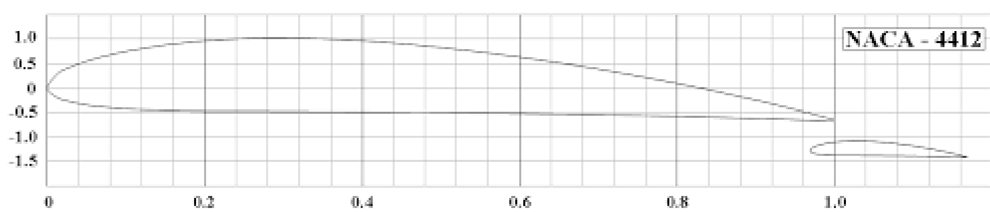
VIBRATION ANALYSIS OF WING

Data of NACA 4412 Airfoil

X_axis	Y_upper	Y_lower
1	0	0
0.95	0.0147	-0.0016
0.9	0.0271	-0.0022
0.8	0.0489	-0.0039
0.7	0.0669	-0.0065
0.6	0.0814	-0.01
0.5	0.0919	-0.014
0.4	0.098	-0.018
0.3	0.0976	-0.0226
0.25	0.0941	-0.025
0.2	0.088	-0.0274
0.15	0.0789	-0.0288
0.1	0.0659	-0.0286
0.075	0.0576	-0.0274
0.05	0.0473	-0.0249
0.025	0.0339	-0.0195
0.0125	0.0244	-0.0143



NACA4412

Numerical Analysis

CAD Modelling of Wing

The solid model of an aircraft wing was made using Ansys. First, The coordinate (X, Y) values of the airfoil were obtained from the UIUC airfoil site and imported to excel. Another column was added for Z-axisand the values were kept zero. That file was saved in the format text document. Later, a curve was drawn in Ansys using the feature “Curve Through XYZ points” using that text file. Then, the curve was converted andthe proper dimension of the cord length was given. The extrude boss feature was used to make a 3D model shown in fig. below.

Fig: NACA 4412

Dimensions

Similar to the theoretical analysis, cord length and wing length are taken as 1m and 5m respectively.

Meshing

The unit cell size of a mesh is very important. The accuracy of the result of the experiment dependson the element size of the mesh. Finer element size enhances the precision of the result, but this requires higher computing power and consumes more time. As the total number of nodes increases with the increase of the total number of element size, the simulation requires solving all those points. Keeping the computing power of the computer used, the mesh was generated shown in fig.Solid 187 was used as an element. The number of elements was 45332 and the number of nodes was 81494.

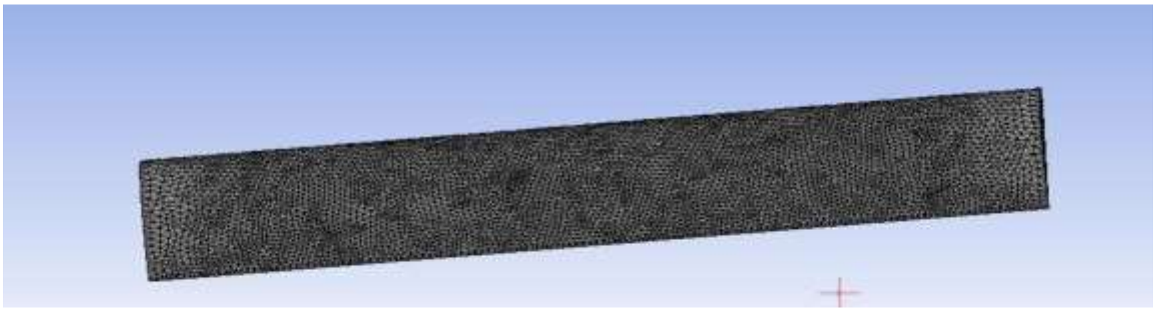


Fig: Zoom view of mesh element

Boundary Conditions

At the Root of the wing, frictionless fixed support was given similar to a cantilever beam. Frictionless support places a normal constraint on the entire surface.

Material

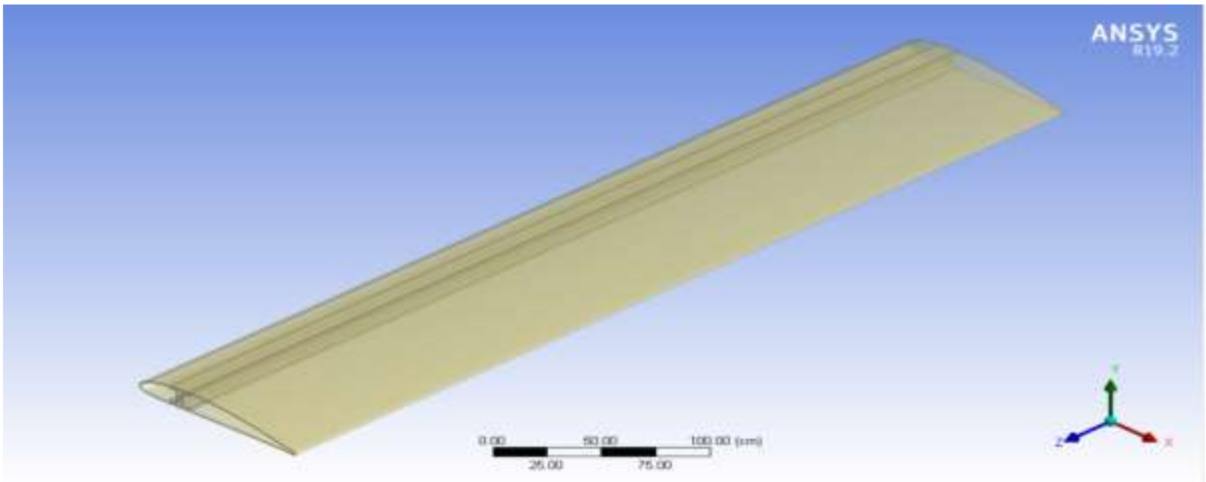
The material selected for this study was Aluminum Alloy 6061

Material properties of Aluminum Alloy 6061

Properties	Values
Young's Modulus	69 GPa
Poisson's Ratio	0.33
Tensile Strength: Ultimate (UTS)	310 MPa
Thermal Conductivity	167 W/m-K
Density	2700 kg/m^3

OUR MODEL STUDY CONFIGURATION

In this fig. our course of study wing has 5 m span with 1cm thickness of skin. Its having chord of 1m. Here , we use I-shaped single spar .We may use C- shaped as well. Through this wing we are trying to study affect on natural frequency and deformation we get with different spacing placement of ribs. With spar keeping it fixed at c/4 we use 4 ribs of thickness 10cm each and relocate at different positions. In case 1, we use linear spacing between ribs of distance 1.53 m . In case 2, we use GP of common ratio 1.229. In case 3, we use golden ratio. In case 4, we use Fibonacci .



LINEAR CONFIGURATION:
Here we have considered distance between two ribs constant
D1=D2=D3=(500-40)/3=153.33cm

GEOMETRIC PROGRESSION:
In this case we have considered the distance between ribs increasing by a factor of r
r+r^2+r^3=500cm-40cm
From here
D1=122.9cm
D2=151.04cm
D3=185.63cm

