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Modelling and Structural Analysis of Three-Dimensional Wing

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ABSTRACT--- This paper attempts to discover the structural behavior of the wing imperiled to flowing loads through the voyage. The study uses a method in the form of finite element analysis of wing flexure distortion. As a first step, two wing models are established by captivating factual features, wing assembly, and plan principles into consideration. The gathering wing prototypical entails of tinny membrane, two poles, and multi-ribs. Two spars which consist of primary and secondary spars. NACA 23015 is chosen as the baseline aerofoil as this is identical alike to the tailored aerofoil being castoff in Airbus A320. Two rods mostly endure the twisting moment and trim strength, which is finished of titanium contaminant to ensure enough inflexibility. The covering and wing spars are made of aluminum amalgam to lessen the structural heaviness. Later, a static structural investigation is smeared, and the overall distortion, comparable elastic strain, and corresponding Von-Mises tension are obtained to analyze the mechanical behavior of the wing. Furthermore, modal investigation is being supported out to determine the natural rate of recurrence, as well as the modal shape of the three orders, which are acquired through the pre-stress modal analysis. The outcomes of the modal scrutiny aid engineers decrease excitation on the natural occurrences and avert the wing from the flurry. In view of the results obtained from the study, designers can emphasize consolidation and analysis the stress attentiveness range and huge distortion area. In conclusion, the recreation consequences indicate that the arrangement is possible and improves the information grade of the lifting surface.

Keywords: Structural Behaviour, Wing, Deformation, Modal Analysis, Stress, Strain, ANSYS.

I. ACRONYMS AND NOMENCLATURE

FEA Finite Element Analysis
CFD Computational Fluid Dynamics
NACA National Advisory Committee for Aeronautics
NASA National Aeronautics and Space Administration
CAD Computer-Aided Design
MTOW Maximum Take-Off Weight
MLW Maximum Landing Weight
MZFW Maximum Zero-Fuel Weight
MW Minimum Weight
MMO Maximum Operating Mach Number
FOS Factor of Safety
UIUC University of Illinois at Urbana-Champaign
ρ Density
P Pressure
T Temperature
a Speed of Sound
µ Aerodynamic Viscosity

II. INTRODUCTION

The composition and manufacture of aircraft wings demand attention to several unique structural requirements. High strength and lightweight are the two primary functional needs to be considered in selecting materials for the construction of an aircraft wing. Different material used to manufacture wing will experience a different type of structural behaviors. As the chief assembly to generate lift, the lifting surface is the total critical share of an airplane. The wing not lone assures flying steadiness but also provides a facility to support the strategic operation unit. There are many types of wing aircraft, such as the conventional wing, delta wing, wings having sweep, dihedral wing, tapered wing, and flexible geometry wing, and each wing will produce different aerodynamic characteristics, stability, and maneuverability. A fact worth to mention, in most commercial airplanes nowadays is classified as a fixed-wing aircraft. In the 1980s, Airbus established the greatest efficacious single-aisle airplane intimate in aeronautics antiquity, the A320. It is the third plane the company built after the A300 and the A310 and is the world's most popular narrow-body airplane.

Numbers of commercial aircraft, including Airbus A320, comes to an end of initial design life due to life extension and structural health. The structural health of the wing is a concern as it is a significant component of an aircraft. The wing's structural health can be affected by the disturbance caused by the pilot's actions or atmospheric phenomena such as wind gusts, wind gradients, or turbulence. The Airbus A320 is nominated as the allusion airplane, and the structural investigation is conducted by means of ANSYS Worktable

quality things are non-boundless and are anticipated to be drained in no longer so removed future. Inward start vehicles works of art for the most extreme component on oil base fills. Diesel vehicles (C.I) are one some of the standard The purpose of this research is to analyze the mechanical behaviors of an A320 commercial airplane's wing as the wing component plays a vital role in producing lift, it also provides stability and maneuverability of an aircraft. This study also recommends an analytical technique for the three-dimensional wing of A320 built on ANSYS. First, a wing prototypical of A320 consisting of tiny-skin, double-spars,

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and multi-ribs is well-known to mimic the concrete lifting surface structure. There will be several limitations and assumptions made throughout the analysis. Consequently, by performing modal analysis, and finally, the dynamic structural analysis is done using ANSYS. Finally, the structural analysis of stress, strain, bending, torsion, and deformation data of the wing acquired from end to end transient structural analysis, which is smeared for optimization and improvement to the design of the aircraft for the future. A fatal accident can occur at the wing part of an airplane due to the influence of the complicated external flight environment, which will result in the pressure of the upper and lower wing surface with variable aerodynamic stream arenas around the wing [1].

III. PROBLEM STATEMENT

The catastrophe of an airplane structural part can have disastrous penalties, with consequential damage to lifecycle and the airplane. The exploration of the structural behavior of the aircraft wing component and thus the catastrophes in airliner structures are of spirited prominence in averting further occurrences. Fatal incidents in the aviation industry are not something new to ponder since there are a lot of cases in aircraft history that shows by catastrophic and disastrous aftermath. Historically, most of the structural catastrophes inspected have been in metal constituents, imitating the preponderance of metal structures in airplane. Nevertheless, ever since the mid-1980s, a growing amount of airplane makers have been creating use of fiber-reinforced polymer amalgams for structural constituents. Thus, structural failures due to metallic structures in aircraft can be reduced. Therefore, to cope with the failure and fatal accidents due to aircraft wing’s component, structural behavior and health of three-dimensional wing must be evaluated even though supporting in the exploration of mishaps in civil airplane, here are numerous instances of wing section catastrophes and faults that were noticed before a misfortune could happen.

