Static and Dynamic Analysis of Aircraft Stiffened Panel

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Abstract- Stiffened panel is a component in aircraft that is used to fasten the stiffener and the skin. These are the components that carry and allocate the loads throughout the surface of the fuselage or the wing. These panels are present in both fuselage and wings. Stiffener or longeron or stringer is a thin metal strip that is used as a supporting member in fuselage and wing. When we consider the issue i.e. resistance of the aircraft's skin towards the loads applied on it, due to frailty the aircraft skin is easily deformed. In order to solve this problem we designed a stiffened panel which can endure to deflection and stress levels. By changing the stiffened panel sections and by changing the material of the skin, the aircraft skin can withstand the deformation. Generally T-section stiffened panel is used but there is a disadvantage of using T-section, it can't resist to deformation. So we designed an I-section stiffened panel (because I-section is more resistant to deformation) in CATIA and Meshing in Hyper mesh and Analysis is done in ANSYS. We considered three types of analysis in ANSYS, Modal analysis, Static analysis, Harmonic analysis respectively and also we considered two materials, one is aluminum and the other is carbon fiber. Aluminum is the common element used in the design of aircraft, but Carbon fiber is recently being used in aircrafts.(1 ,10)

Keywords – Stiffened Panel, Design, , Finite Element Analysis

I. INTRODUCTION

Generally in aircrafts there are two types of structures Monocoque and Semi Monocoque. Monocoque structure is a structural approach that supports loads through an object's external skin, where as the semi Monocoque system uses a substructure to which the airplane's skin is attached. The substructure, which consists of bulkheads and/or formers of various sizes and stringers, reinforces the stressed skin by taking some of the bending stress from the fuselage. The semi Monocoque is the most often used construction for modern, high-performance aircraft. Hence in the aircrafts today semi Monocoque structure is used. In these semi Monocoque structure components like bulk heads, formers, stringers, stiffeners, ribs, spars, etc are present. Among these components we have selected stiffener component as it carries the maximum load, in fuselage the stiffener is called as stringer also. We have selected the fuselage stiffener for our project.. Stiffeners are secondary plates or sections which are attached to beam webs or flanges to stiffen them against out of plane deformations. In aircraft construction, a longeron or stringer or stiffener is a thin strip of material, to which the skin of the aircraft is fastened. In the fuselage, stringers are attached to formers (also called frames) and run the longitudinal direction of the aircraft. They are primarily responsible for transferring the loads (aerodynamic) acting on the skin onto the frames/ formers.(11,22)