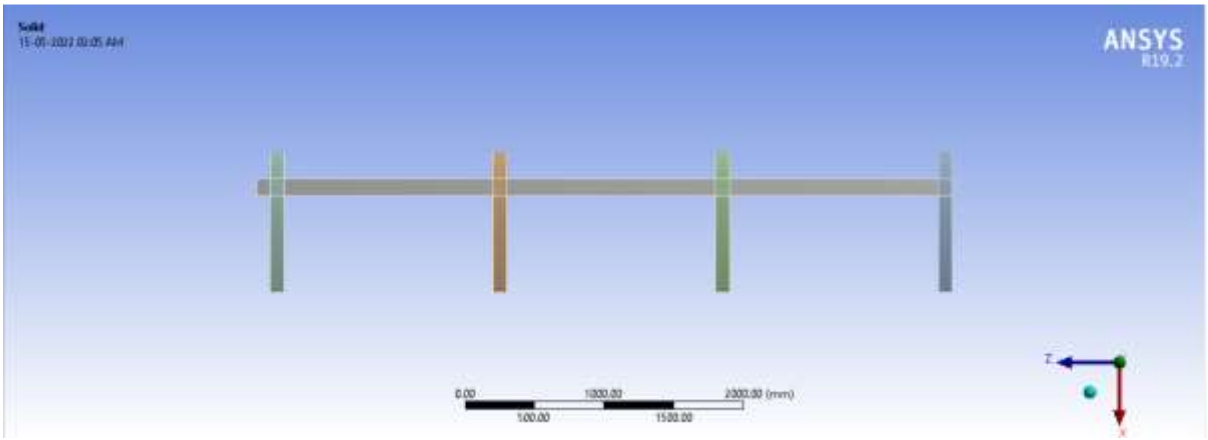
GOLDEN RATIO:
In this case we have considered common ratio 1.6
x+1.6x+1.6*1.6*x=500cm-40cm
From here we got
D1=89.84cm
D2=143.74cm
D3=229.99cm

FIBONACCI:
D1=x
D2=x
D3=2x
So we have

X =460/4=115cm
From here we got-D1=115cm;D2=115cm;D3=230cm

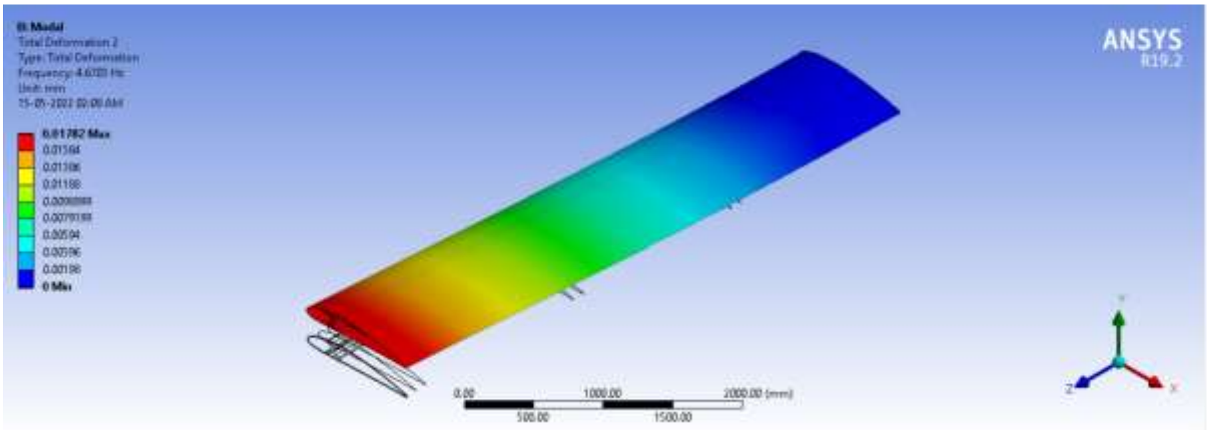
Different Ribs Spacing

1.Linear



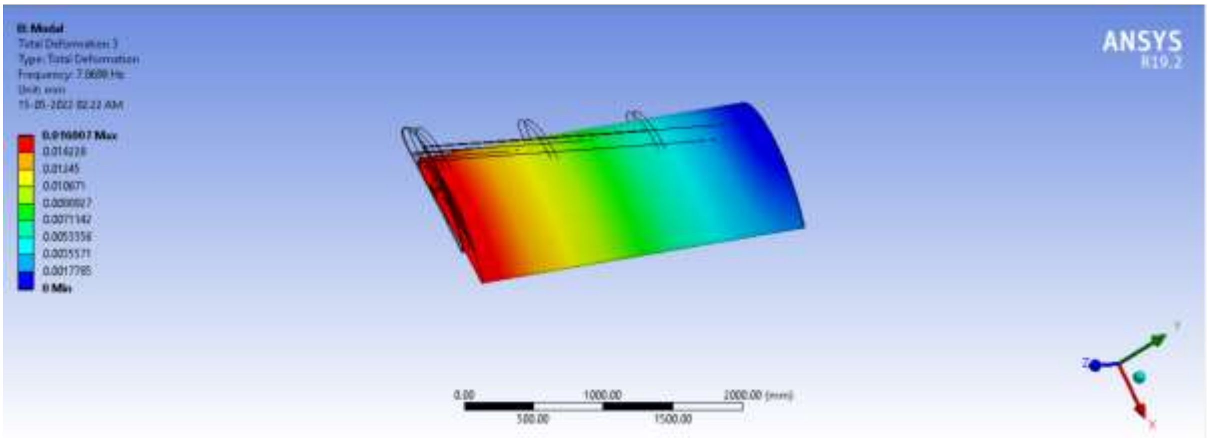
Deformation 1

Fig. shown here represents the total displacement of the wing structure at the first nodal displacement, in which at one ends the deformation is maximum highlighted in red colour and the blue colour denotes the minimum deformation occurs due to frequency of the aircraft wing while flying in the sky.



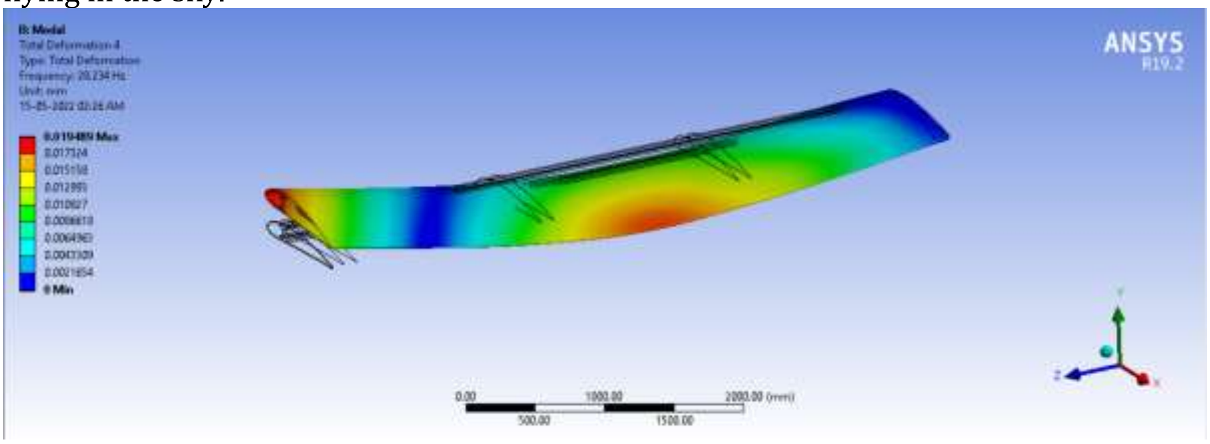
Deformation 2

Fig. shown here represents the total displacement of the wing structure at the second nodal displacement, in which at one ends the deformation is maximum highlighted in red colour and the blue colour denotes the minimum deformation occurs due to frequency of the aircraft wing while flying in the sky.



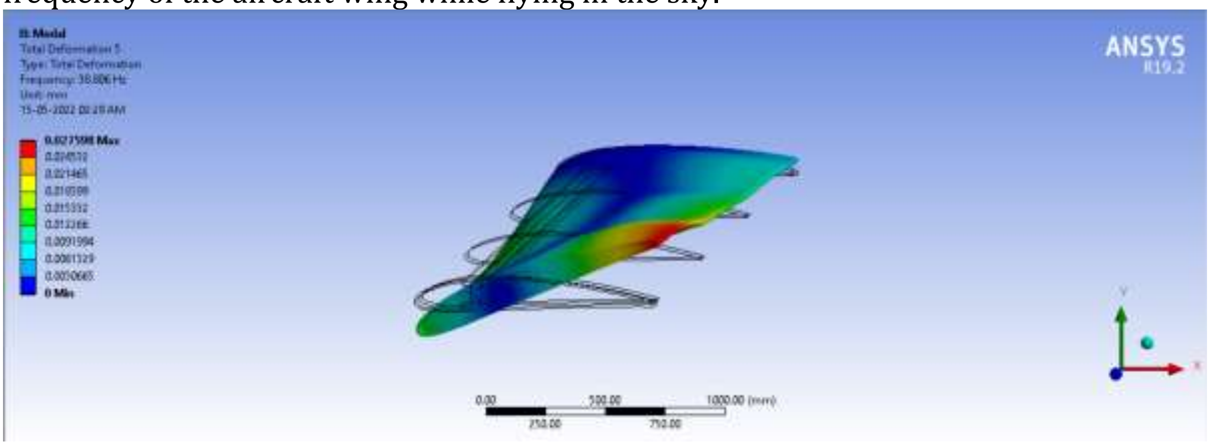
Deformation 3

Fig. shown here represents the total displacement of the wing structure at the third nodal displacement, in which at the end the deformation is maximum highlighted in red colour and the blue colour denotes the minimum deformation occurs due to frequency of the aircraft wing while flying in the sky.