IV. WING MODEL ESTABLISHMENT

As the Airbus A320 was designed for slightly lower operating speeds than the A300 and A310, which its maximum operating Mach number is equivalent to 0.82, and the cruise speed is ranging from Mach number 0.79 to 0.80 [2]. Additionally, the wing sweeps angle of an A320's is only 25 degrees.

On the other hand, few reports from Zhang et al. [1] and Vani, Reddy, Prasad, & Shekar [3] are characterized by the establishment of a wing model based on their objectives. This can be seen when Zhang et al., [1] established a wing based on a large-aspect-ratio prototypical. This is because to evaluate the wing flexural rigidity distortion, and it is more efficient to analyze a large-aspect-ratio wing model since large deflection can be attained easily from that model. Whereas Vani, Reddy, Prasad, & Shekar [3] established an A320 wing model but in a scaled dimension of 1:5. As the original scaled dimensions are tough to obtain, and due to the intricacy of the lifting surface structure to replicate and fabricate, a scaled dimension is chosen for the sake of simplicity.

4.1 Related Parameters

The A320 wing is shorter and much lighter compared to the A321's, but the plan of the wing remains the same. A modified plan wing with double-slotted inner flap, a lengthened, and a much more substantial version of A320, the A321 is built to prevent a deterioration of high and low-speed performance [2]. Comparatively, a wing component will experience stress, bending, torsional, and deformation. Hence, to study the three dimensional of the wing structures, this research establishes an extended aerofoil wing model.

Additionally, the construction and configuration of the A320 wing for these studies are about the same as the real one. This project is concerned with only the chord length since the leading edge to the straggling edge, length, wing area, aspect ratio, and semi-span. Other chief constraints of the lifting surface are lists in a tabletop. Correspondingly, semi-span considers as the case in this project. The wing part can be attained from the following factors. The wingspan measured the whole wing, but what concerned is half of it by considering the parameter of semi-span. The wingspan can be divided by two because the wing component of the aircraft is doubly symmetrical. Meanwhile the model is a traditional wing, the narrowing of the wing is equal to 1, and thus, the dominant chord length can be gained.

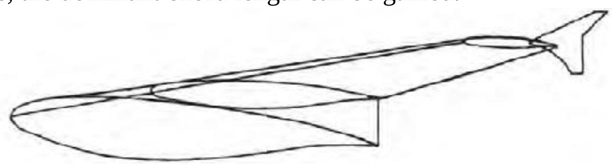

Figure 1: Root, kink, and the tip of the Airbus A320 wing.

The geometrical, aerodynamics, and structural data are gained from the Obert [2]. The typical mission of A320 is flying at a Mach number of 0.79 at 10,000 km altitude and a range of 3,000 km. The planform is defined using the following six parameters, which are root chord length, taper from root to tip, wingspan, leading-edge sweep angle, kink twist angle, and tip twist angle.

4.2 Selection of Aerofoil

Beforehand the scheme plan underway, values for several constraints must be selected. These comprise the aerofoil as, in numerous venerations, it is the core of the aircraft. Correspondingly, the aerofoil upsets the voyage quickness, take-off, and landing stage spaces, cubicle speed, management abilities, and total aerodynamic efficacy through all stages of voyage [4]. According to Karukana [5], one Kline-Fogleman variation of NACA 23015 is being used in Airbus A320, and NACA 23015 is chosen as the baseline aerofoil since this aerofoil is identical and similar to the customized aerofoil in Airbus A320. And as stated by Karukana [5], the Kline-Fogleman aerofoil design has a high lift characteristic in subsonic speed, and thus it is very suitable for the transport aircraft of A320.

4.3 Wing Model

According to Raymer [4], the reference lifting surface is the elementary lifting surface geometry castoff to initiate in the plan. The form of the reference lifting surface can be resolute from its aspect ratio, taper ratio, and lifting surface with sweep angles. Since wing components are considered as a significant plane structural component, it can generate lift and drag for the aeroplane to soar. When a lifting surface is creating lift, it has a lesser pressure on the higher surface and high pressure on the lesser surface. And the air will flow and seepage from the lowest of the lifting surface in the direction of the upper surfaces. Conversely, for a three-D wing, the airborne can outflow round the tip of the lifting surface. To put it differently, the stress variance between higher and minor sides will drop owing to the escaping of air and thus reduces the lift near the tip.

Additionally, the swept-wing part is vastly used by modern aircraft. The lifting surface sweep is applied mainly to decrease the opposing properties at Mach number closed to unity and at Mach number greater than unity flow field. Wing sweep must offer the preferred acute Mach Number be governed by upon the designated 2-D section of the wing, ratio of the wing section thickness, taper ratio, and added factors. In-plane the lifting surface structure, and the ribs will supply contour to the lifting surface and scuffle will take utmost of the twisting loads on the lifting surface structure. In the case of a fixed-lifting surface airplane, the spar is frequently the principal structural supporter of the lifting surface, seriatim spanwise at the ninety degrees to the aircraft fuselage. The spar transports voyage loads and the load of the lifting surface even though on the ground. Additional structural and founding associates, for example ribs, maybe clubbed to the spar or spars, with stressed membrane structure also partaking the masses wherever it is castoff. Here might be more than one scuffle in a lifting surface or no one. Nevertheless, wherever a single spar conveys a mainstream of the forces on it, it is known as the main spar.

