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Comparative Modal Analysis on Different Aircraft Wing Models

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ABSTRACT

This paper gives a brief description about Modal Analysis and how it is performed on two different Conventional aircraft wing models and also its comparative study is performed by considering the natural frequency into account. In order the structure is stable and to know the flexibility of the model the model is tested at different mode shapes enlarging its capabilities by presenting different motions with different deflections. The modal analysis presented in this study highlights the structural stability of the wing.

Keywords: Modal Analysis, Natural frequency, Mode shapes

INTRODUCTION

Modal analysis is an analysis procedure used to study the dynamic behavior of structures under loading conditions [1]. It involves the determination of natural frequencies, mode shapes, and damping ratios of the structure[3]. In the context of a conventional aircraft wing, modal analysis can be used to understand the wing's vibration characteristics and identify potential failure modes.

It is essential to know the natural frequencies of the wing because if the wing is subjected to a load close to one of its natural frequencies [2], it can lead to resonance, which can cause excessive vibration and potentially damage the wing. In summary, modal analysis is a procedure that can be used to study the dynamic behavior of wings.

It can provide valuable insights into the vibration characteristics of the wing and can help to identify potential failure modes[1][3]. The modal analysis helps to reduce the noise emitted from the system to the environment. It helps to point out the reasons of vibrations that cause damage of the integrity of system components.

Using it, we can improve the overall performance of the system in certain operating conditions[8]. Modal analysis is performed on the wing for a total of 10 mode shapes, and corresponding frequency is obtained for each mode listed below.

The main agenda of this paper is to find out the corresponding frequency for different mode shapes ranging from 10 to 10, as a result the following procedure is followed: [6]

- Considering the design criteria of the wing & wing span.
- Design of the wing with the considered spanlength.
- Mesh of the wing.
- Solving the problem.

METHODOLOGY AND BOUNDARY CONDITIONS

Design

Airfoil models such as Eppler 171 and Selig S6062 are considered to identify the natural frequency[7]. Above mentioned airfoils are subjected to a span of 500mm in a designing software and its Modal analysis is performed in ANSYS 2022 R2 student version.

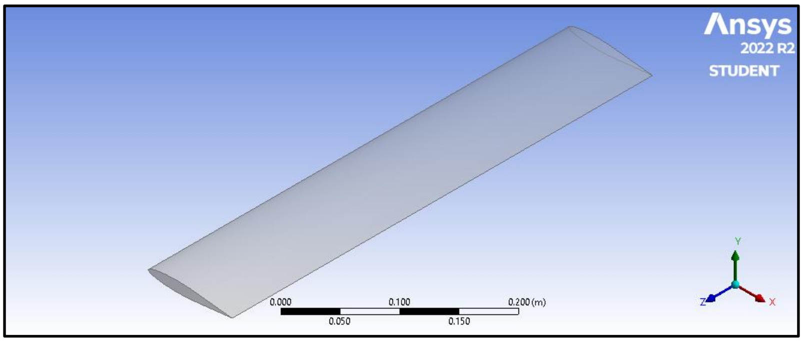


Fig. 1 Eppler 171 wing of span length 500mm.

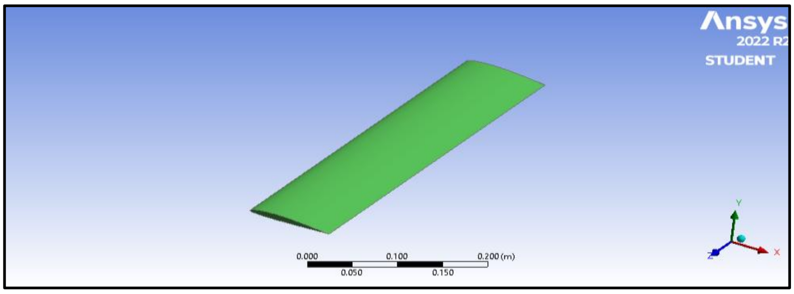


Fig. 2. Selig S6062 wing of span length 500mm

Material Considerations

Upon literature review, it is considered to use Aluminium alloy as a material. In the software the material is considered as Aluminium.[5][10]

Mesh Conditions

Both conventional aircraft wing models are meshed with a size as 10mm. Based on an iterative process various sizes are considered such as 20mm, 25mm, 30mm, based on all the results the 10mm mesh size is finalised because it produces a fine mesh.[9] The Eppler 171 wing produces fine mesh with the no of nodes as 4919 and no of element as 700 whereas the Selig S6062 wing produces fine mesh with the no of nodes as 2488 and no of element as 1066.

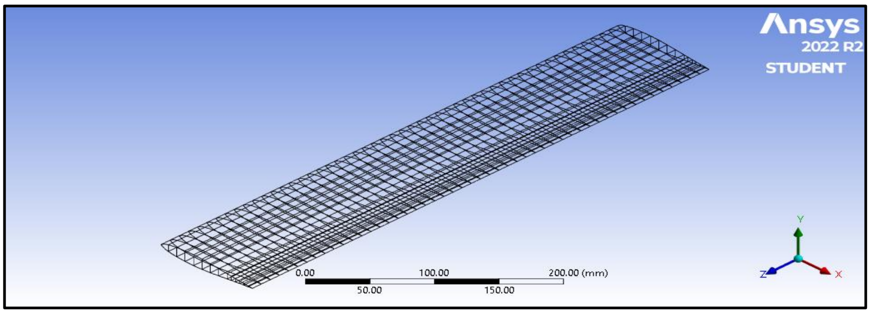


Fig. 3. Mesh on Eppler 171 wing.