Deformation 4

Fig. shown here represents the total displacement of the wing structure at the fourth nodal displacement, and it depicts torsional vibration. The end the deformation is maximum highlighted in red colour and the blue colour denotes the minimum deformation occurs due to frequency of the aircraft wing while flying in the sky.



Deformation 5

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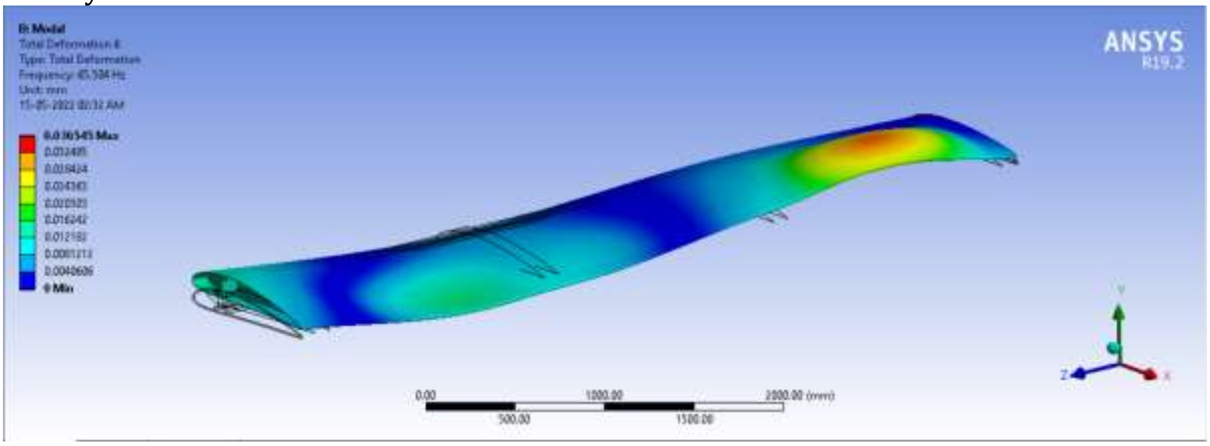
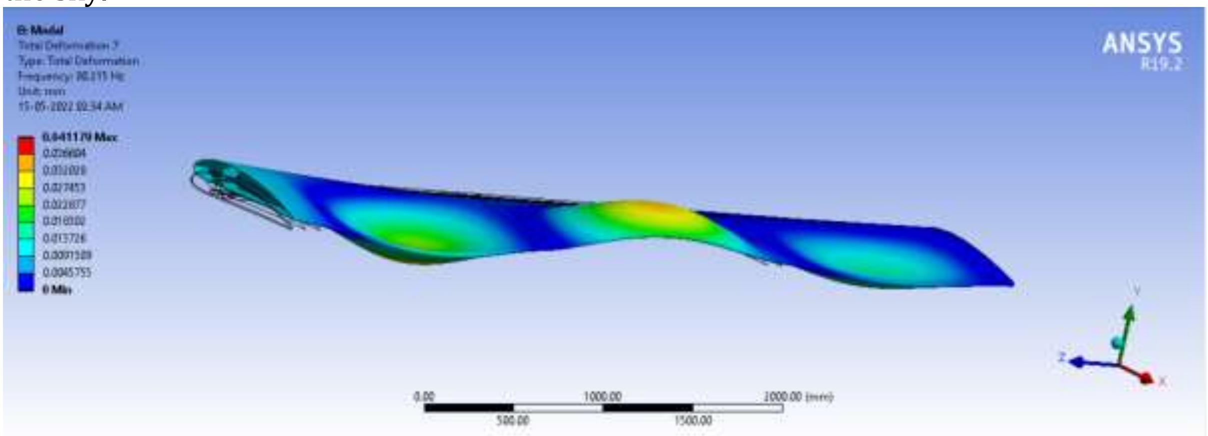


Deformation 6

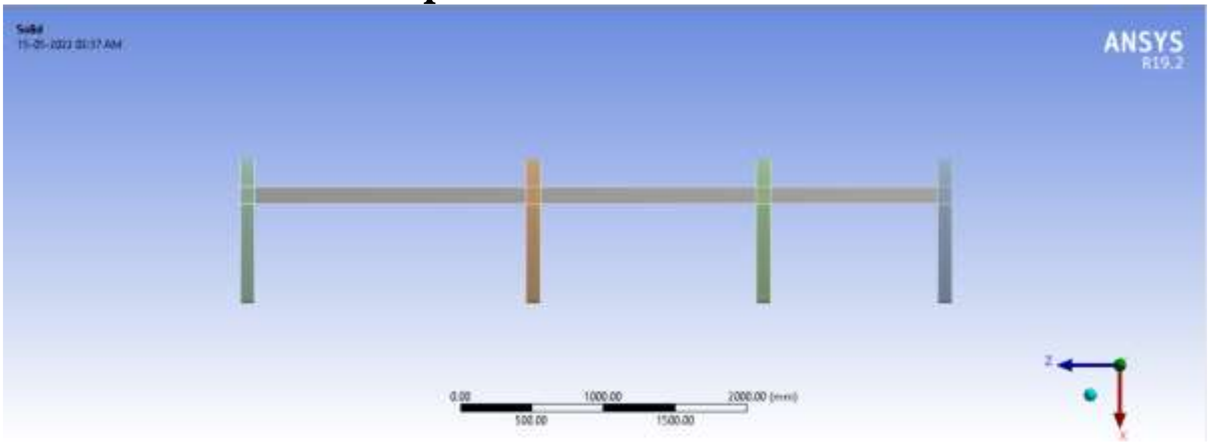
Fig. shown here represents the total displacement of the wing structure at the sixth nodal displacement. The end the deformation is maximum highlighted in red colour and the blue colour denotes the minimum deformation occurs due to frequency of the aircraft wing while flying in the sky.



Total deformation of the wing structure according to its nodal displacement as shown in the table.

Mode	Max. Deformation	Min. Deformation	Frequency(Hz)
1	0.01782	0.0	4.6703
2	0.016007	0.0	7.8698
3	0.019489	0.0	28.234
4	0.027598	0.0	38.806
5	0.036545	0.0	65.504
6	0.041179	0.0	80.215

2. Geometric Proportion



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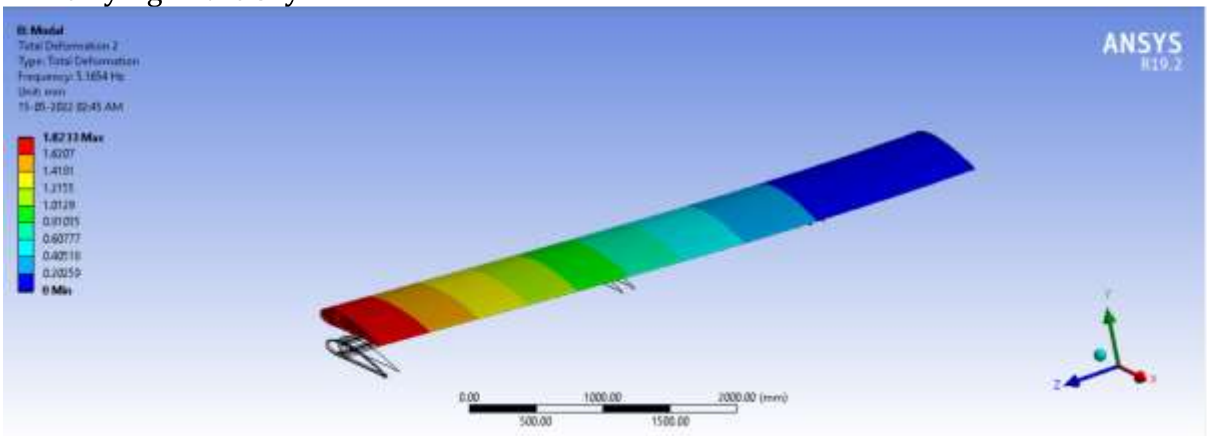