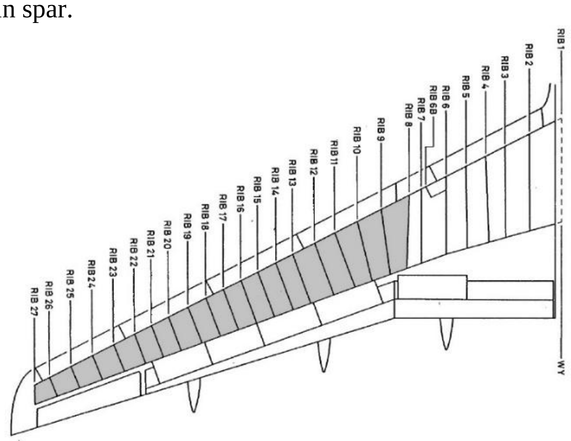

Figure 2: The Wing model of Airbus A320 consists of ribs and spars.

4.4 Reference Aircraft

As mentioned earlier, an Airbus A320 was selected as the reference aircraft, and the following specifications were applied to proceed for analyzing the wing structure.

Table 1: Airbus A320-100 specifications.

Airbus A320-100		
Wingspan		33.91 m
Semi-span		16.955 m
Aircraft Maximum	MTOW	68,000 kg
	MLW	63,000 kg
Weight	MZFW	59,000 kg
	MW	39,000 kg
Airfoil	Root Airfoil	NACA 23015
	Kink Airfoil	NACA 5-digit
	Tip Airfoil	NACA 5-digit
	Root Chord Length	7.05m
	Tip Chord Length	1.50m
Skin Thickness		9.1mm
Spar	Thickness	
	Position of Front Spars	0.2m
	Position of Rear Spars	0.65m
Operating Limit Speed	MMO	0.82
	Cruise Speed	0.79-0.80

Since there are several limitations and due to the wing structure complexity and tremendously laborious if not challenging to convey out, the geometry of the exemplary is streamlined by declining the scale of the wing and omitting numbers of struts as they do not underwrite in contradiction of twisting. This can be finished since collapsing on the membrane was not shaped. Moreover, this wing component design is made up of a 1:4 ratio since there are limitations that the software cannot solve the design problem. Thus, the wing structure design specifications are made purposely for this research paper is as follows

Table 2: Wing component design specifications

Wing Component Design Specifications		
Maximum Weight		9750 kg
Wing Span		4.05m
Chord Length		1.05m
Airfoil		NACA 23015
Taper Ratio		1
Sweep Angle		0°
Ribs Design	Root and Tip's Thickness	0.4m
	Other Ribs	0.2m
	Holes	0.01-0.05m
Spars	Length	4.00m
	Thickness	0.07m

4.5 Aerodynamic Parameters

Besides, for static analysis, a factor of safety is needed to acquire the compression of the lift capacity on the inferior surface of the lifting surface. To begin with, the issue of protection or FoS regularly mentions one of two kinds of stuff. Firstly, the actual load-bearing capability of an assembly or element and secondly is the necessary brim of protection for an assembly or element conferring to code, law, or design requirements. A FOS on the packing issue is castoff, accounting for thrilling stuffing due to human fault or unforeseen climate circumstances such as gust load. Therefore, the FOS is designated to be 1.5, and thus, the manufactured lift per wing can be calculated as follows.

$$\textbf{Weight}, \mathbf{W}\ (\mathbf{N}) = \mathbf{9,750\ kg} \times \mathbf{9.81}\tfrac{\mathbf{m}}{\mathbf{s^2}} = \mathbf{95,647.5\ N} \qquad (1)$$

Then, by using this equation to get total lift capacity acting on the lifting surface.

$$\boldsymbol{\eta}_{\mathbf{max}} \times \mathbf{FoS} = \frac{\mathbf{L}}{\mathbf{0.4(W)}} \qquad (2)$$

$$\mathbf{L}_{\mathbf{total}} = (\boldsymbol{\eta}_{\mathbf{max}} \times \mathbf{FoS}) \times \mathbf{0.4(W)} \qquad (3)$$

$$\mathbf{L}_{\mathbf{total}} = \mathbf{200,859.75\ N} \qquad (4)$$

After calculating the total lift weight acting on the lifting surface is calculated, the lift capacity is then divided into two since the aircraft is symmetry, and it is regarded as two wings that are separated by a fuselage at the center of the aircraft. Before that, there is only 80% of the lift load is appear on behalf of on the lifting surfaces, and the extra 20% is represented on the fuselage. Comparatively, lift load is deliberated as an essential principle while planning an airplane as fuselage and lifting surfaces are the two central regions wherever lift load interim in an airplane. Therefore, only 80% of the total lift capacity is considered represented in the lifting surfaces.

$$\mathbf{L}_{\mathbf{wing}} = \mathbf{0.8(L_{total})} = \mathbf{160,687.8\ N} \qquad (5)$$

$$\mathbf{L}_{\mathbf{each\ wing}} = \frac{\mathbf{160,687.8\ N}}{\mathbf{2}} = \mathbf{80,343.9\ N} \qquad (6)$$

$$\textbf{Pressure}, \mathbf{P} = \frac{\mathbf{L}}{\mathbf{S}} = \mathbf{9,626.981559\ Pa} \qquad (7)$$

V. FINITE ELEMENT GEOMETRY & MODELLING

Firstly, to have a very smooth curved line of NACA 23015 aerofoil, the point coordinates were exported from the aerofoil tools and UIUC aerofoil Coordinates Database. It is much accurate compared to sketching the curved line of NACA 23015 aerofoil. Secondly, spars and holes are sketched at the front plane. The dimensions of main spars, secondary spars, and holes are tabulated in the table below.