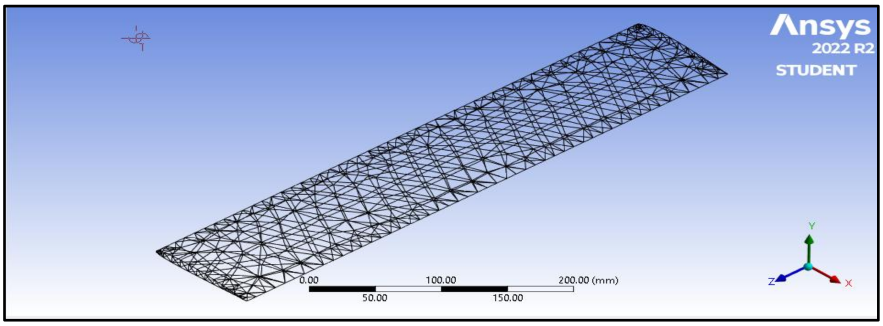


Fig. 4. Mesh on Selig S6062 wing.

The front side of the wing is considered as a fixed support and based on different mode shapes the wing will be deflected in different motions such as plunging, pitching, and twisting motions.[4]

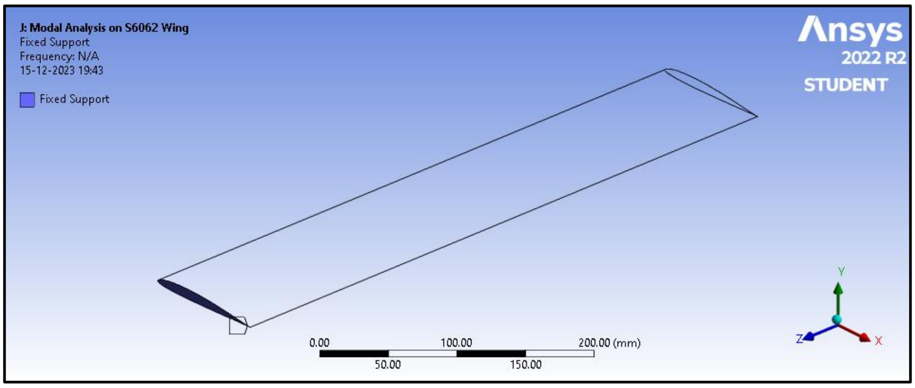
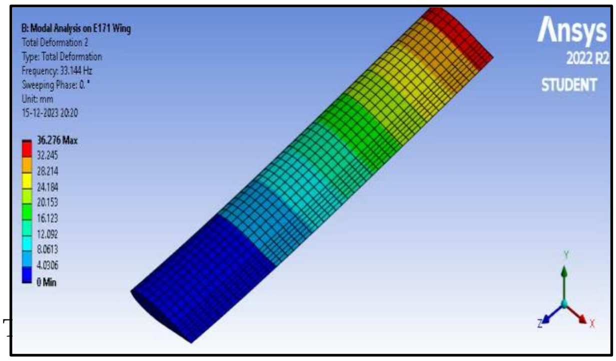


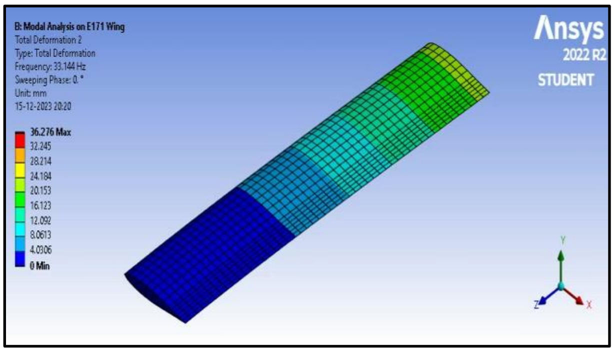
Fig. 5. Fixed support for Selig S6062 wing.

The wing is operated at a total of 10 mode shapes which produce different frequencies and deflections.

Eppler 171 Deflections at different timestamps:

