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# Active flutter suppression for an aircraft wing structure by utilizing FE analysis for Al7075+Sic alloy

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**Abstract.** An instable stimulated vibration resulting from the combination of aerodynamic, inertia, and aeroelastic forces is known as "active flutter" in the context of aircraft wing structures. The primary destabilizing element that the airplane structures display and which causes active flutter is limit cycle oscillation. Ultimately, it results in fatigue-related harm and catastrophic aircraft mishaps. Two modern techniques, namely enhanced aero-elastic analysis and flutter control for wings and panel structures, are established by means of these developing technologies. comparable stiffness values and comparable stresses are assessed, together with theoretical and practical approaches, to enhance the features of aero-elastic analysis of aircraft structures. Additionally, it makes reducing flutter mandatory in order to enhance aero-elastic stability. Using Ansys software, a thorough FE analysis is carried out to improve and analyze the benefits of Al7075+ SiC alloy aircraft wing structure. With the aid of Ansys software, a thorough FE study is carried out to enhance their aeroelastic stability and to offer recommendations for the design of revised wings and panel structures. For the chosen NACA4412 aircraft wing, modal analysis is carried out, and frequencies are assessed. The advantages of AL7075+ SiC alloy material will be examined with equal stress, equivalent strain, and equivalent stiffness.

## 1 Introduction:

The aircraft construction with the aerodynamic characteristics of the aerofoil NACA4412 wing type is chose.n in order to set up the simulation strategy and apply input parameters.

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The aircraft wing structure is a complicated structure, and a FE model has been built, as can be seen by looking at the rib itself (Figs. 1&2). The profile of the NACA four-digit aerodynamically described wing sections is composed of the first digit, which describes the maximum camber of 4% chord placed at 40% of the chord, and the second digit, which is positioned at the rear from the leading edge with a thickness of 12 mm. The latter two figures, expressed as a percentage of the chord, add up to the maximum thickness of the airfoil. This experiment describes the numerical process for analyzing the NACA 4412 airfoil with a one-meter chord length. To compare fluent's accuracy in the two-dimensional analysis, a two-dimensional model is made. In terms of the rib's design, the chord-wise beam that shifts the stresses from the skin to the spars is idealized. The weight is transferred from the skin to the rib body by the rib feet. The wing box is introduced as the load-bearing part of an aircraft wing. Figs.1 & 2 are shown for example. It is made up of ribs, spars, and skin, all of which are essential to the body's ability to withstand aerodynamic stresses. Typically, wing structures are constructed in a semi-monocoque manner, with skin resisting shear stresses and stiffners resisting compression. Resisting torsional and shear loads is the spar web main purpose. Stringers are used to tighten the skin.The aim of the proposed work is to make and use fibre reinforce an Al-7075 Metal with SiC to suppress the flutter for an aircraft wing of NACA4412 type with support of calculating equivalent stress, equivalent strain & equivalent stiffness

## 2 Literature survey

Since the very beginning of the wing structure design process, the flutter issue with aircraft structures has been a persistent issue, and iteration process for assessing new designs have always been highly recommended. There has never been an end to the flutter issues. Scientists have done some experiments on flutter issues with isotropic panels, shells, and wing structures top importance [11][12][13]. In order to investigate the linear and non linear flutter qualities of composite laminated plates with curved fibres Ribero[18] has conducted research using reduced order models. Printo, G.M. Nayak.J.[23] conducted a study review that highlighted the implications of boundary conditions, laminar thickness and geometric inspection. A study on the aeroelastic ability of two dimensional (2D) panels under oblique shocks waves was conducted by Anjaneyulu N and Lakshmi Lalitha.J [14]. Along with the developments of materials science are observed, the aircraft industry has consistently used a variety of innovative materials. According to M. Ragamshetty and TS. Deepthi[10], the limit cycle flutter of cantilever panels were investigated using the deformation and supersonic piston theories[9]. The aspect ratio of wing structural panels has a significant impact on flutter characteristics, according to numerical results[17][18]. Under oblique shock waves, the aeroelastic stability of two-dimensional (2D) panels was examined. For instance, using the nonlinear FEM, Singh.V&Prasad.R.C.22 examined the flutter behaviors of laminated plates with non-smooth friction boundaries. The mechanical qualities of a composite structure, which is a type of laminate construction with high stiffness and low weight, may be modified by varying the angle at which the fibers are laid. Scientists with notable interests have applied and reviewed by literature survey. Regarding the study review of Singh, V., and Prasad, R. C. [20][21][22] for the design of aircraft structures. According to Zappino's study review and P. Singh's research review, they conducted an aero-elastic analysis of composite pinched panels and examined the impact of pinched points at the margins on critical dynamic pressure. The impacts of boundary conditions, laminated thickness, and geometric imperfection were studied by S. N. MadevNagaral, V. Auradi, and others [19].