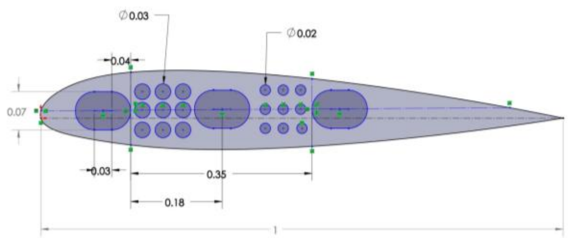

Figure 3: Dimension and specification of the rib.

Figure 4: Isometric view of the rib in XYZ-plane.

Figure 5: Structure of ribs of the wing

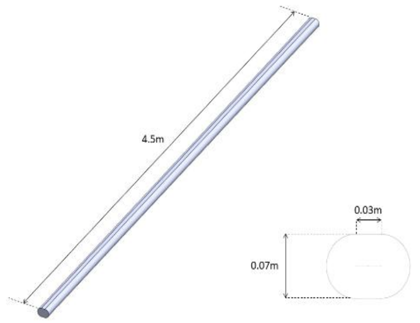

Figure 6: Dimension of both primary and secondary spars.

Figure 7: Internal structure of the wing model.

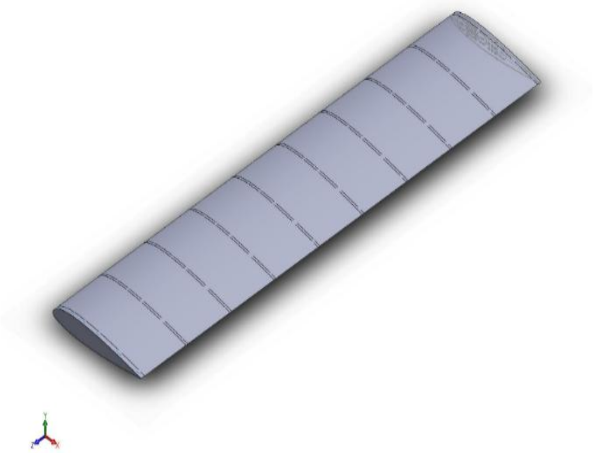

Figure 8: Wing skin of the wing.

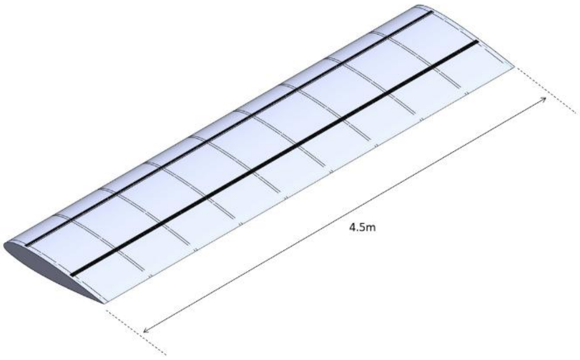

Figure 9: Full assembly of the wing.

VI. FINITE ELEMENT MESHING & BOUNDARY CONDITIONS

The number of elements and nodes must be high to create an excellent meshing for good results. The steps that are considered are similar compared to the previous wing design. Similarly, some definitions need to be set up first before generating the mesh. Mesh defeaturing, capture curvature, and capture proximity in the sizing section is included for obtaining a better mesh result.

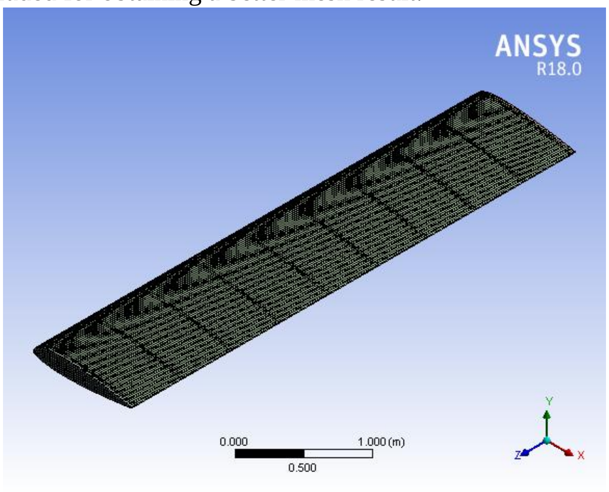

Figure 10: Mesh preview of second case wing design.

