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Analysis of Stiffeners in a Semi Monocoque System of an Air Craft

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ABSTRACT: *This Paper deals with the analysis of Stiffener's sections and the material used in a Semi Monocoque structure of an air craft. The Semi Monocoque system uses a sub structure to which the Air planes skin is attached. The Stiffener component carries the maximum load. At present, the stiffened panel with a T-section is used and is made of Aluminum. The alternate section and material for the stiffeners is analyzed and the recommendations, based on Static and Modal analysis, are proposed.*

KEYWORDS: *Semi Monocoque system, Stiffeners, Von Mises Stresses, Skin, Stiffened Panel, Modal Analysis*

I. INTRODUCTION

In present day Air Craft construction, Semi Monocoque structure system is used. A Semi Monocoque system has a substructure to which the skin is attached. The substructure may have components like bulk heads, stiffeners, ribs, spars, etc. The project is the study of Stiffeners sections and the material used for its construction. These stiffeners are used at the fuselage. Stiffeners are of two types. They are 1) Longitudinal stiffener, aligned in the span direction and 2) Transverse stiffener, aligned normal to the span direction.

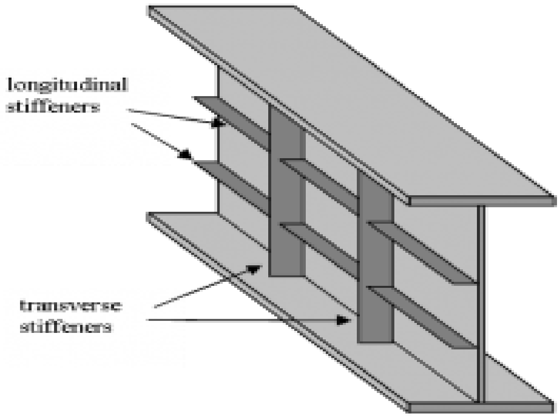

Fig.1 Stiffeners Longitudinal & Transverse

Longitudinal stiffeners can be continuous or discontinuous. Continuous stiffeners are continuous through transverse stiffeners and diaphragms. Discontinuous longitudinal stiffeners stop and start again either side of the transverse stiffeners. Continuous Longitudinal stiffeners are subjected to global stresses whereas Discontinuous stiffeners are to resist buckling to the web or flange. Stiffened panel is a panel that is used to fasten stiffener and skin. The loads are carried by the panel and transferred throughout the components. The stiffened panels are the basic structural Elements of most of thin wall structures especially aircraft structures (fuselage, wing, empennage structure). The stiffened panel is the elementary part of most of the airframe structures with intermediate and higher loading intensity.

The existing Stiffened panel is generally made out of T-section and aluminum material is most commonly used. The main disadvantage with Aluminum is pure Aluminum has very low strength, less temperature resistance and hence cannot be suggested as structural material. However, Aluminum alloys have their strength vastly improved, and they form the most widely used group of airframe materials. Alloying metals include zinc, copper, manganese, silicon and lithium, and may be used singly or in combination.

Aluminum alloys are more prone to corrosion than pure aluminum, so pure aluminum is often rolled onto the surfaces of its alloys to form a protective layer. The process is known as cladding, and sheets of alloy treated like this are known as clad sheets or Al-clad. Another common means of protecting aluminum alloys is anodizing - conversion of the surface layer to a form which is more corrosion-resistant by an electro-chemical process. Their use is limited because they are around three times as expensive.

Carbon fiber doesn't get deformed easily. Carbon fiber is heat resistant even at high temperatures. 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 is denser than Carbon fiber, Aluminum density is about 2700 kg/m^3 and carbon fiber density is 1500kg/m^3. 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. 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.

Von Mises stress is a geometrical combination of all the stresses (normal stress in the three directions, and all three shear stresses) acting at a particular location. If the Von Mises stress at a particular location exceeds the yield strength, the material yields at that location. If the Von Mises stress exceeds the ultimate strength, the material ruptures at that location.

II. PROBLEM DEFINITION

Aircrafts are losing their strength and are getting deformed very easily due to various loads that act on the aircraft. Hence the study of the project is to reduce the deformation caused due to application of various loads like the pressure loads, gust loads, compressive loads, buckling loads etc. At first a stiffened panel is modeled in CATIA and then the same model is analyzed using ANSYS.

