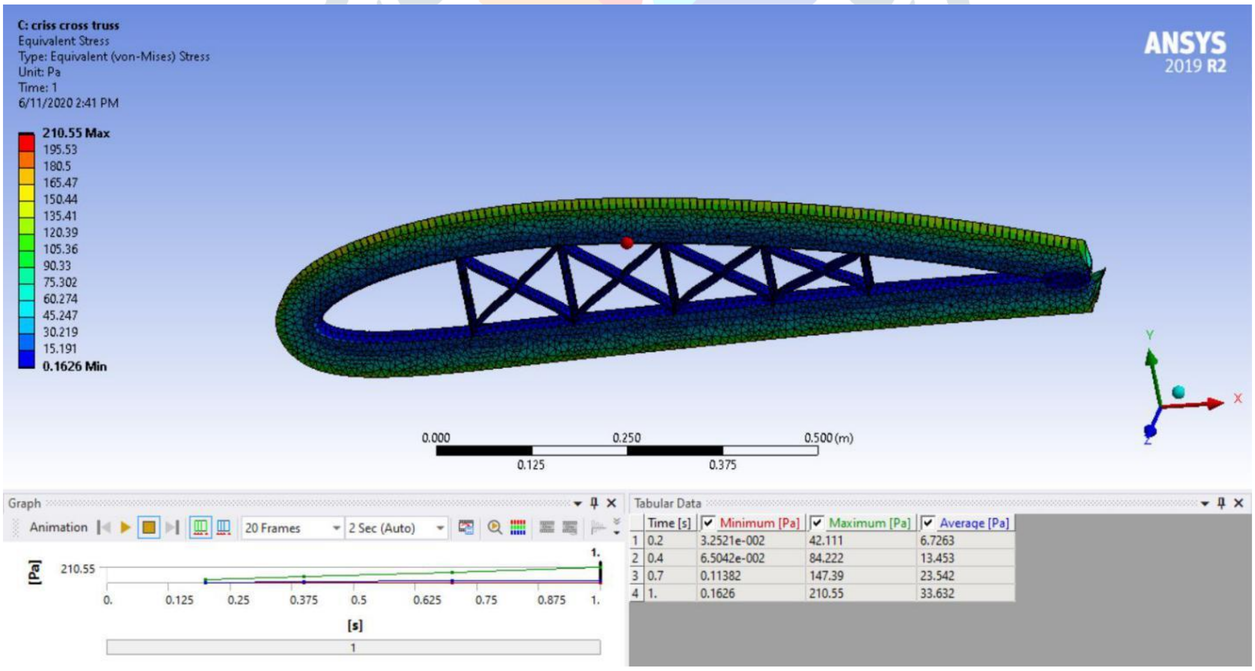

Figure 10: Analysis of Wing rib design with criss cross

Type	Mass (Kg)	Min. Stress (Pa)	Max. Stress (Pa)
Solid Rib	11.89	4.98	365.3
Rib with 3 holes	10.71	5.975	356.88
Rib with 2 holes	11.08	5.946	382.99
Rib with vertical Strips	9.68	0.1476	210.9
Ribs with criss cross	10.6	0.1626	210.55

Conclusion:

From the study of above design and analysis Rib with vertical Strips and criss cross is experiencing less stress compare to other design. Ribs with criss cross may have developed less stress but compare to vertical strips it may not be that effective due to more mass and less space which can be used for storing more fuel etc. So, we can conclude that ribs with vertical strips is having better performance than other designs mentioned above.

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