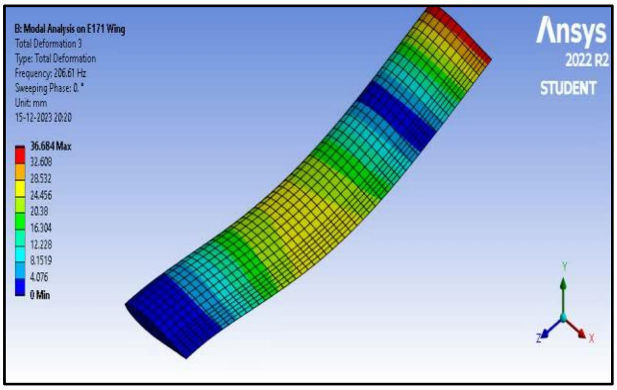
Mode 1



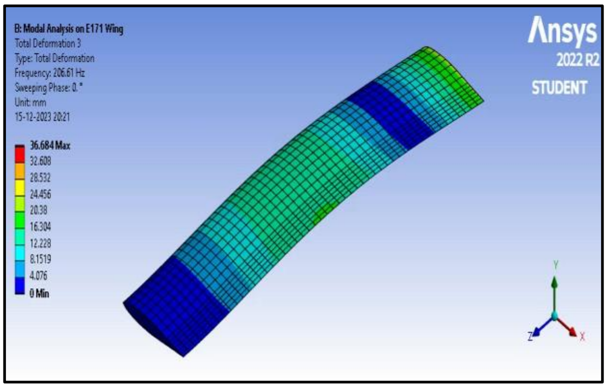


Time stamp 15

Mode shape – 02

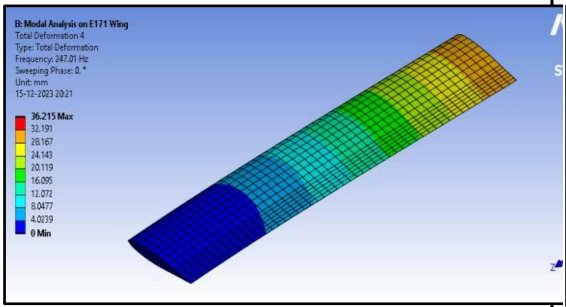


Time stamp 07

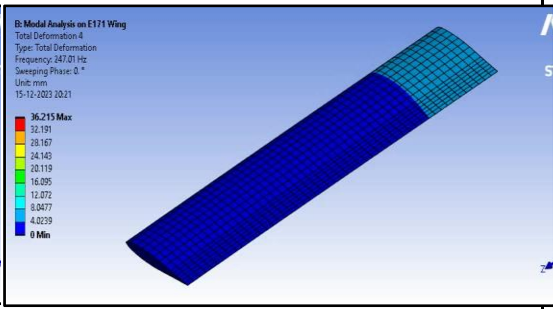


Time stamp 25

Mode shape – 03

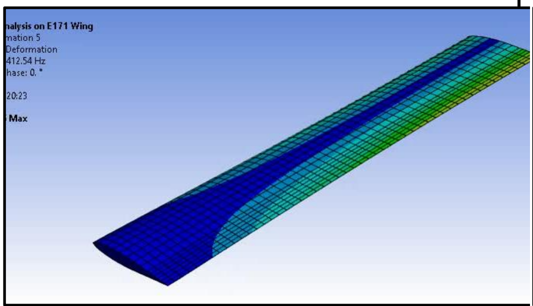


Time stamp 04



Time stamp 32

Mode shape – 04



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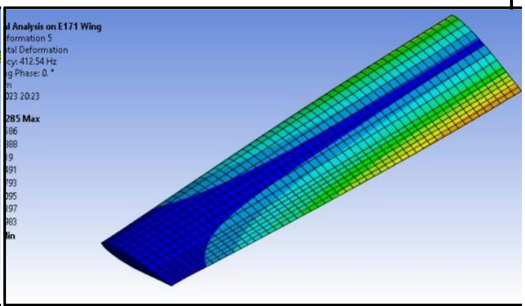
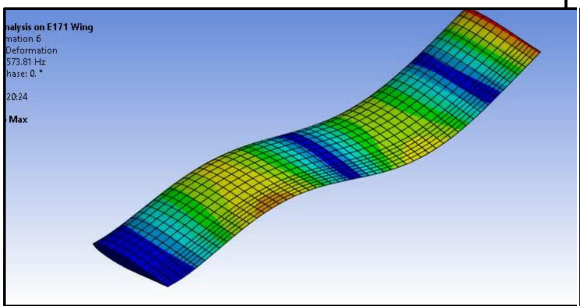


Time stamp 24

Mode shape – 05



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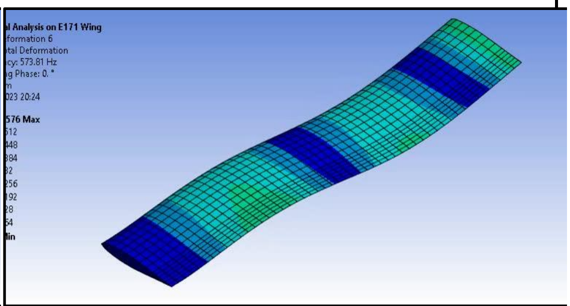

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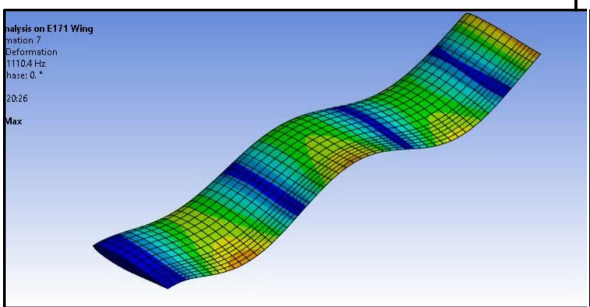
Mode shape – 06