1. The model of Stiffened panel with T Section is created and Stresses are found out.
2. The model of Stiffened panel with I Section is created and Stresses are found out.
3. The optimized section is selected.
4. Aluminum material is used for analyzing. The Modal analysis is done.
5. Carbon Fiber is used for the same section and analyzed.
6. The better material is suggested..

III. FIGURES STATIC ANALYSIS

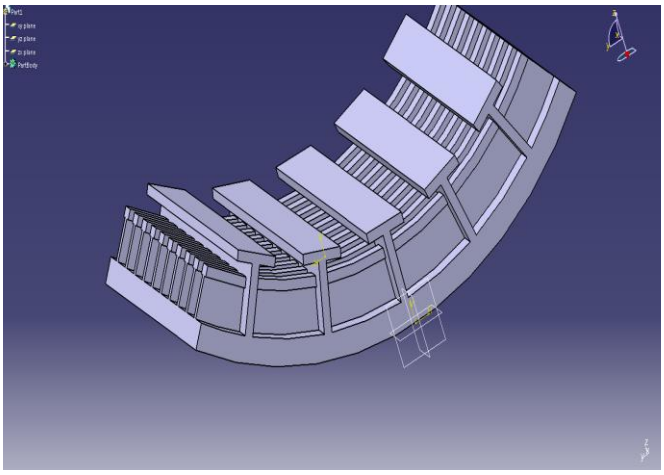

Fig. 2 Final T – Section model

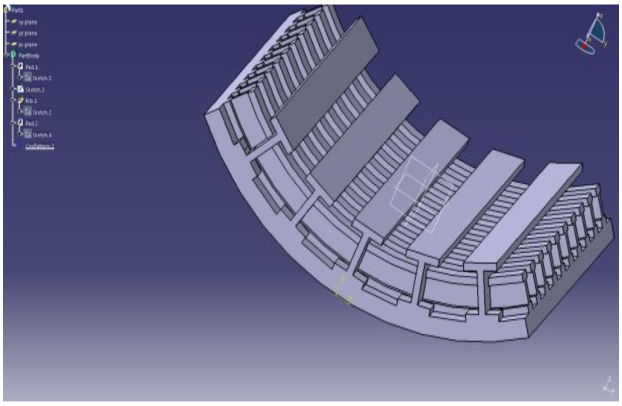

Fig. 3 Final I – Section model

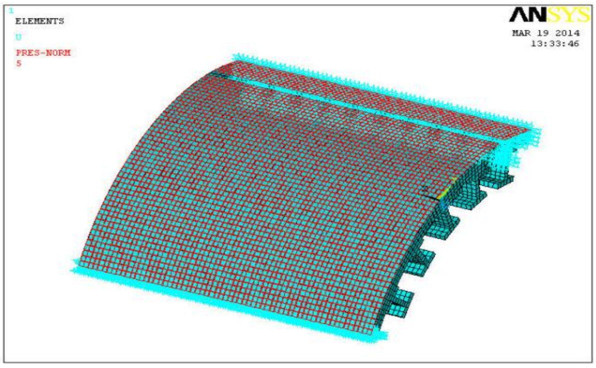

Fig. 4 Mesh and Boundary conditions of Stiffened Panel

Fig. 5 Deformation of T-Section (Aluminum)

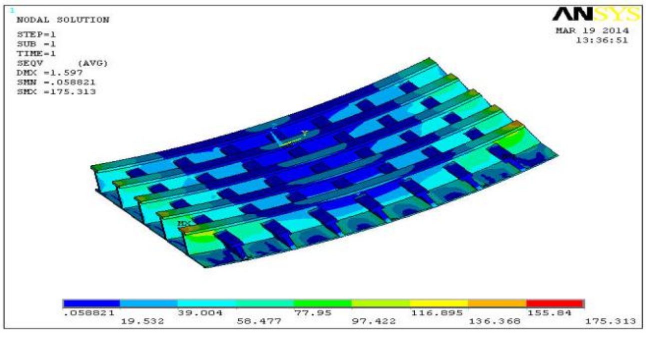

Fig. 6 Von Mises Stress of T-Section (Aluminum)