Figure .1(a) - Fuselage stiffened panel

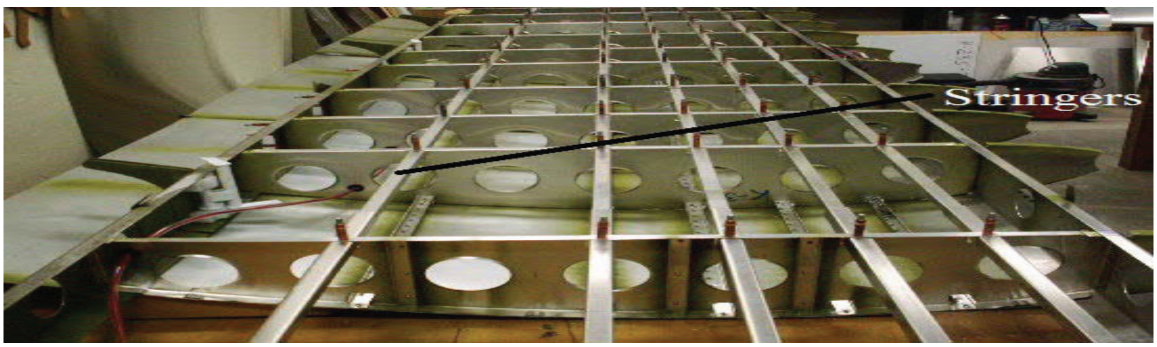


Figure .1(b) – Stringers in wing

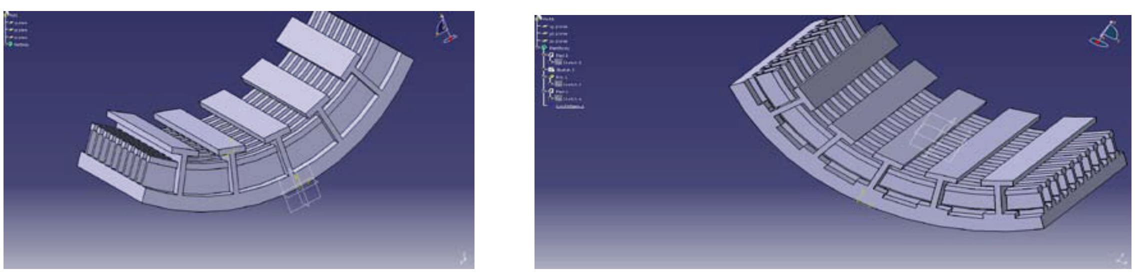


Figure- 1 (C) Final T-section model

the table below shows the Static Analysis of I-section and T-section of aluminum and carbon fiber

	T-Section (Aluminum)	I-Section (Aluminum)	T-Section (Carbon Fiber)	I-Section (Carbon Fiber)
Deformation	0.54525	0.52362	0.036083	0.038195
1st Principle Stress	111.621	196.63	175.37	226.104
2nd Principle Stress	24.916	56.59	31.558	55.636
Von misses stress	157.168	200.758	213.209	206.53

From above table we conclude that I-Section is better than T-section then we done Modal Analysis for only I-section Final I- section model.

II. MODAL ANALYSIS

We use modal analysis to determine the vibration characteristics (natural frequencies and mode shapes) of a structure or a machine component while it is being designed. It also can be a starting point for another, more detailed, dynamic analysis, such as a transient dynamic analysis, a harmonic response analysis, or a spectrum analysis.We can do modal analysis on a pressure stressed structure, such as a spinning turbine blade. Another useful feature is modal cyclic symmetry, which allows you to review the mode shapes of a cyclically symmetric structure by modeling just a sector of it. Modal analysis in the ANSYS family of products is a linear analysis. Any nonlinearity, such as plasticity and contact (gap) elements, are ignored even if they are defined. (5,20)

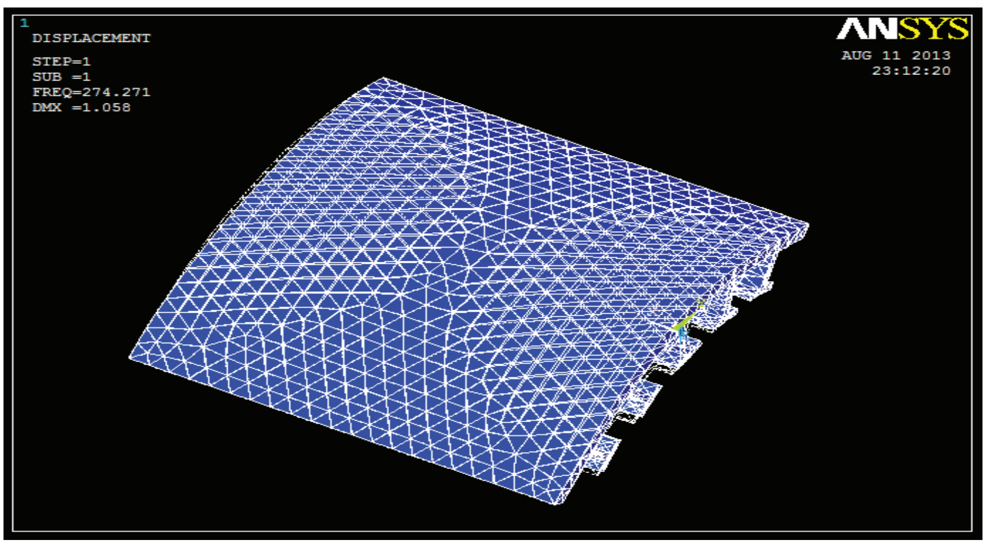
Review the results

Main Menu > General Postproc > Read Results > First Set > Plot results .Utility bar > Plot controls > Animate > Mode Shape > ok