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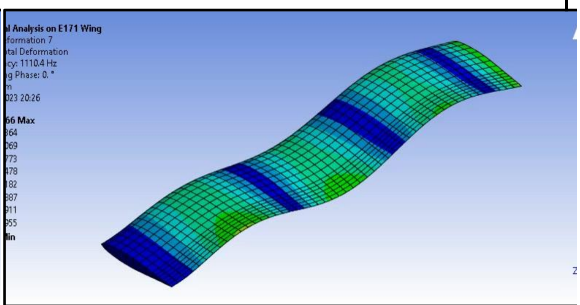

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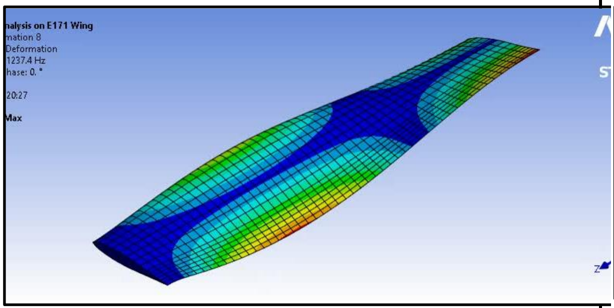
Mode shape – 07



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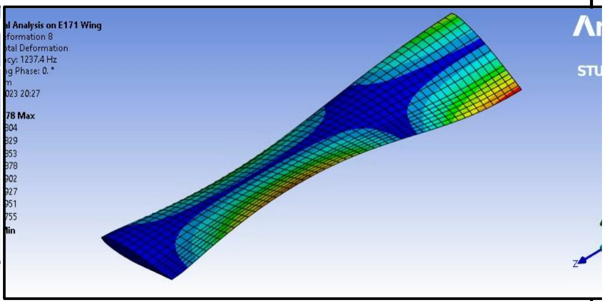
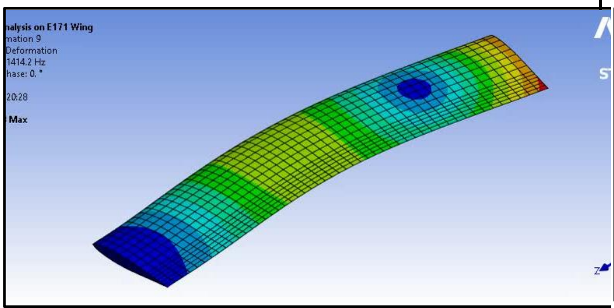


Time stamp 19

Mode shape – 08



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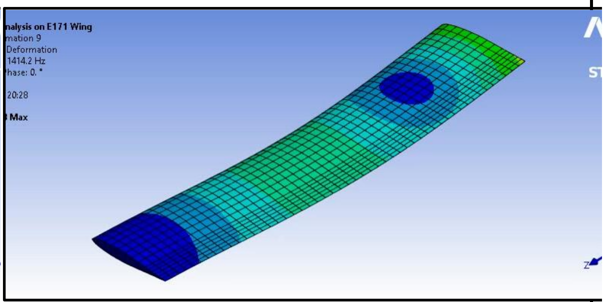
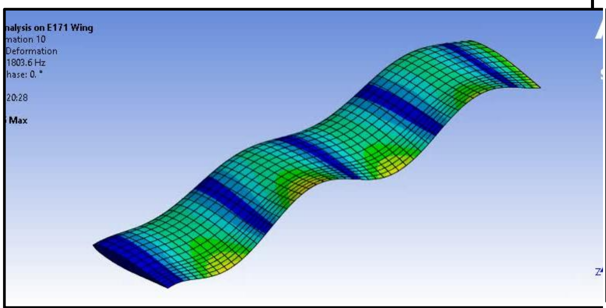


Time stamp 27

Mode shape – 09



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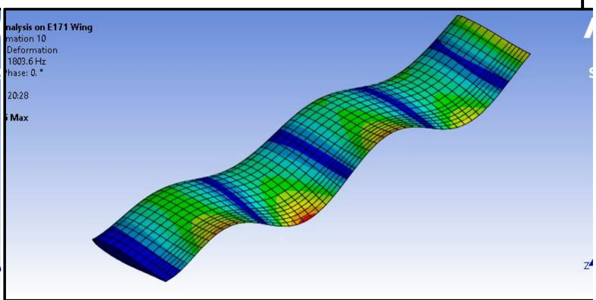
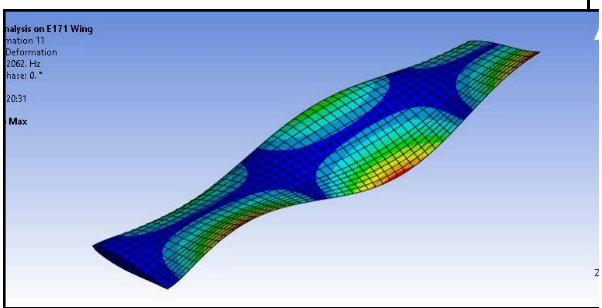
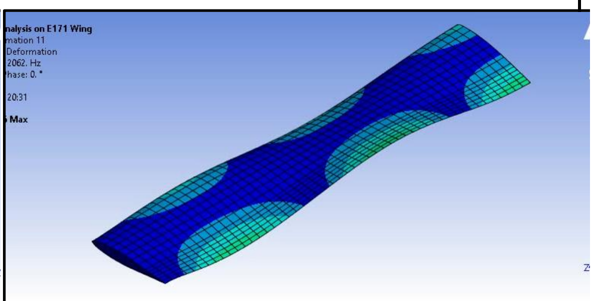