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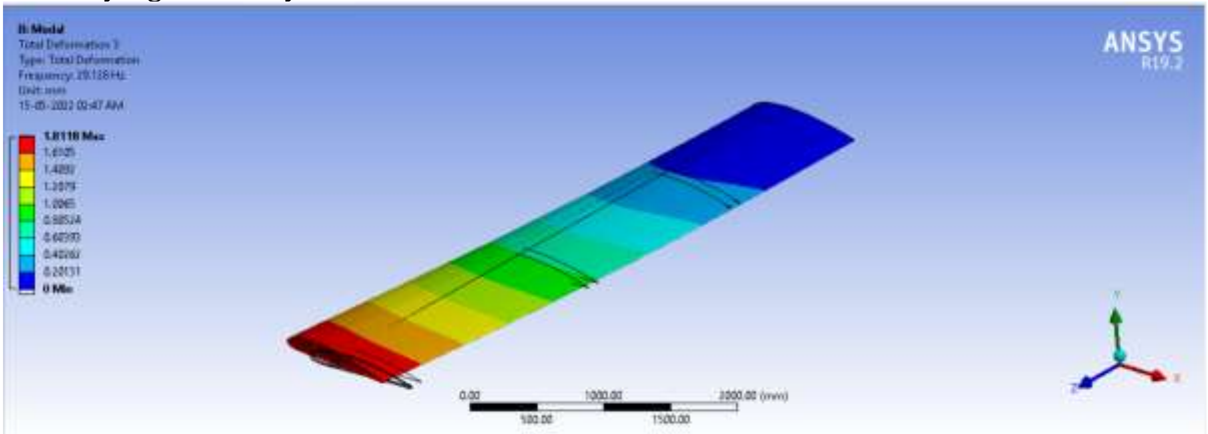

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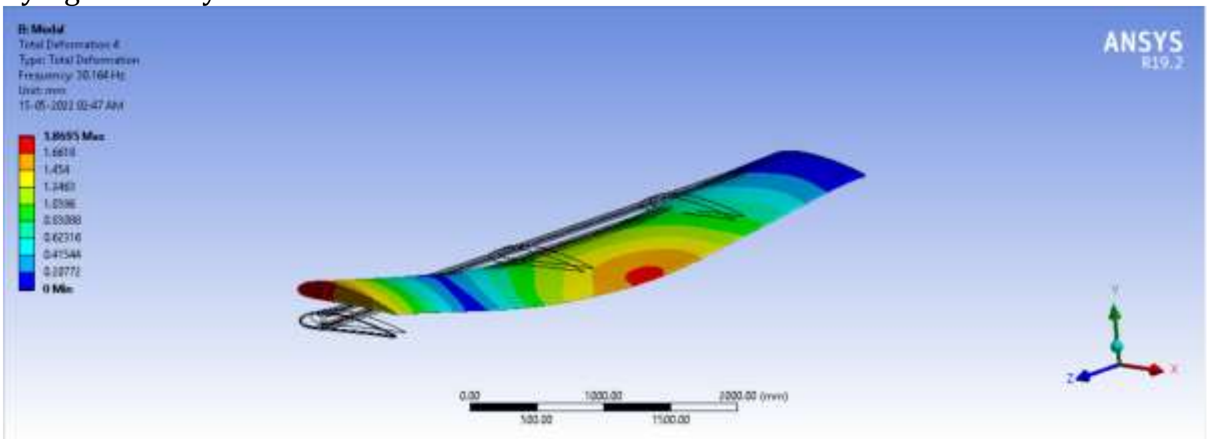

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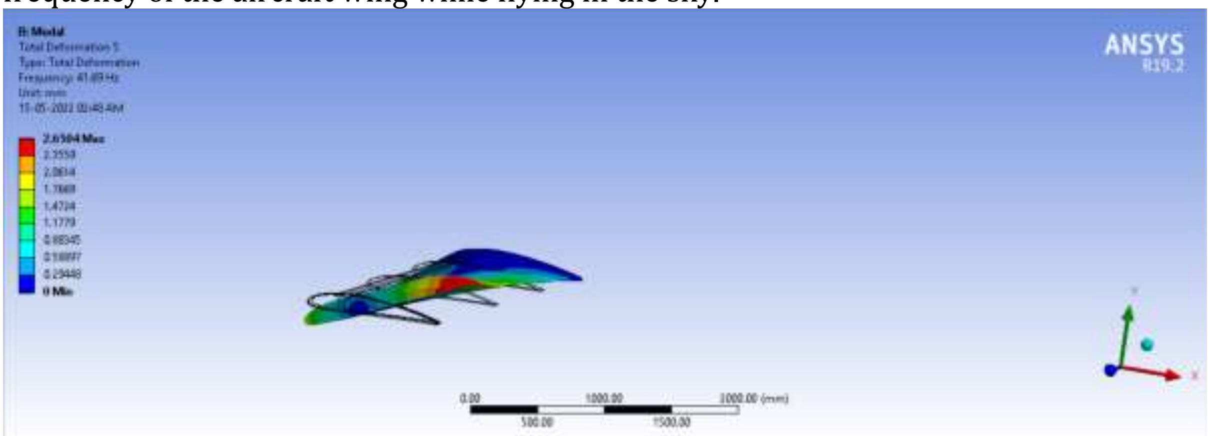

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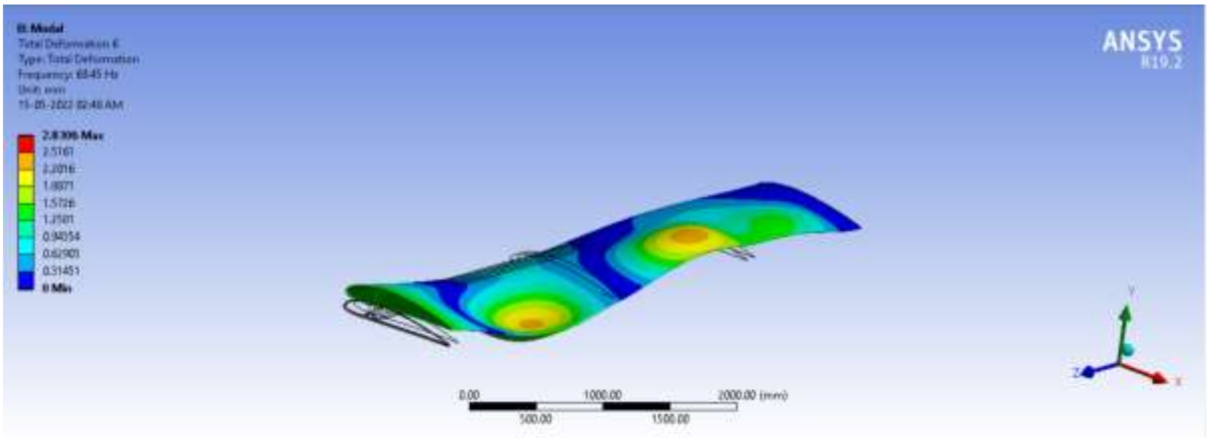