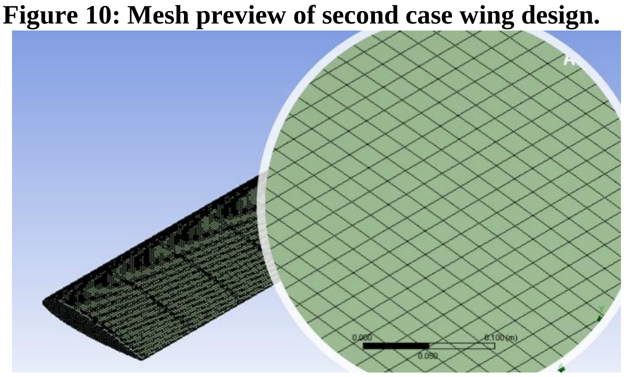

Figure 11: Mesh preview of wing design and the close-up view of the face meshing.

The balloon above-mentioned indicates the close-up view of the top and bottom surface of the wing. It can be understood that the upper and bottommost surface of the lifting surface face meshing is structured while the ribs line on the wing skin is unstructured.

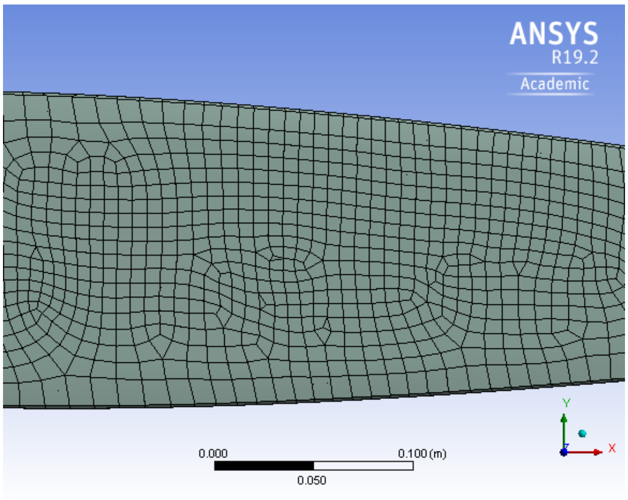

Figure 12: Close-up view of finite element face meshing on the front view.

The face meshing on the front view of the wing is partially unstructured, while others are structured one. Some changes have been made to correct and debugging the face meshing, but the results remain constant. For the wing skin of top and bottom surfaces, the result of the face meshing is considered a structured type. Thus, the static and modal analysis that is obtained later will have an accurate and better result compared to the unstructured face meshing. As for the boundary condition, two analysis settings and boundaries are set to analyze the static structure of the wing. Two boundaries that are applied are fixed support and a vertical pressure load at Y-component. Fixed support is applied at one end of the wing because it is devoted to the fuselage of the aircraft. It is the same as the first case wing design as the boundary condition that is established in this research paper is kept constant to analyze the structural behavior of the wing.

VII. MATERIAL SELECTION

There is aluminum alloy as well as titanium alloy, and the structural properties of each material have been explained and elucidate in Table 3. The reduction in the mass of the lifting surface structure, aluminum amalgam, is selected as the factual of the membrane. The booms and spars are prepared for titanium amalgam to warrant enough toughness.

Table 3: Selection of materials for wing design

Wing Component	Material Selection
Ribs	Aluminum alloy
Wing skin	Aluminum alloy
Primary and secondary spars.	Titanium alloy

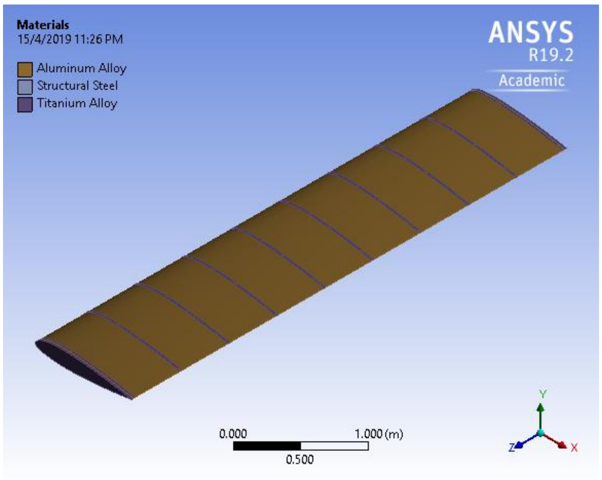

Figure 13: The materials selection for parts of the wing.

VIII. STATIC STRUCTURAL ANALYSIS

Static structural scrutiny is functional to analyze the wing as it does not depend on the time motion. The aim of this study is to do the analysis and the structural trend of a three-dimensional wing with no motion of time. Thus, to observe the structural behavior of the wing, static structural analysis is the best pick

8.1 Total Deformation

For this case, some outcome can be expected for both static structural and modal analysis with the presence of spars and ribs where spars are the maximum deeply burdened portions of the airplane that sustenance huge loads nurture to twist and curl the wing while ribs prevent the wing from the buckle. As shown in figure 14, the whole extreme distortion happened at the tip of the lifting surface, whereas at the root, there is only minimal deformation is developed. The maximum total distortion calculated is 0.10126 m, while zero deformation is the minimum for the second case.