Time stamp 19

Mode shape – 10



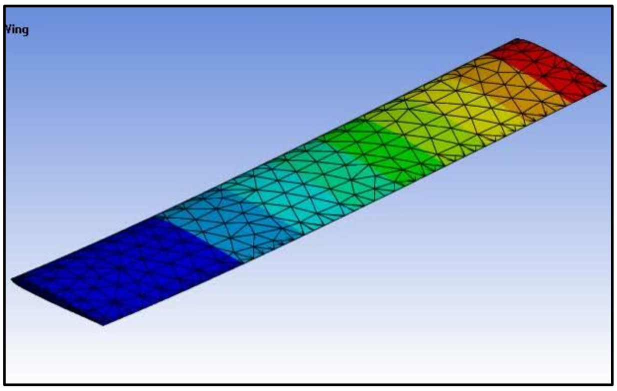
Time stamp 02



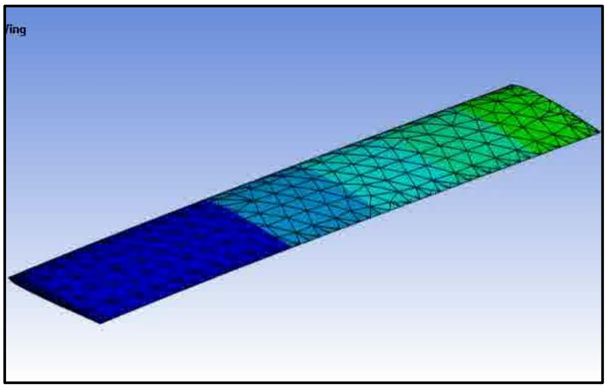
Time stamp 28

Selig 6062 Deflections at different time stamps:

Mode shape – 01

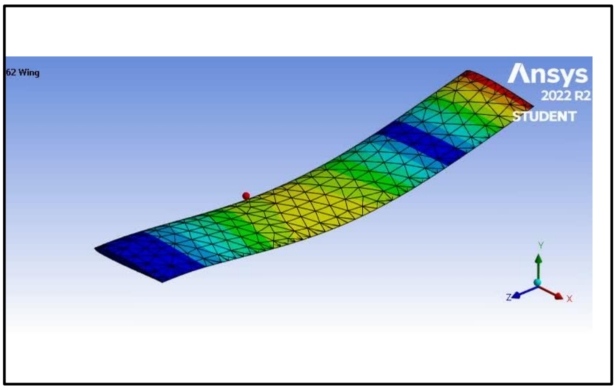


Time stamp 03



Time stamp 25

Mode shape – 02



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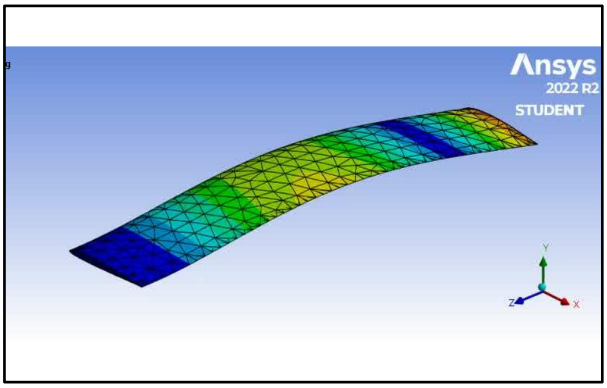

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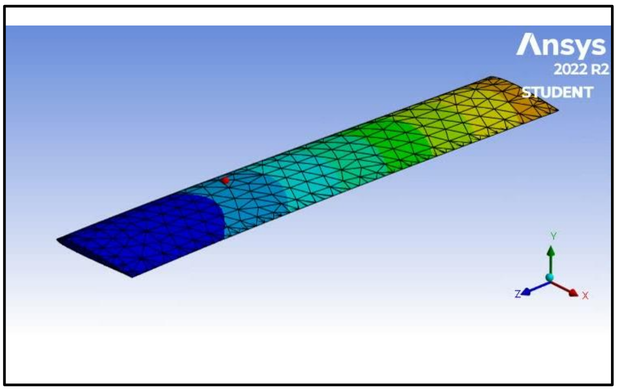
Mode shape – 03



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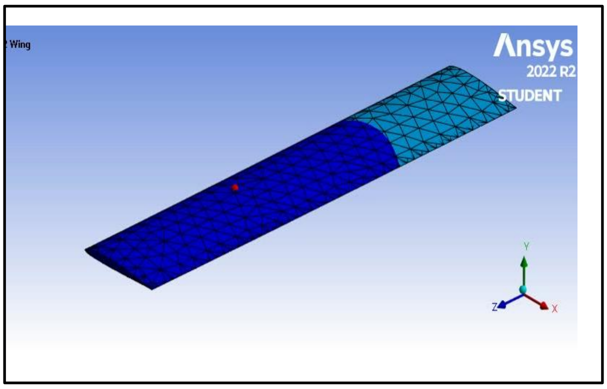
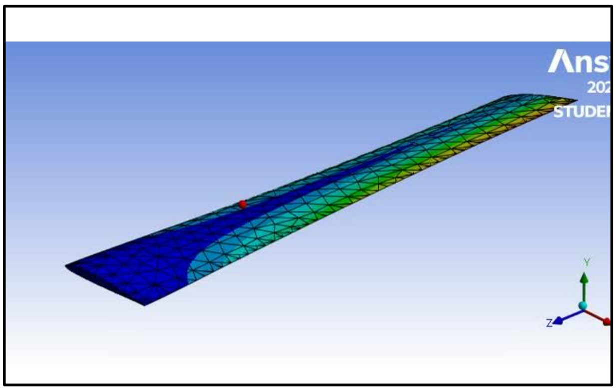