## 3 Design methodology

Typically, a wing is built using four components and is joined to a rib:A] the wing's aerofoil structure's distinctive shape B] the shift in air pressure loads from the skins to the spars c] Pressure loading factor as a result of pressure d] localized dispersal of concentrated loads, as in the case of pylon mounts and the attachment of mobile surface engines. Hydraulic lines must be able to pass through the wing structural rib by the use of systematic design slots. This design process identifies the design as a complex type and defines an aerofoil. Defined explanations of the compex behavior involved in the design of aircraft wings and ribs were provided by Bindu HC and Muhammad Muhsin Ali H [6]. There are cuts in the ribs to either lighten the weight or provide room for holes for the service system.

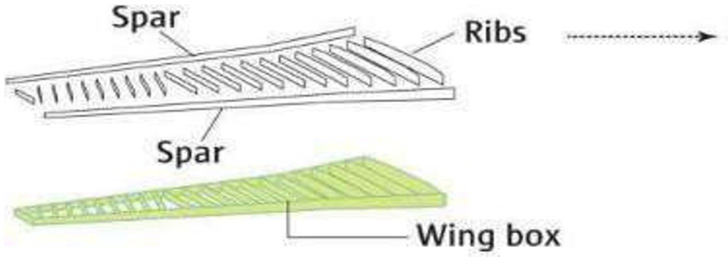


**Fig 1.** Breakdown Of Main Components Of An Aircraft Wingbox [12]

### 3.1. Aerofoil air-craft model NACA4412:

According to the design process, the vertical stiffeners resist compressive stresses because of air pressure, whereas the horizontal stiffeners resist shear loads. Fig 1 illustrates the interaction between the steady aerodynamic forces and static structural elastic forces are known as static aero elasticity and another one is the interaction between the steady and unsteady. The basic disadvantage is increase in wing taper decreases the area of the wingtip of the wing which leads to the increase in wing divergence and flutter speeds. Double lattice method was used for the aerodynamic analysis. Separation control using a small number of fluidic oscillators located near the natural flow separation line is highly effective on a swept-back wing.