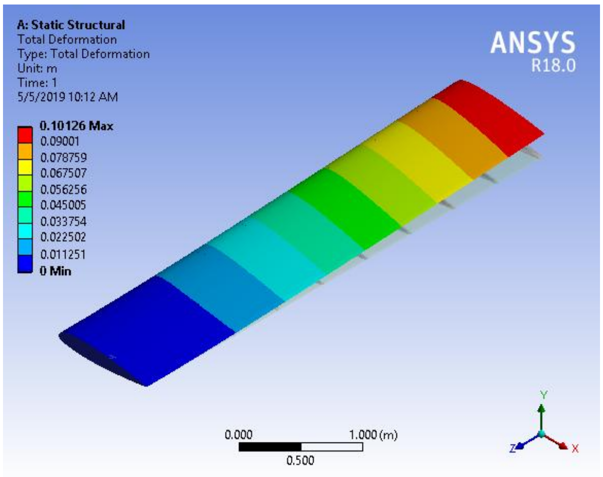

Figure 14: Total deformation for wing design.

8.2 Equivalent Elastic Strain

Like the same flexible strain (Fig. 15), it appears that the von-Mises stress on the second case is mostly in the minimum value at most surfaces at top and bottom, and the maximum Von-Mises stress developed at the core of the lifting surface. Here the emphasis is on the development of extreme stress on the root of the lifting surface; for the same reason, there is static support assigned as one of the boundary conditions, and thus, the highest percentage of deformation will be most likely to have happened at the root.

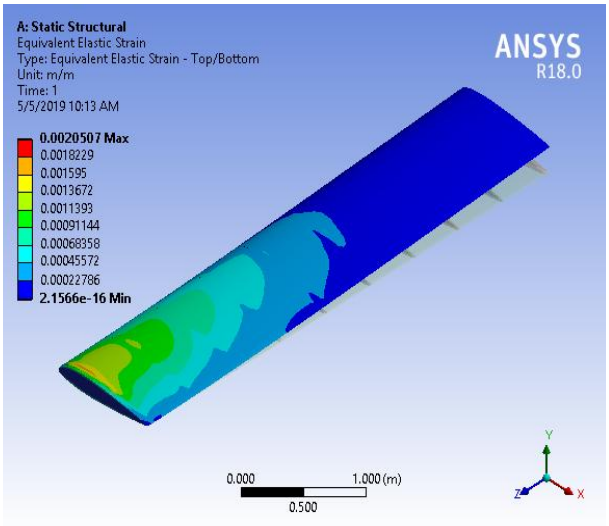

Figure 15: Equivalent elastic strain.

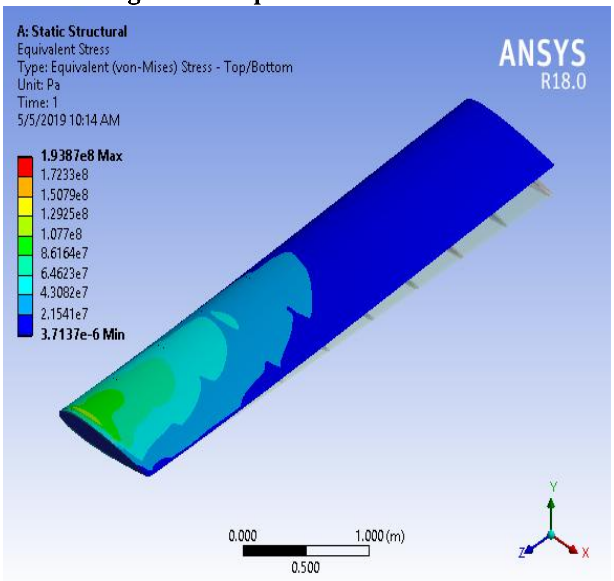

Figure 16: Equivalent von-Mises stress.

IX. RESULTS FOR STATIC STRUCTURAL ANALYSIS

Table 4 shows a comparison of outcomes for stagnant structural examination for both cases of wing design. This can be realized that the supreme over-all distortion for the first case is more considerable as compared to the second one. This is true because, in the second case of wing design, primary and secondary spars are included in the structure of the wing component. Henceforth, the spars tend to counter the shear and bending forces that are developed and caused by the external pressure load. Besides, for the equivalent elastic strain, the difference is not much since both cases of wing design are being set for the same boundary conditions which fixed support at the root of the wing and a pressure load is applied on y-component of the wing.

Table 4: Results of static structural analysis

	Total Deformation (m)	Equivalent Elastic Strain (m/m)	Equivalent (von-Mises) Stress (Pa)
Min	0.00000	2.1566×10^{-16}	3.7137×10^{-6}
Max	0.10126	0.0020507	1.9387×10^{8}

X. MODAL ANALYSIS

The Modal examination is a procedure to define the shuddering features (natural occurrences and mode forms) of an assembly or an instrument element, although it is premeditated. Therefore, for case one, as mentioned before, is a wing structure without any ribs and spars. It only comprises of aluminum wing skin with NACA 23015 aerofoil.

10.1 Mode 1

The first mode of vibration for the second case of wing design is pure bending mode in the vertical direction with a regular occurrence of 4.9647 Hz. As illustrated in figure 17, the wing structure appears to bend upward in a vertical direction. As the wing is inclining to curvature around the core section's least moment of inertia. Besides, at the tip of the wing, there is no support to resist and overcome the applied load in the y-component, which is at the bottom of the wing. It is observable in both figures below that the maximum deformation is developed at the wingtip with 0.082128 m, while zero deformation happens at the root.