Time stamp 34

Mode shape – 04



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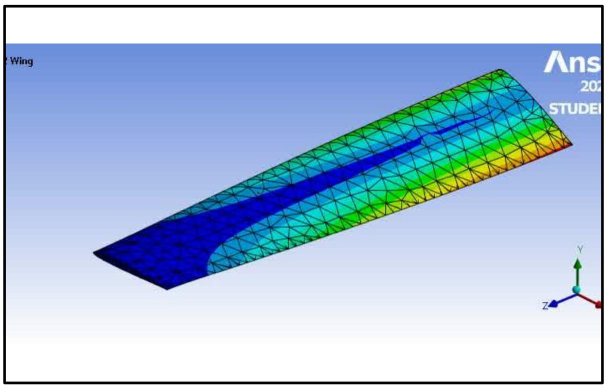
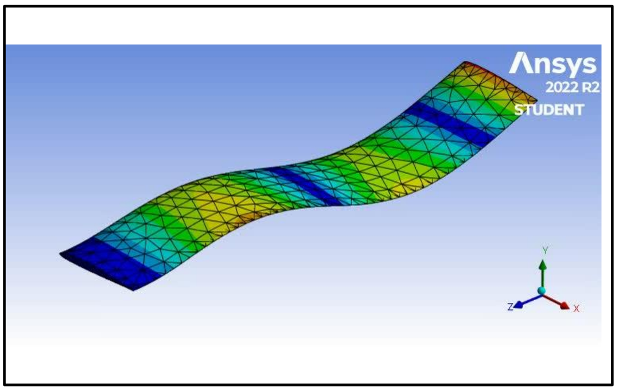


Time stamp 44

Mode shape – 05



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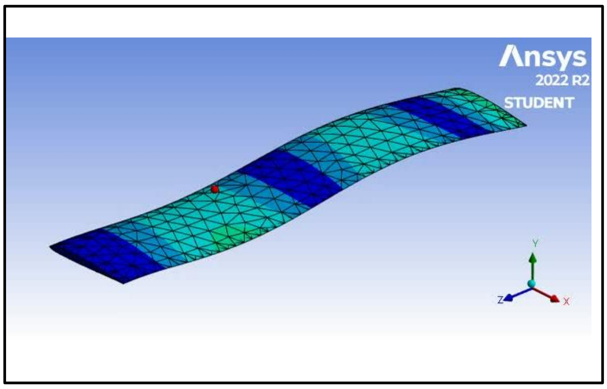

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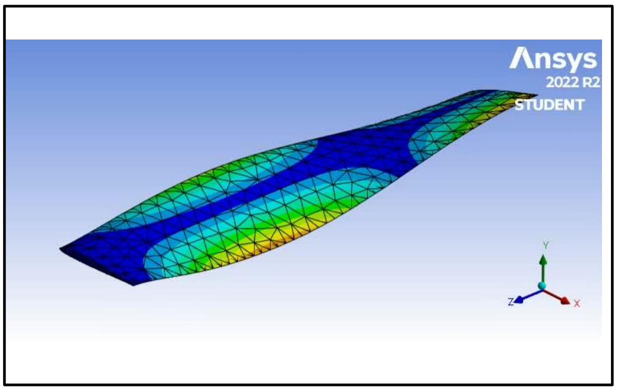
Mode shape – 06



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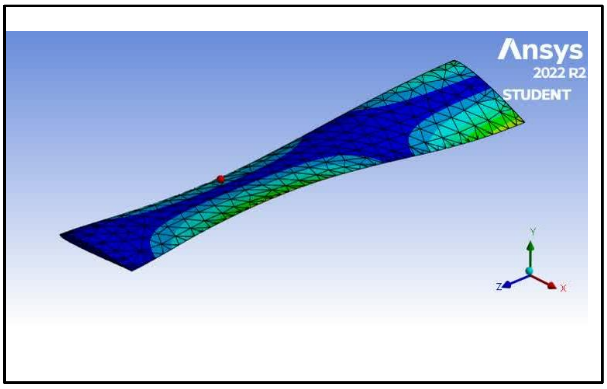
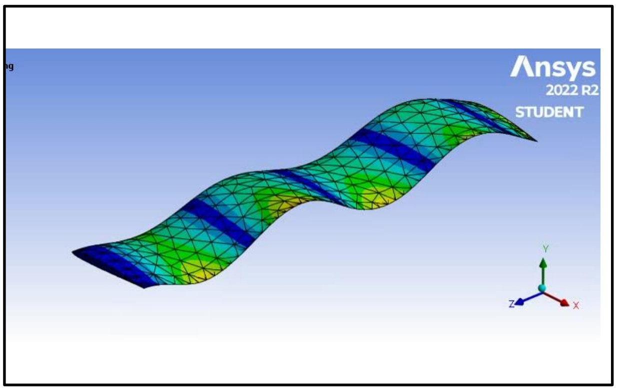