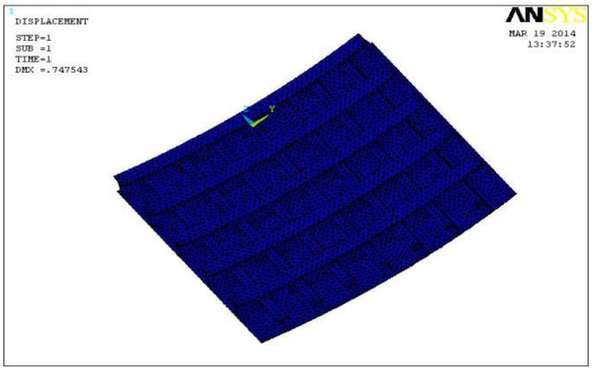

Fig. 7 Deformation of T-Section (Carbon Fiber)

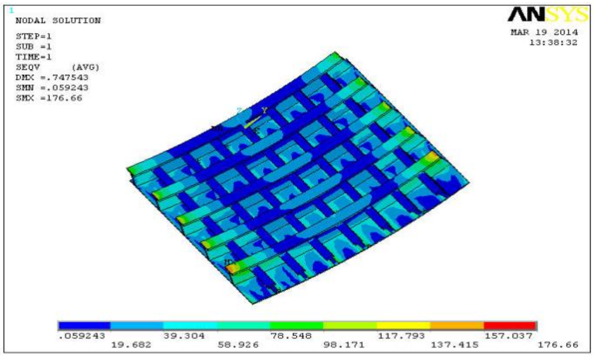

Fig. 8 Von Mises Stress of T-Section (Carbon Fiber)

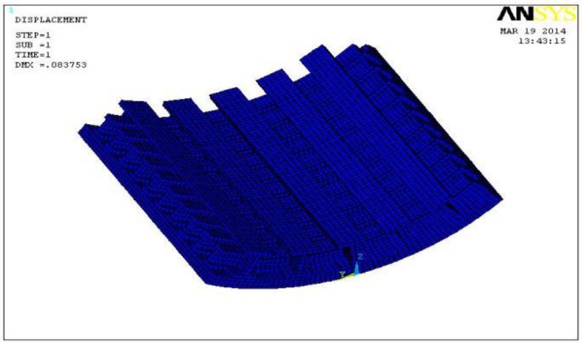

Fig. 9 Deformation of I-Section (Aluminum)

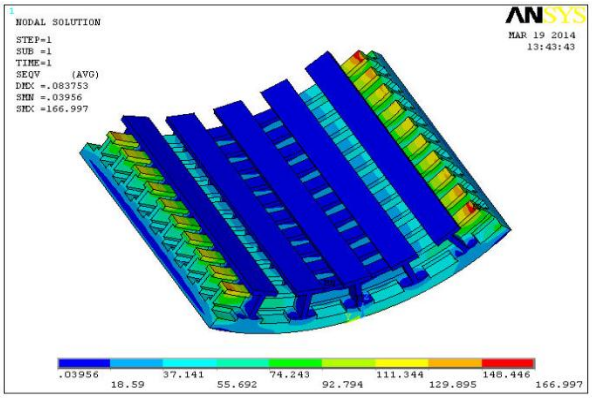

Fig. 10 Von Mises Stress of I-Section (Aluminum)

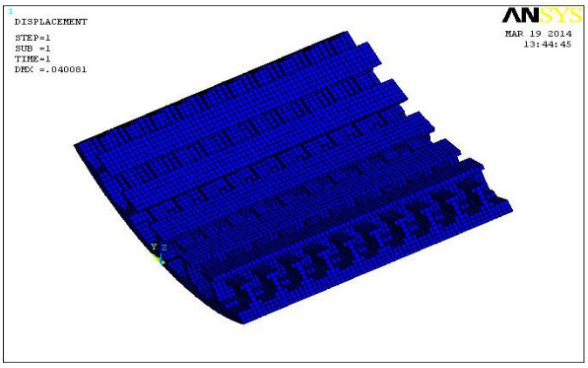

Fig. 11 Deformation of I-Section (Carbon Fiber)