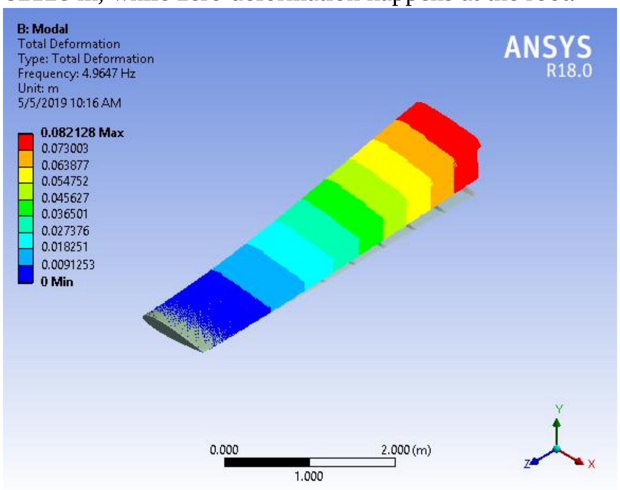

Figure 17: Vector display for the first modal shape of wing design.

10.2 Mode 2

Then, another mode of vibrations is too twisting method, and the regular occurrence is 27.397 Hz. As shown in figure 18, the wing experienced a bending failure in the vertical direction, with two areas having a significantly more significant deformation. One of the two areas is at the wingtip, as the wing experienced 0.080771 m of total deformation. Another one is around the center of the wing, with 0.071796 m of deformation. On the other hand, there is zero deformation at the core of the lifting surface as there is reliable support that can resist and counter the force applied.

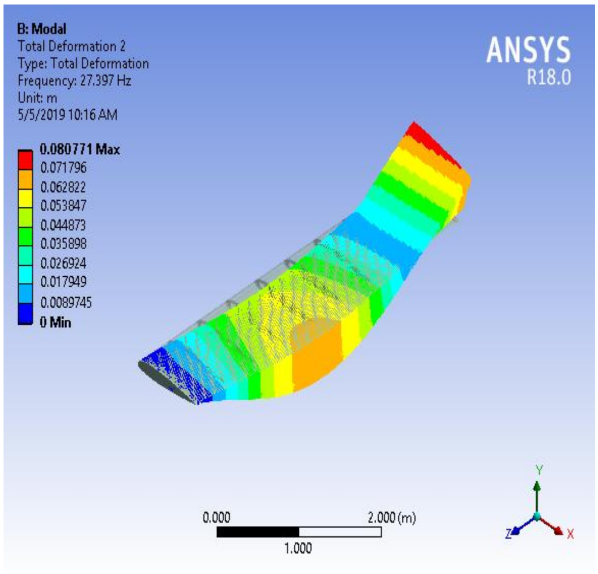

Figure 18: Second modal shape on the side view.

10.3 Mode 3

Then, the 3rd type of vibration is a combination of bending mode in an upright and horizontal way with a natural frequency of 28.04 Hz. As seen in figure 18 and figure 19, the highest deformation occurred at the tip of the wing with 0.080383 m while zero deformation at the root.

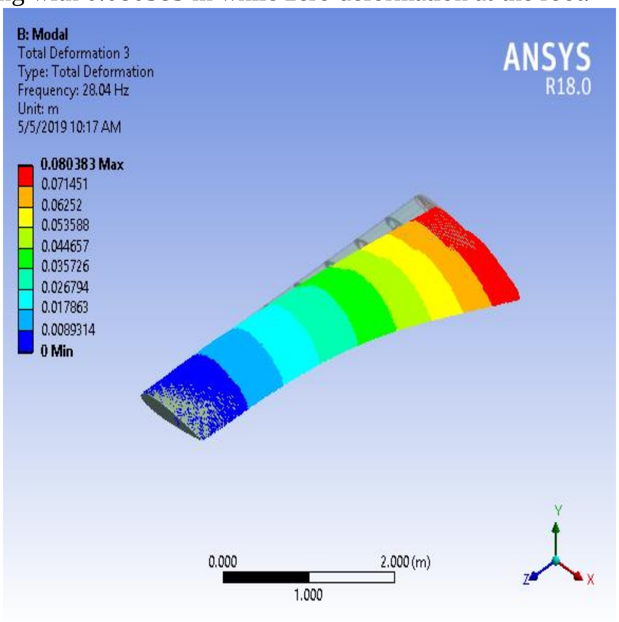

Figure 19: Third modal shape of the wing structure.

10.4 Mode 4

Finally, one other mode that should be analyzed on the wing component is if there will be a torsion deformation acting on the wing. As shown in this last mode, twisting occurred on the wing structure as the wing is applied with given pressure on Y-component. It cannot be denied that torsion is one of the deformations that could happen at the wing during flight. The stresses arising from this action are shear stress caused by the rotation of adjacent planes past each other.

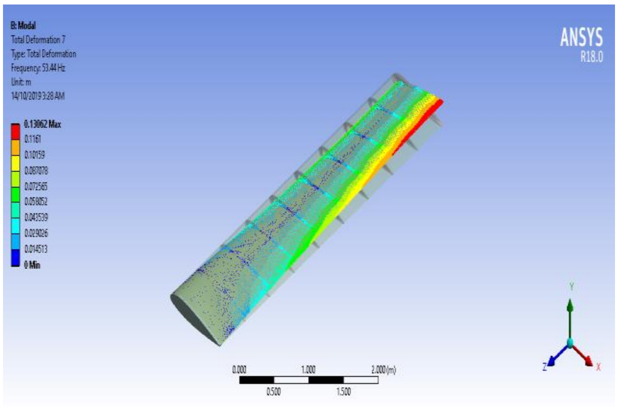

Figure 20: Last modal shape of the wing structure to evaluate torsional stress.