Time stamp 37

Mode shape – 07



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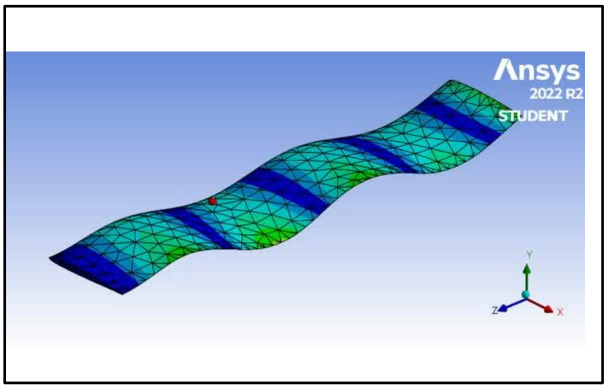
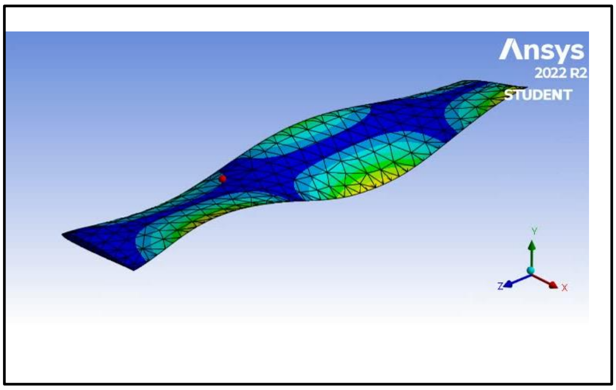


Time stamp 35

Mode shape – 08



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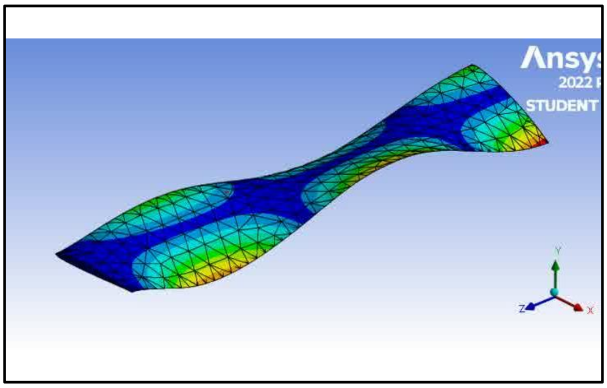
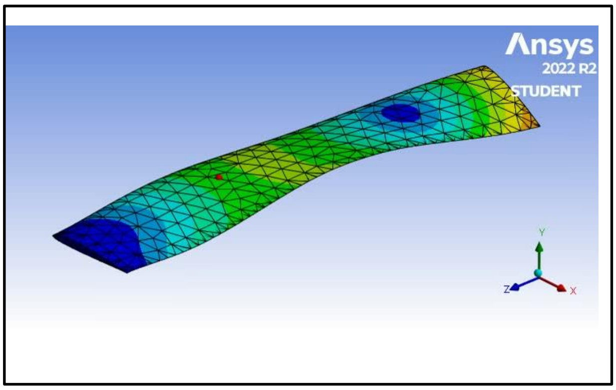


Time stamp 48

Mode shape – 09



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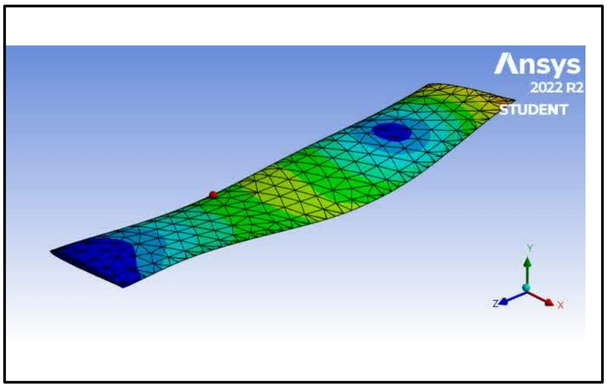

Time stamp 43

RESULT AND DISCUSSION

The below data depicts the information about frequencies obtained for two different wing models of different mode shapes.