Repeat the whole process with another material i.e carbon fiber reinforced plastic with EX=150 e3, PRXY=0.25 and density=1.72e-

Aluminum Material Results

Figure .2. (a) Mode Shape of I- section (Aluminum Material)



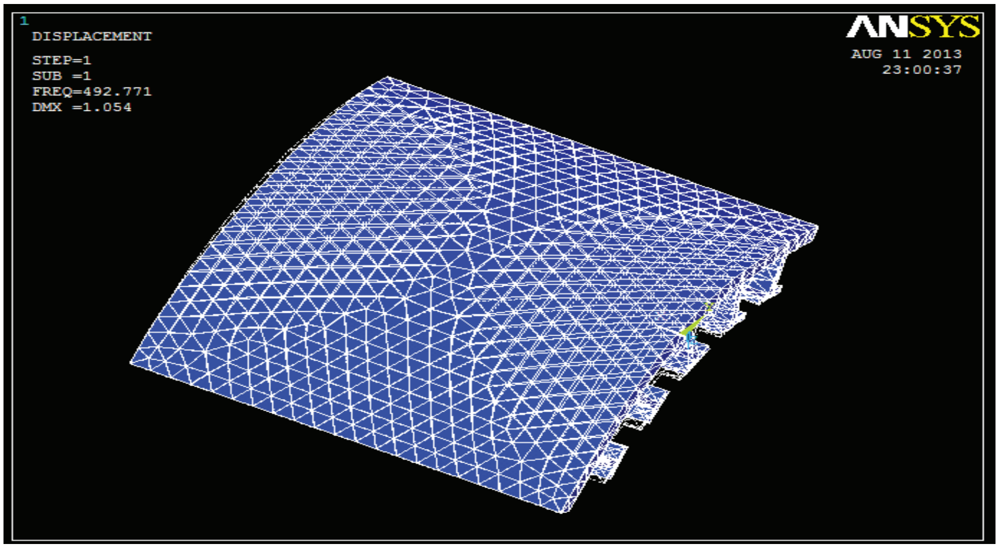


Figure .2. (b) Mode Shape of I- section (Carbon Fiber Material)

III.EXPERIMENT AND RESULT

3.1 HARMONIC ANALYSIS

Any sustained cyclic load will produce a sustained cyclic response (a harmonic response) in a structural system. Harmonic response analysis gives you the ability to predict the sustained dynamic behavior of your structures, thus enabling you to verify whether or not your designs will successfully overcome resonance, fatigue, and other harmful effects of forced vibrations.(6,12)

Harmonic response analysis is a technique used to determine the steady-state response of a linear structure to loads that vary sinusoid ally (harmonically) with time. The idea is to calculate the structure's response at several frequencies and obtain a graph of some response quantity (usually displacements) versus frequency. "Peak" responses are then identified on the graph and stresses reviewed at those peak frequencies. These analysis techniques calculate only the steady-state, forced vibrations of a structure. The transient vibrations, which occur at the beginning of the excitation, are not accounted for in a harmonic response analysis

Main Menu > General Postproc > Next set

3. 2. Review the results

Graph of Amplitude Vs Frequency

Repeat the whole process with another material i.e carbon fiber reinforced plastic with EX=150 e3, PRXY=0.25 and density=1.72e-6 (18,22)

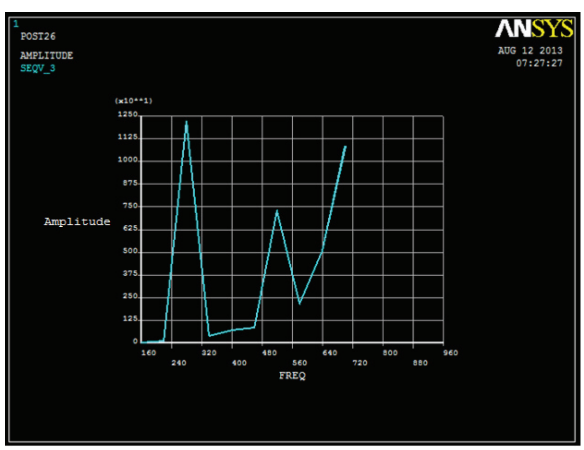


Figure .3.(a) Amplitude Vs Frequency of I- Section (Aluminum Material)