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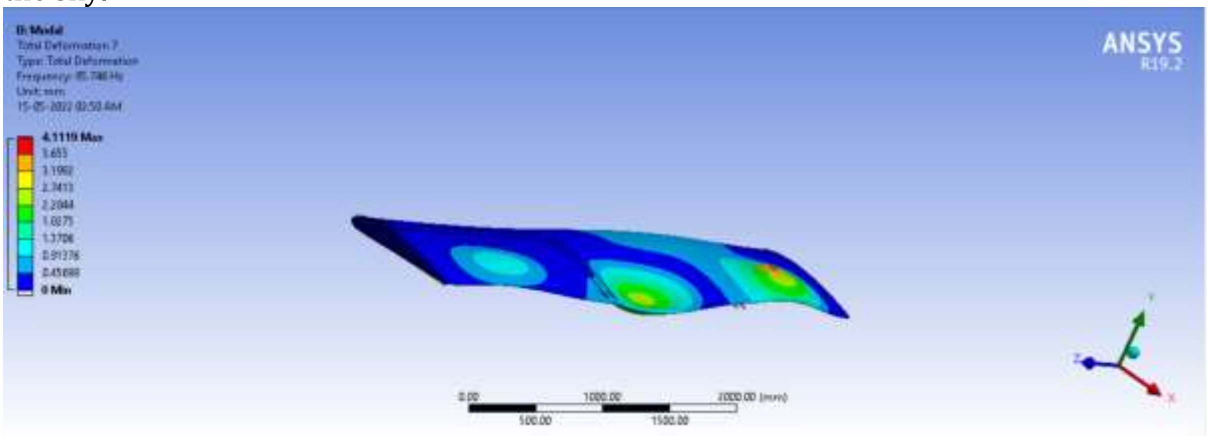
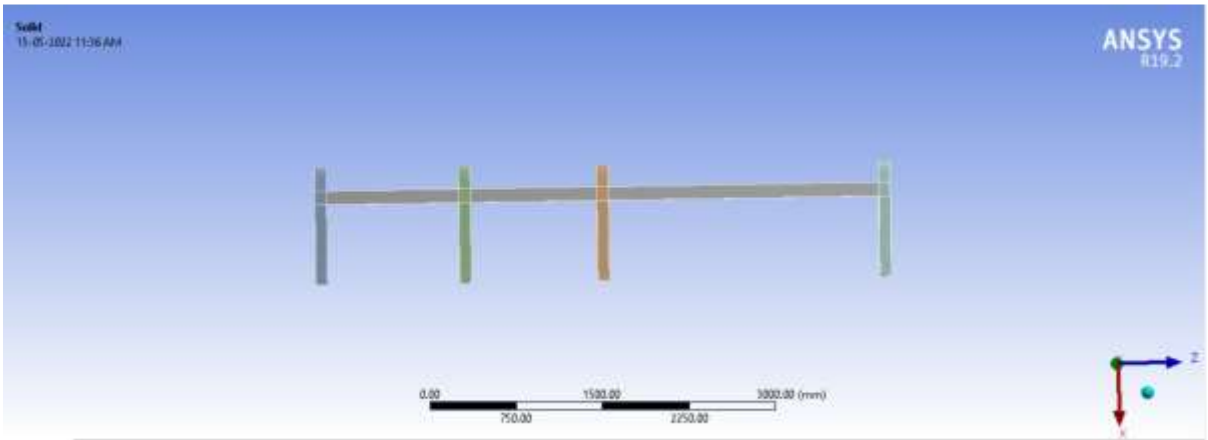


Mode	Max. Deformation	Min. Deformation	Frequency(Hz)
1	1.8233	0.0	5.1654
2	1.8118	0.0	29.128
3	1.8695	0.0	30.164
4	2.6504	0.0	41.69
5	2.8306	0.0	69.45
6	4.1119	0.0	85.746

3. Golden Ratio



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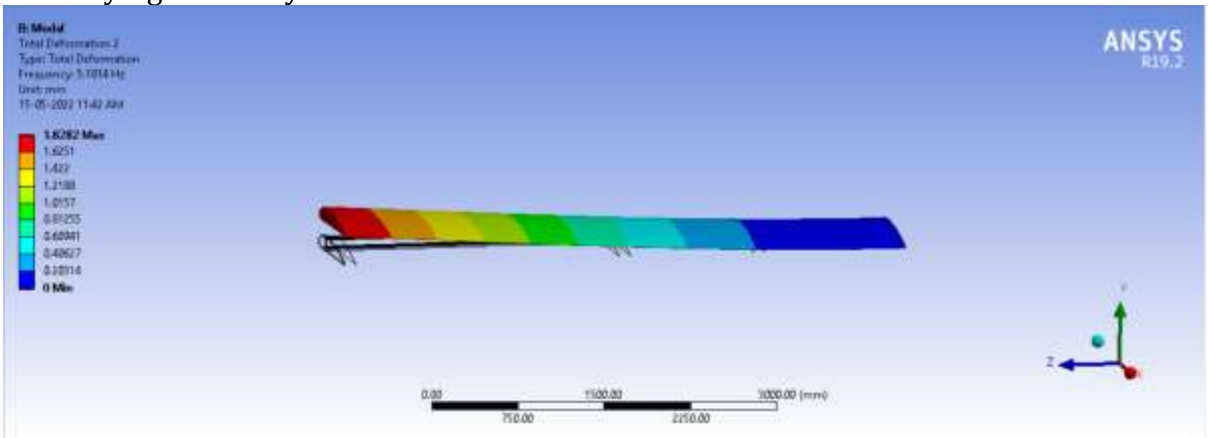

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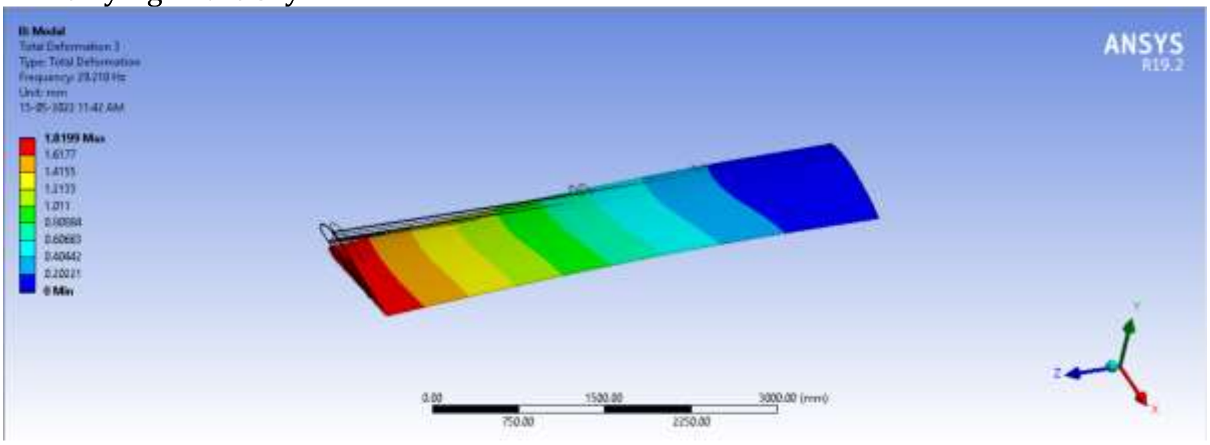

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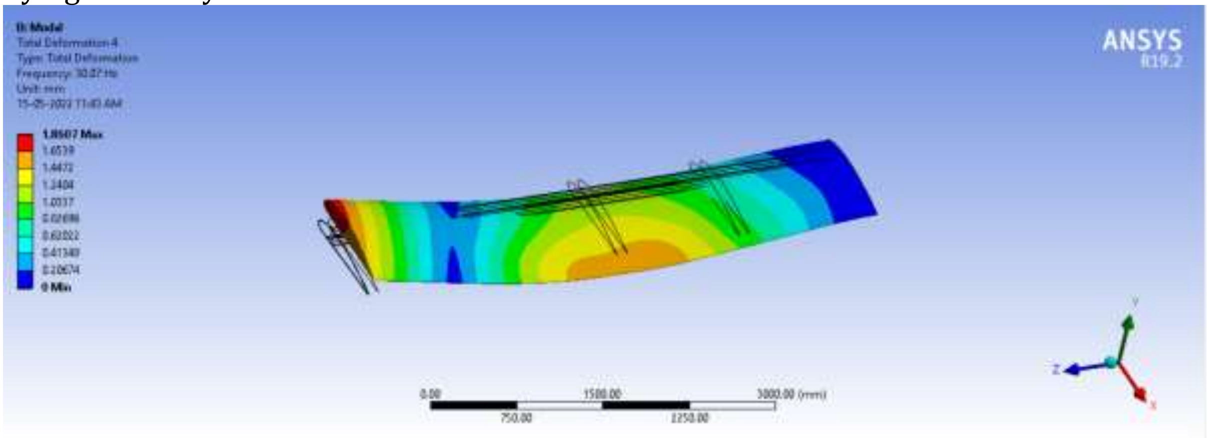