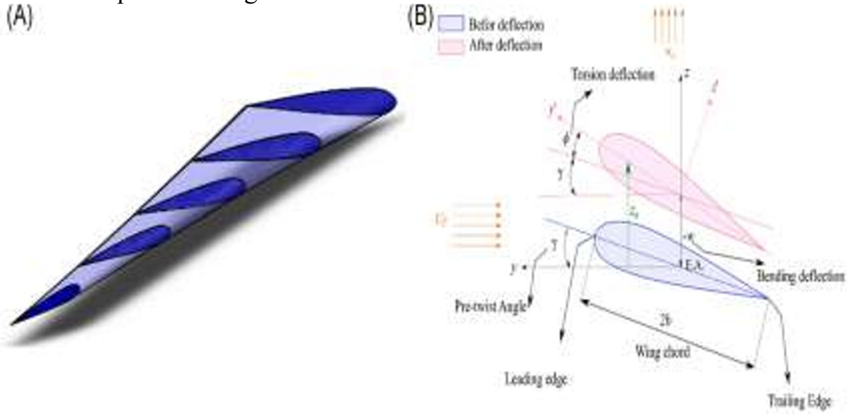


**Fig. 2** A) swept wing, and (B) wing crosssection.[3] [12]

### 3.2. Experimental details (Material specifications)

Figure 5 is a graph that illustrates the effect that $Fe_3O_4$/RHS has on the malleability of the composite material. The graph shows a downward trend when $Fe_3O_4$/RHS particles are added, with the percentages ranging from 0 to 9 weight percent. The integration of $Fe_3O_4$/RHS into the composite product resulted in an increase in the composite's strength, which is the cause of this reduction. The reduction in malleability that was found highlights the trade-off that exists between strength and malleability, indicating the significant influence that different percentages of $Fe_3O_4$/RHS have on the mechanical behaviour of the material.

**Table.1.** materials specifications evaluated from structural analysis

| **Compositions** | **Mode Shape1** | **Mode Shape 2** | **UTS Sample1** | **UTS sample2** |
|---|---|---|---|---|
| Al 7075 | 98.97 | 97.42 | 78 | 81 |
| Al7075&2%SiC | 115.318 | 111.268 | 111 | 108 |
| Al7075&4%SiC | 106.779 | 100.234 | 110 | 104 |
| Al7075&6%SiC | 91.918 | 115.43 | 86.3 | 105 |
| Al7075&8%SiC | 64.746 | 72.761 | 53.8 | 56.3 |
| Al7075&10%SiC | 119.304 | 125.714 | 43.9 | 49.8 |

### 3.3.Examination of experimental process & Results [modal analysis with frequency range:

**Table 2.** frequencies evaluated from modal analysis

Available Data Sets:

| Set | Frequency | Load Step | Substep | Cumulative |
|---|---|---|---|---|
| 1 | 1.9689 | 1 | 1 | 1 |
| 2 | 4.1606 | 1 | 2 | 2 |
| 3 | 4.7516 | 1 | 3 | 3 |
| 4 | 11.041 | 1 | 4 | 4 |
| 5 | 12.943 | 1 | 5 | 5 |

The study's objective encompassed the evaluation of equivalent stiffness, equivalent stress and equivalent strain. With these reinforced fibres Al 7075+SiC material has given vital statics and calculations were updated. Specifications were observed and fea analysis by utilizing ansys software is performed. The static and dynamic analysis were performed and mode shapes were presented with appropriate frequencies.

## 3.4. Results of Structural Analysis:

**Table: 3** material properties

| **MATERIAL** | **AL7075+ SiC** |
|---|---|
| **Deformation(mm)** | **2.6745** |
| **Equivalentstress (Mpa)** | **1.5525** |
| **Equivalent strain** | **0.00017759** |

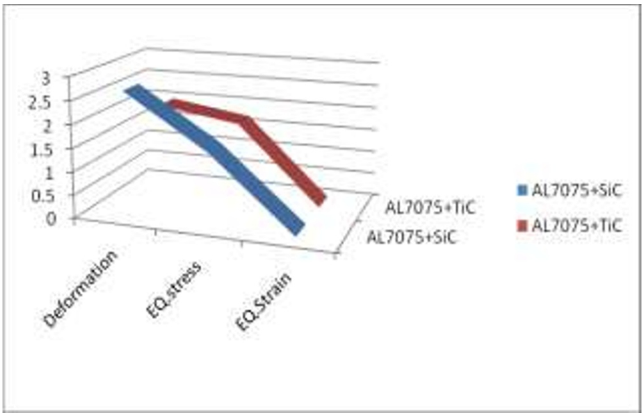


**Fig. 3.** Structural l Analysis: results comparison

## 3.5. FE Model entities:-

Element defined for ansys: NACA4412 aerofoil wing structure with element quad 8 noded 183 & brick 185 is shownresults comparison below with finite element model analysis Ansys. Linear analysis is performed by mentioning its material models and density value.