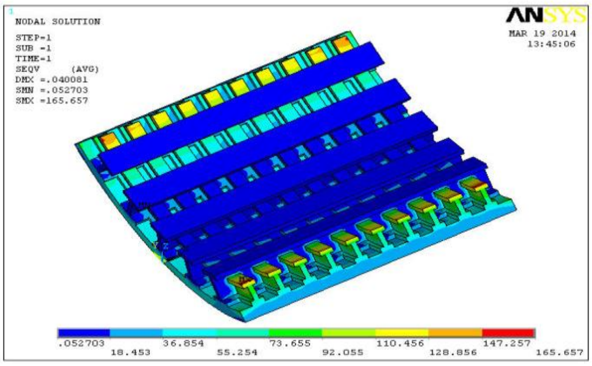

Fig. 12 Von Mises Stress of I-Section (Carbon Fiber)

Modal Analysis

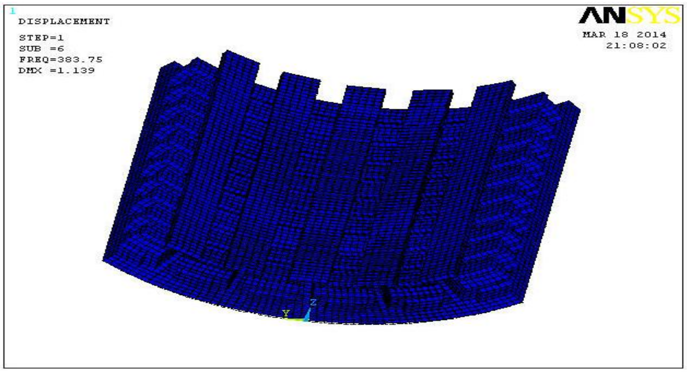

Fig. 13 6th Mode Shape of I- section (Aluminum)

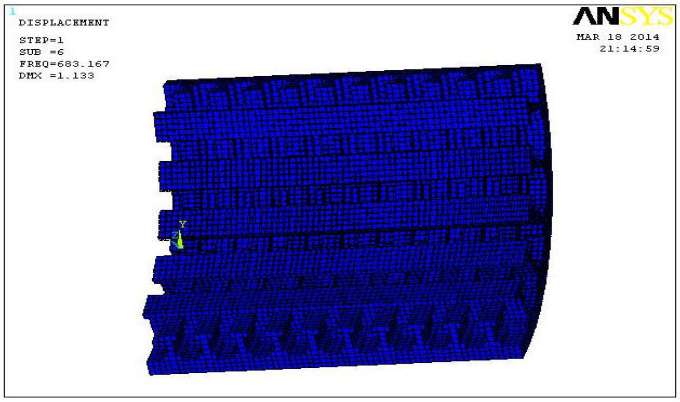

Fig. 14 6th Mode Shape of I- section (Carbon Fiber)

IV. TABLES OF STATIC AND MODAL ANALYSIS RESULTS

a) Static Analysis results

Table 1 Deformation and Von Mises Stresses values

Material	Aluminum		Carbon Fiber	
Type of Section	T-Section	I-Section	T-Section	I-Section
Deformation	1.597	0.8375	0.7473	0.4008
Von Mises Stresses	175.31	166.99	176.66	165.65

Deformation for an I-Section is less than T-Section.
Von Mises Stress for Carbon fiber is less than Aluminum.

b) Modal Analysis results

Table 2 Natural Frequency (Hz) values

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

Natural frequencies of Carbon fiber are superior to Aluminum.

CONCLUSIONS

[1] Semi Monocoque structures are the most often used construction for modern day high performance aircrafts.
[2] The main disadvantage with the existing stiffened panels is T-section and the material being used, Aluminum.
[3] Pure Aluminum, due to low strength, is unsuitable for structures.
[4] Alloyed Aluminum is prone to more corrosion than Pure Aluminum. To avoid corrosion, Aluminum cladding has to be done. They are three times more expensive.
[5] Carbon Fiber has less density, high heat resistance, good vibration damping, high chemical resistance compared to Aluminum (Pure or Alloy).
[6] On comparison of I Section with T section, I section has less deformation and low Von Mises Stress.
[7] The vibration characteristics for Carbon fiber are much better than the Aluminum material.
[8] Future work on Transient Dynamic analysis, Harmonic Response analysis and Spectrum analysis can be done.

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