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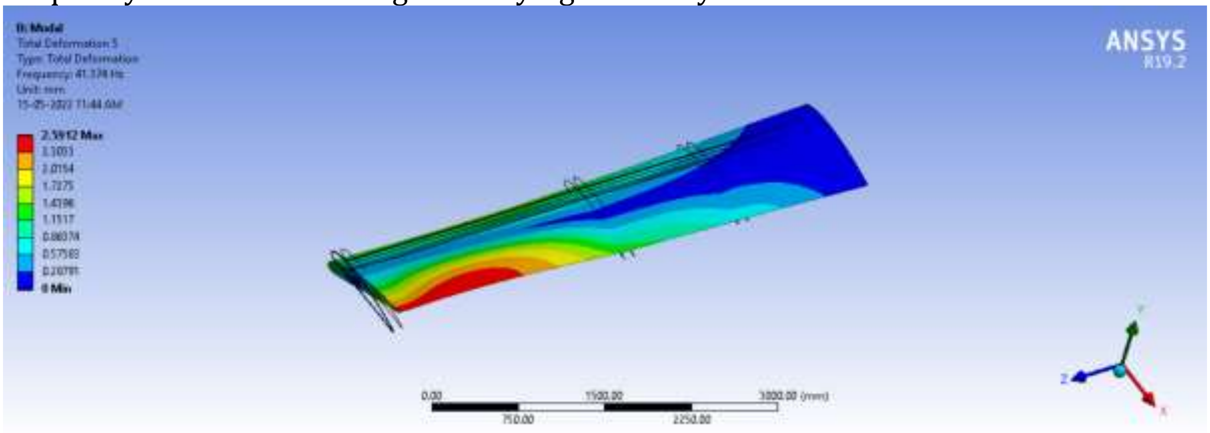

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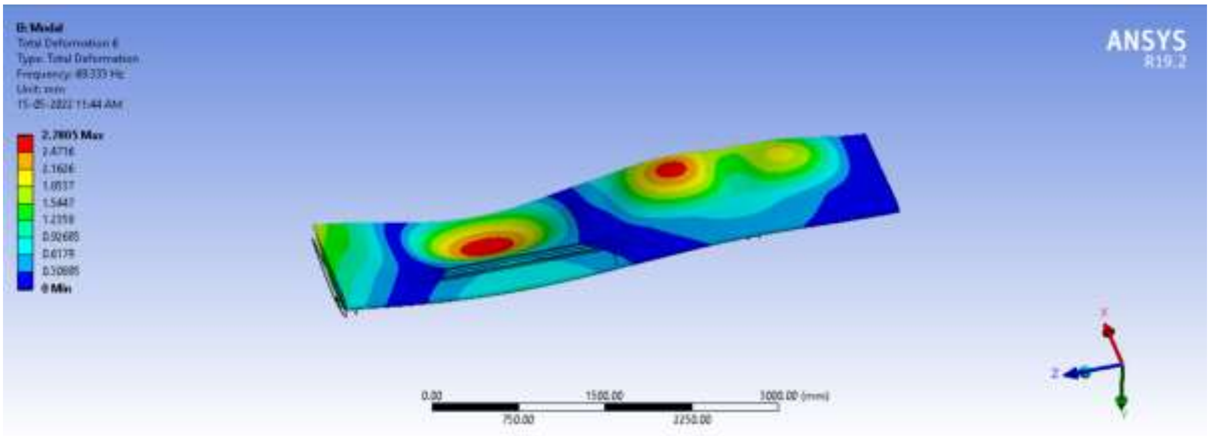

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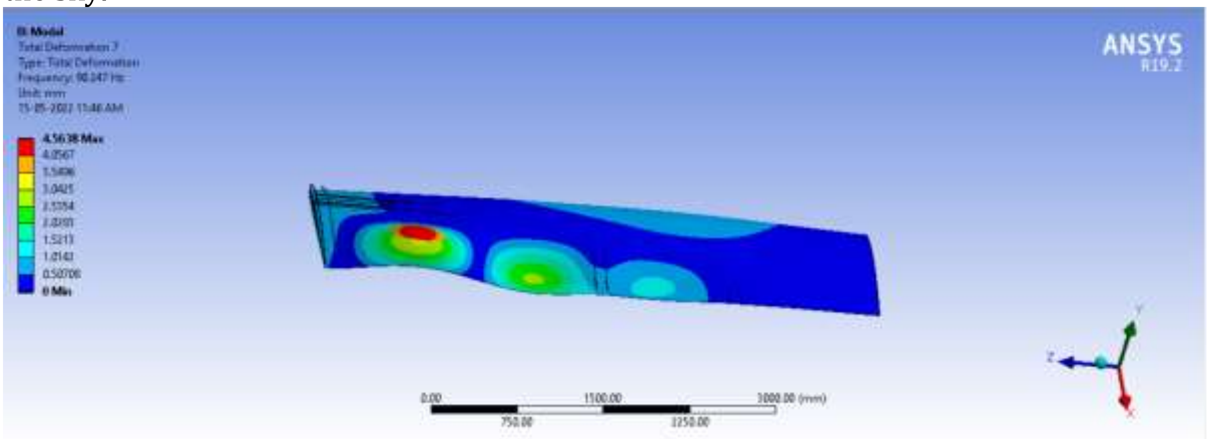
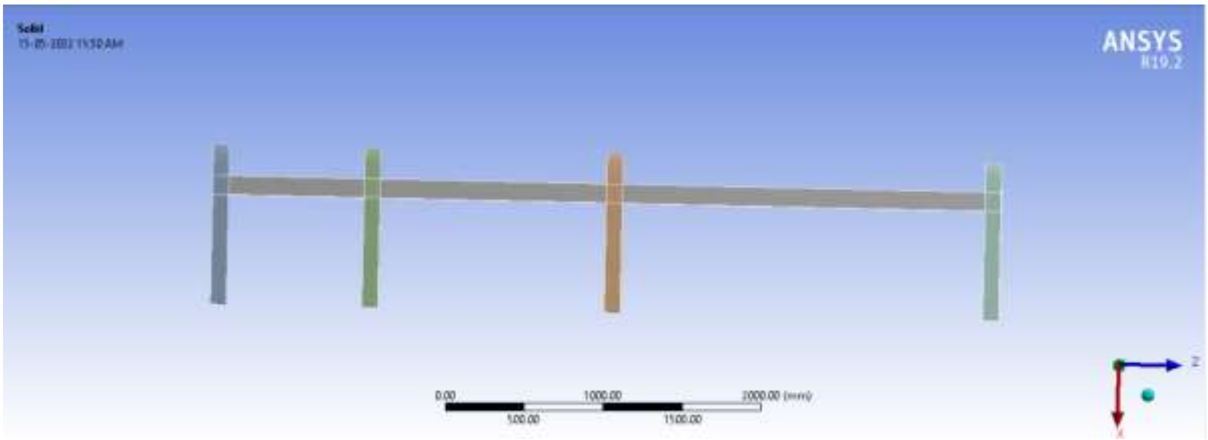


Total deformation of the wing structure according to its nodal displacement as shown in the table.