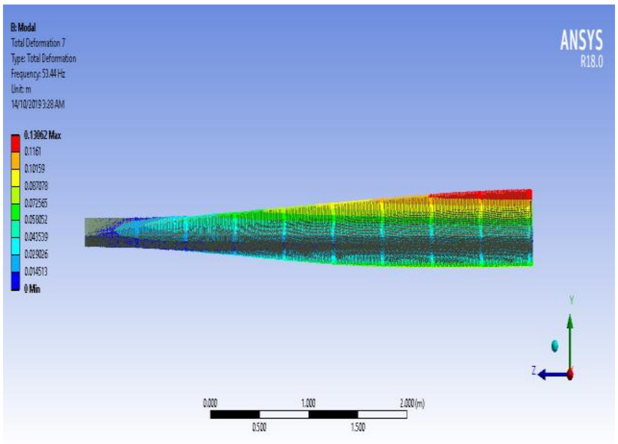

Figure 21: Torsional stress acting on the wing shown in a side view.

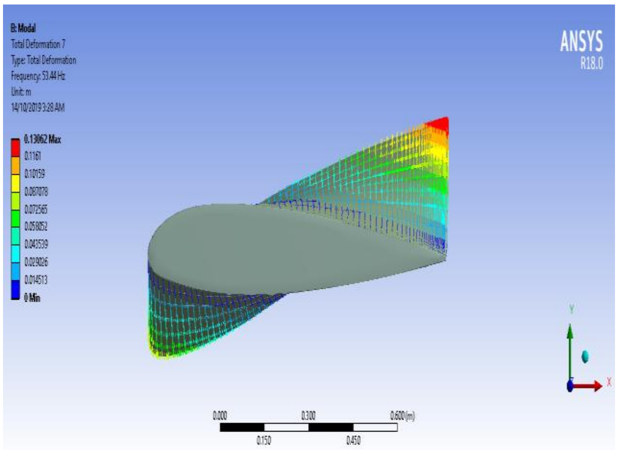

Figure 22: Front view of the torsional stress occurred on the wing.

As shown in the figure stated above, the mode of vibration is a torsion mode with a natural frequency of 53.44 Hz. It can be said when a 54 Hz of natural frequency acting on the wing, a torsion happened. The highest deformation during torsion mode occurred on the edges at the tip of the wing with 0.13062 m.

XI. RESULTS FOR MODAL ANALYSIS

Table 5 displays the table of outcomes for the second case of modal analysis. If it is going to be compared with the first case of wing design, the deformation that happened is much lesser and minimal. This is because of the spars and ribs located in the wing structure.

Table 5: Table of results for modal analysis.

Order	Frequency (Hz)	Modal Shape	Direction of Deflection	Largest Deformation (m)
1	4.9647	Bending	Y-axis	0.082128
2	27.3970	Bending	Y-axis	0.080771
3	28.0400	Bending	X-axis and Y-axis	0.080383
4	53.4400	Torsion	-	0.130620

XII. DISCUSSION FOR MODAL ANALYSIS

In the airplane design, the protagonist of the airplane decides the essential properties and, thus, the suitable ingredients. Amalgamations of varied ingredients guarantee the optimum in terms of strength, firmness, precise mass, and erosion confrontation. As for metals in the airplane project, steel, aluminum, titanium, and amalgams are particular metals classically used in aeroplane manufacturing.

Aluminum amalgams have lesser mass paralleled to steel amalgams, with brilliant erosion confrontation properties, yet steel amalgams have superior yield strong point. Due to this cause, steel is cast-off in the portions of the design where the extraordinary strength is desirable, like in the touchdown gears; the aluminum is used for parts like the lifting surface where small mass and elasticity are vital. Moreover, titanium amalgams provide an amalgamation of low mass with particularly extraordinary strength, and excellent heat and corrosion fighting properties. Titanium and other superalloys are used for engine parts where mass and heat resistivity are predominantly significant.

In view of the above discussion and the analysis and outcomes, there is twisting distortion in the modes of the 1st three orders. It can be observed that the distortion upsurges along the way of the semi span and extents the extreme at the lifting surface tip. Due to the investigation, the scuffles mostly endure the twisting distortion, and the membrane and spines mainly endure the torsional distortion. As a consequent, when the aeroelastic occurrence of the lifting surface is near to the natural occurrences of the first three orders, the wing is thought to reinforce the spars.

XIII. CONCLUSION

In conclusion, the structural behavior of a three-dimensional wing has been simulated through two different cases of wing structure, which contain spars and ribs while the other one has only two ribs at root and tip of the wing. The second case of the wing shows lower deformation compared to the first case in both fixed structural investigation and modal investigation. This is due to the contribution of spars that sustenance huge loads inclining to twist and spiral the wing. Comparatively, the spars are primarily shear beams. Besides, the validation of results from the past studies using ANSYS is considered as a success and dependable as the percentage error is allowable. Finally, through the static structural and modal investigation, the deformation of the lifting surface structure has also been observed and is figured out. The wing deformation, such as stress, strain, and deflection due to bending and torsion failure, are obtained

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