Table.1 Mode vs Frequency for two wing models

Mode	Frequency (Hz) of Eppler 171	Frequency (Hz) of Selig 6062
1	33.144	28.045
2	206.61	174.8
3	247.01	248.02
4	412.54	345.99
5	573.81	485.89
6	1110.4	941.78
7	1237.4	1037.7
8	1414.2	1418.9
9	1803.6	1533.9
10	2062	1733.1

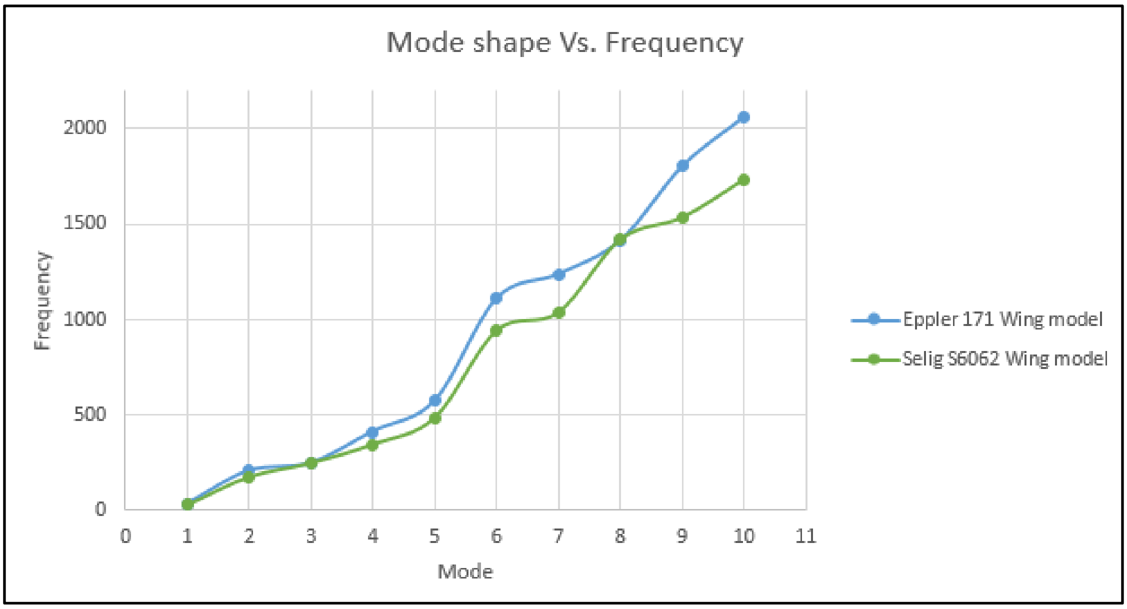

Fig. 6. Mode Vs. frequency

CONCLUSION

It is observed from the Mode shape vs Frequency graph for Eppler 171 airfoil that as the no. of mode shapes increases, the frequency is gradually increasing from 33.144 Hz to 2062 Hz. And for selig 6062 airfoil model the frequency is gradually increasing from 28.045 Hz to 1733.1 Hz.From the graph it is clearly understood that the frequency is increasing gradually as the modes are increasing for two wing models whereas the Eppler 171 model is producing more frequency when compared to other wing models.

REFERENCES

[1]. Md Akhtar Khan, Chinmaya Padhya, Modal and Harmonic Analysis of Bio-Mimic Corrugated Dragonfly Aerofoil, International Journal of Engineering and Advanced Technology, ISSN: 2249 – 8958 (Online), Volume-9 Issue-4,2018.

[2]. M. Darvizeh, A. Darvizeh, H. Rajabi, A.Rezai, Free Vibration analysis of dragonfly wings using finite element method, Int. Journal of Multiphysics, 3, 2019.

[3]. J.S. Chen, J.Y. Chen, Y.F. Chou,On the natural frequencies and mode shapes of dragonfly wings, J.Sound and Vibration,Volume 313, Issues 3–5, 17 June 2008, Pages 643-654, 2008.

[4]. Ali DEMİRTAŞ, Meral BAYRAKTA, FREE VIBRATION ANALYSIS OF AN AIRCRAFT WING BY CONSIDERING AS A CANTILEVER BEAM, ISSN: 2147-9364 (Electronic), 2018,DOI: 10.15317/Scitech.2019.178

[5]. Ismail Bogrekci, Pinar Demircioglu, H. SayginSucuoglu, Emrah Guven, Neslihan Demir, and M. Numan Durakbasa, Structural and Modal Analyses of Naca 66-206 Aircraft Wing Model, Springer, ISPR 2019, LNME, pp. 182–191, 2020.

[6]. Nikhil A. Khadse, S. R. Zaweri, Modal Analysis of Aircraft Wing using Ansys Workbench Software Package, International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 4 Issue 07, 2015.

[7]. Pranjal Agrawal, Pankaj Dhatrak, Paras Choudhary, Comparative study on vibration characteristics of aircraft wings using finite element method, Materials Today: Proceedings, Volume 46, Part 1, Pages 176-183, 2021.

[8]. M.SAI KIRAN, M. NAVEEN,Structural and Modal analysis of Air craft wing, International Journal of Scientific Development and Research, ISSN: 2455-2631, Volume 3, Issue 12, 2018.

[9]. Ramindla Praveen, Elumagandlasurendar, K shyam kumar, Design, Static Structural and Modal Analysis of Aircraft Wing (Naca 4412) Using Anasys Workbench 14.5, International Journal of Engineering Science Invention, Volume 7 Issue 12 Ver I, PP 61-71, 2018.

[10]. Balaji Jadhav, MODELING AND STRUCTURAL ANALYSIS OF AIRCRAFT WING USINGALUMINIUM ALLOY AND TITANIUM ALLOY, International Research Journal of Engineering and Technology, Volume: 07 Issue: 12, 2020.