Mode	Max. Deformation	Min. Deformation	Frequency(Hz)
1	1.8228	0.0	5.1814
2	1.8199	0.0	29.218
3	1.8607	0.0	30.07
4	2.5912	0.0	41.374
5	2.7805	0.0	69.333
6	4.5638	0.0	90.247

4. Fibonacci



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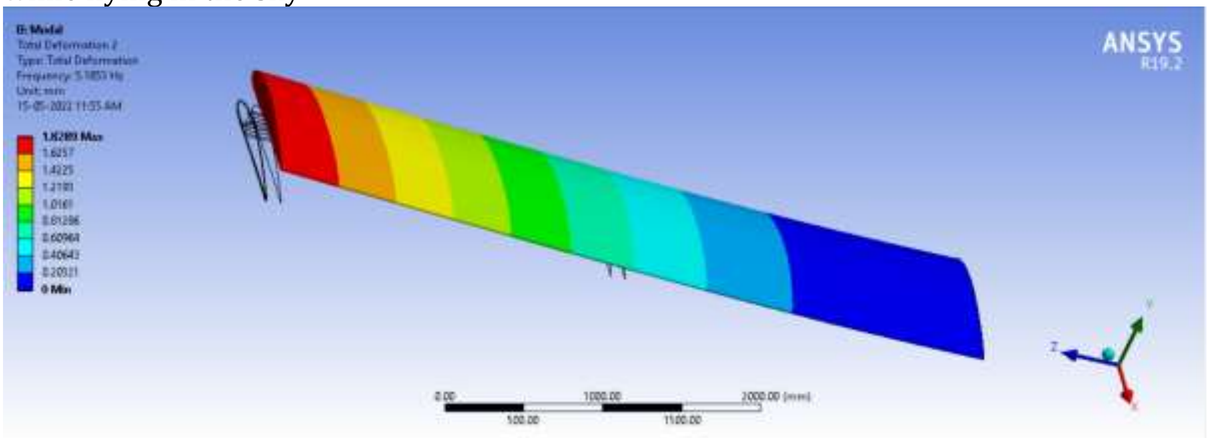

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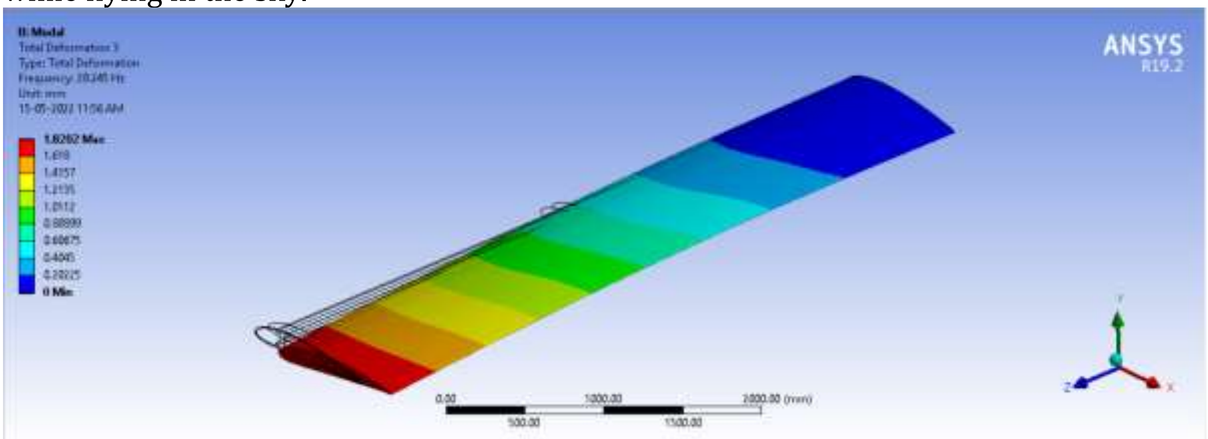

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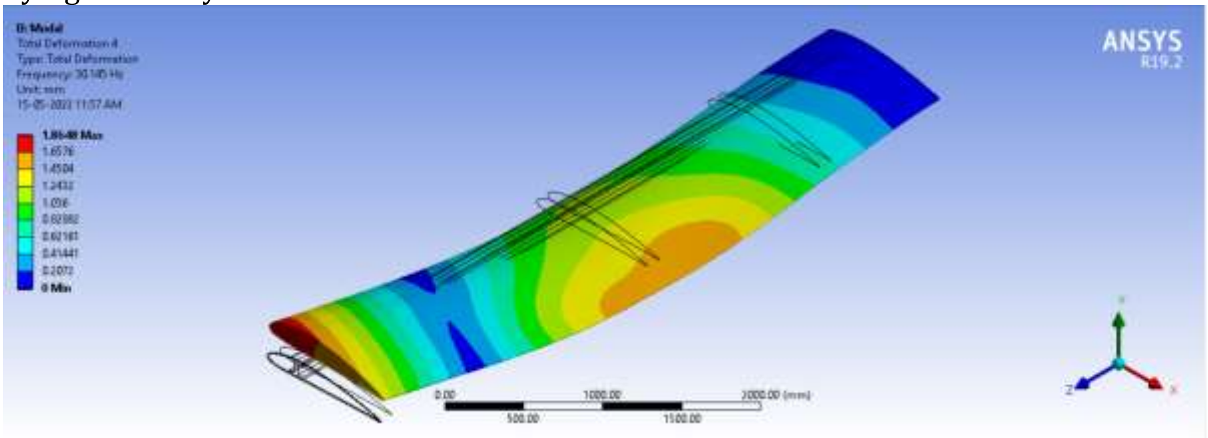

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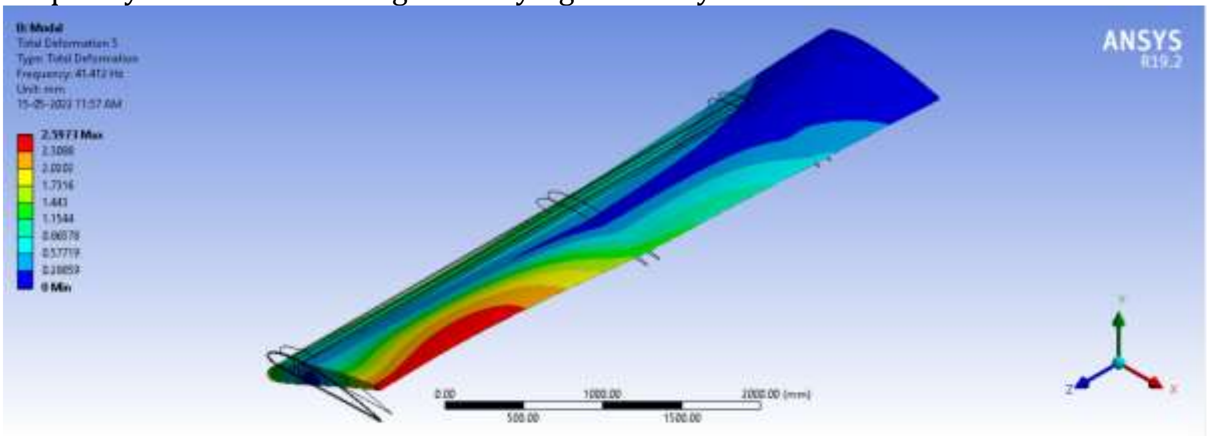

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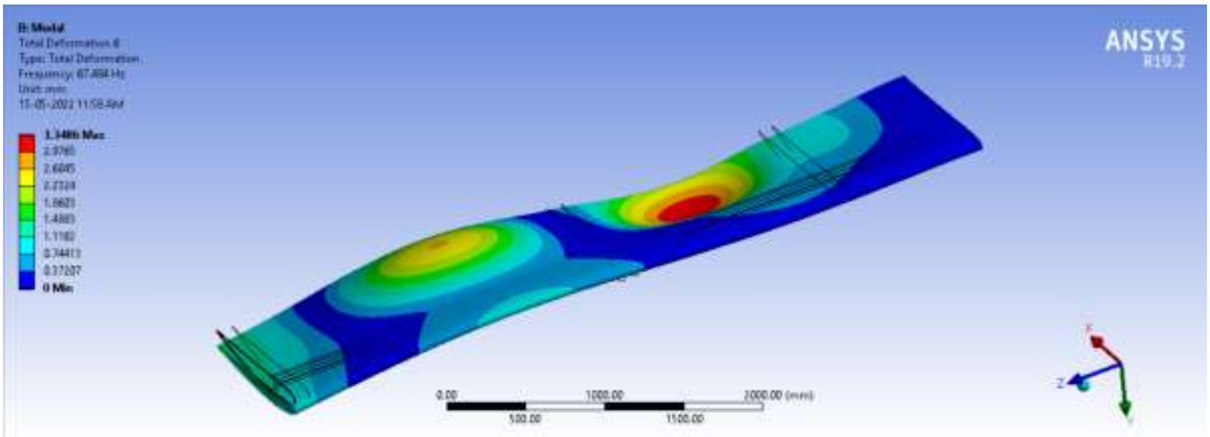