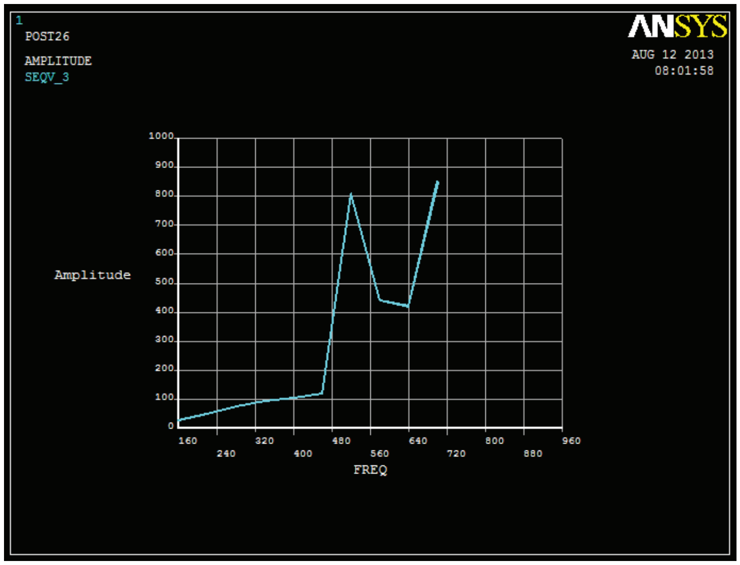


Figure .3. (b) Amplitude Vs Frequency of I- Section (Carbon Fiber Material)

Modal Analysis Results of I-section

Mode Shapes	Aluminum Material	Carbon Fiber Material
1 Mode	274.271	492.771
2 Mode	278.962	500.787
3 Mode	302.209	555.867
4 Mode	326.012	587.591
5 Mode	337.144	610.266
6 Mode	379.972	677.697

IV.CONCLUSION

In this paper, Generally, the material that is used in the construction of aircraft is aluminum. But now the bigger aircraft companies like Boeing Airbus have already started using carbon fiber material also for their aircraft. So we tried to compare the two materials i.e. aluminum and Carbon fiber and through ANSYS found out the results that which material can withstand the loads applied and have less deformation. So below is the comparison theoretically and analytically. Aluminum gets deformed easily with some amount of loads where as Carbon fiber doesn't get deformed easily with less loads. At high temperatures Aluminum strength decreases unlike that carbon fiber is heat resistant and when the temperature is above 100, aluminum gets very much affected. Physical strength, toughness and light weight are the features of carbon fiber. Carbon fiber also has good vibration damping, chemical conductivity compared to aluminum. The properties of carbon fibers, such as high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion, make them very popular in aerospace. Aluminum has some disadvantages like they are Prone to corrosion, so need protective finishes, particularly magnesium alloys Many alloys have limited strength, especially at elevated temperatures .

When we compare density, then aluminum is denser than carbon fiber, aluminum density is about 2700 kg/m3 and carbon fiber density is 1500kg/m3. Therefore carbon is much lighter and young's modulus for aluminum is around 70-79 mpa and where as for carbon fiber it is 150 mpa. We know that young's modulus measures the resistance of a material to elastic (recoverable) deformation under load. So the material with high young's modulus changes its shape slightly under elastic loading. Poisson's ratio for aluminum is 0.33 and where as for carbon fiber it is 0.25. The ratio of lateral strain by longitudinal strain is Poisson's ratio. So material with less possion's ratio has less deformation. From the analysis we found that carbon fiber is more robust than the aluminum material; also found that I-section gives less deformation than that of T-section.

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