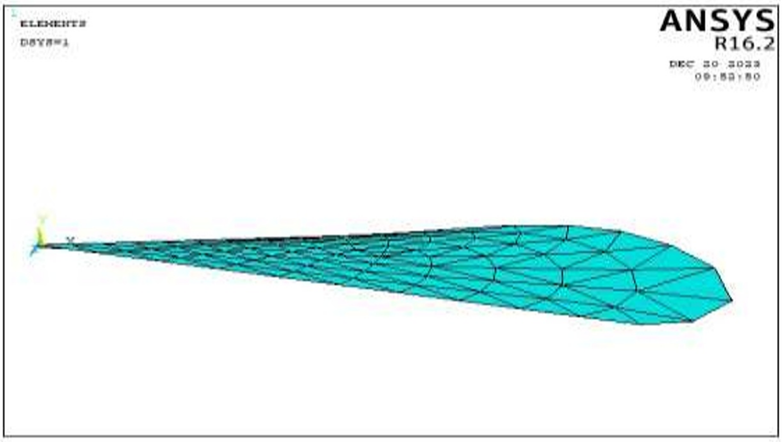
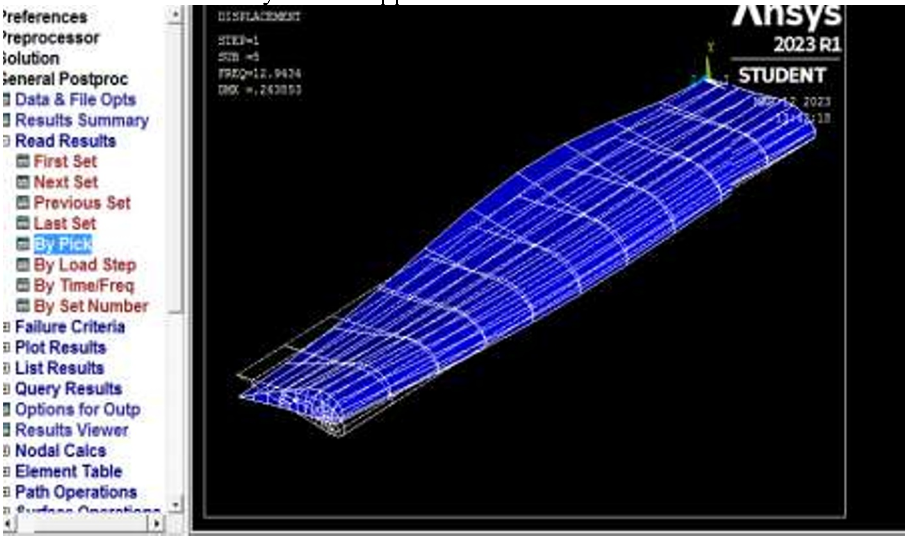


**Fig.4.** wing entities

### 3.6. Findings derived from the current investigation

We can use Al 7075+SiC fibre reinforced instead of using any Aluminium alloy in order to give the weight to the strength of the structure. The effect of stress during take-off condition is more for Al 7075+SiC alloy which is strongest and light weight, and also reduces the weight of the wing. On behalf of calculations, analysis & FE model it is observed that all technical parametersi.e. equivalent stress, equivalent strain and equivalent stiffness parameters will be achieved as required and expected level with AL7075+SiC alloy. Regarding weight to strength ratio technology, we can presume AL7075+SiC alloy will be applicable.



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DISPLACEMENT
STEP=1
SUB =5
FREQ=12.9424
DMX =.243853
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**Fig. 5.** Wing shape fe model with flutter and buckling

## 4. Future scope & Conclusions

Research analysis was performed with a mode of simulation and it will be extended by selecting different materials other than AL-Zn-Mg alloy 7178. Wing of aircraft geometry is selected from NACA4412. AL7075 with Silicon carbide like a alloy will be the predominantly one of the best option material for manufacturing aircraft wing and also it is technically proved by these experiments to optimize wing weight. Research analysis will be applied by selecting other kind of geometry from different sources. Further in addition to this research a proto type air craft wing blade and an experimental analysis of flutter model design and ground vibration testing will be executed.

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