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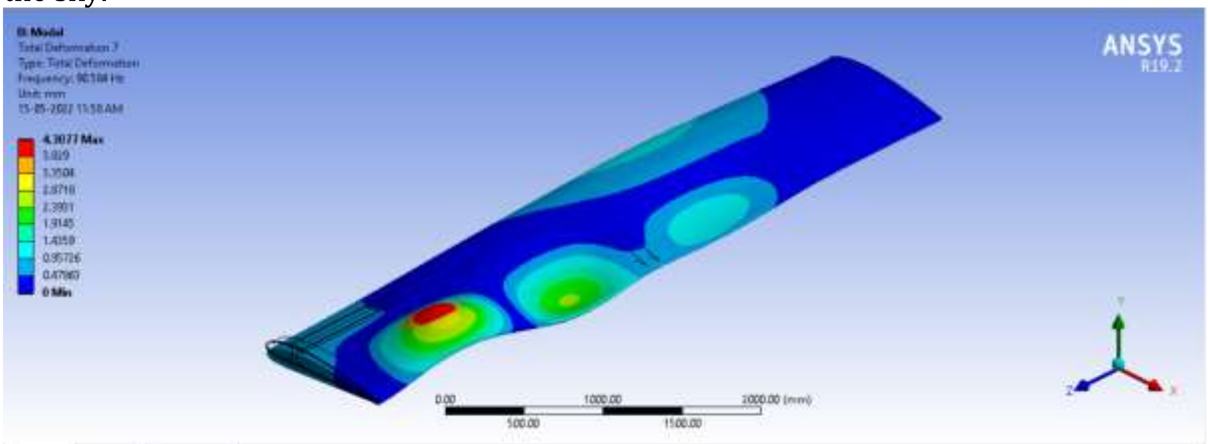
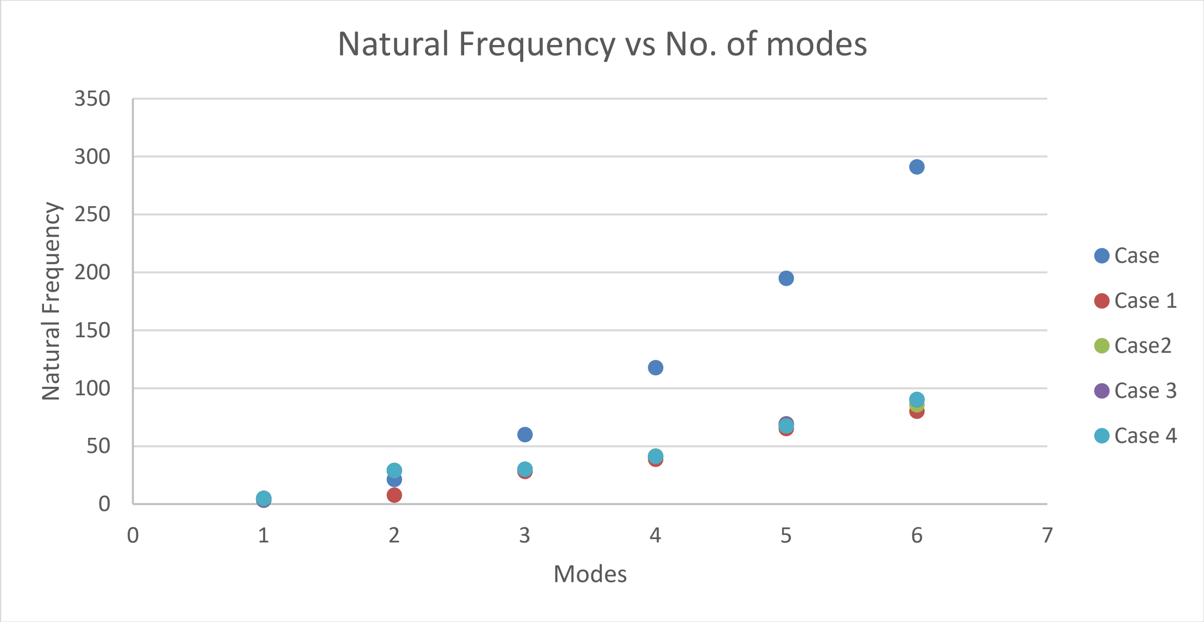


Total deformation of the wing structure according to its nodal displacement as shown in the table.

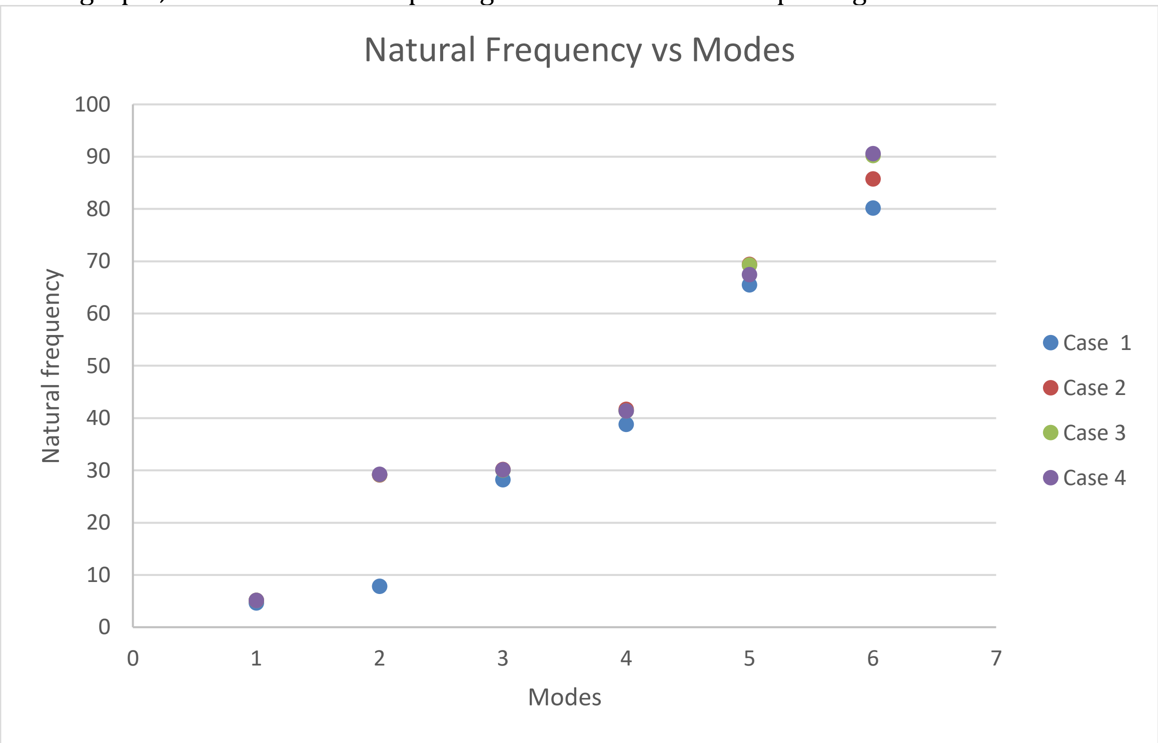
Mode	Max. Deformation	Min. Deformation	Frequency(Hz)
1	1.8289	0.0	5.1853
2	1.8202	0.0	29.245
3	1.8648	0.0	30.145
4	2.5973	0.0	41.412
5	3.3486	0.0	67.484
6	4.3077	0.0	90.584

Comparison of Results of deformation

In this graph, the first line shows clear exponential curve type shape .This is the case of our study on beam .Else are frequency of different cases on wings. We find here all the cases nearly same natural frequency with case i.e. linear spacing one least frequency.



In the graph , different curves depicting different cases of ribs placing discussed above.



In this graph, blue one depicting the linear case while all other are g.p. , golden ratio and fibonacci cases.