International Journal for Ignited Minds (IJIMIINDS)

Design and Analysis of Effect of Core Thickness in UAV Wing

Puttappa H R[1], Ravi Prakash M[2] & Madhusudhan Reddy[3]

[1]P G Scholar, Dept of Mechanical Engineering, The Oxford College of Engineering, Bengaluru.

[2,3]Asst. Prof, Dept of Mechanical Engineering, The Oxford College of Engineering, Bengaluru.

ABSTRACT: ***Sandwich construction is enormously using in airliner, rocket and satellite structures because of high strength to weight ratio. Sandwich constructed with thin, high strength and high stiffness sheets of fiber or metallic composite material divided by a thick layer of less density substance as shown in Figure 1 The thicker sheet of less density substance commonly known as core material having light foam type (e.g. Rohacell or Nomex core as shown in Figure 2 or metallic honeycomb as shown in Figure 3 or corrugated core as shown in Figure 4. The core material adhesively bonded to the face sheets.***

A sandwich-prepared composite is an exceptional class of composite materials which is fabricated by combining two thin substances but having rigid films with lightweight but having wide core. The core substance is typically prepared which is having less strength substance; however it is having high thickness present the sandwich composite which is having larger bending stiffness and when we take it as whole material will be having less density.

The open and closed compartment prepared foams made up of with the following materials.

- ***Balsa wood***
- ***Polyvinylchloride***
- ***Honeycombs and***
- ***Syntactic foams are frequently used core materials.***

This open and closed compartment metal foam can be called as core materials.

KEYWORDS: Core Thickness, Composite, UAV, Rustom, Wing, Honeycomb, Stress, Stran, Bending Moment, Nestron.

1. INTRODUCTION

Laminates which is made up of glass or carbon fiber-reinforced thermoplastics or largely used thermo set polymers (polyesters, epoxies...) are extensively formed as skin substance. In some of the cases Sheet metal is acts as a skin material.

Main factors depend of the composite material strength is as follows:

The external skins: If the sandwich covered by face sheets on both sides and the whole sandwich is stressed by applying forces on the core of the beam, and then the bending moment will happens by means of shear forces in the sandwich. The outcome of the shear forces are tension in bottom skin face sheet and compression on the top skin face sheet. The core material separated between top and bottom face sheet. If I increase the thickness of the core the composite material will be stronger as stronger. This working principle is same as I beam concept.

Between the core and the skin the adhesive acts as resign: after applying a load on the composite the shear stress on the core and the face material will going to change rapidly. There will be a small amount of shear stress due to applied load and due to bending on the adhesive cannot be neglected. If the adhesive bond between the top face sheet and core material and also core material and bottom face should not be weak because of this there may be leads to a de-lamination.

1.1 Advantage of Sandwich Constructed Composites:

- There is improved bending stiffness to weight ratio when I compared with monolithic construction.
- There is a high resistance to mechanical properties and this leads to a more sonic fatigue.
- There is better damping feature when compared to other materials.
- There is better improvement in the thermal insulation.

But for this project I am going to use specific set of material for the sandwich construction which is already pre determined. I am going to use foam as the core and carbon fiber in the face.

1.2 RUSTOM II

The Aeronautical Development Establishment, a laboratory under the DRDO, in collaboration with HAL and Bharath Electronics Limited, is developing a largely indigenous RUSTOM II which will be in the same class as the predator of the US. It will field advanced capabilities, additional payloads and an endurance of 24 hours. Maiden flight is scheduled for February 2014 and the $342.25 million RUSTOM II project for 10 RUSTOM II UAV’s, spare vehicles and support equipments is planned to be completed by august 2017. Unmanned Aerial Vehicle having medium altitude long endurance. Properties which elaborates the RUSTOM are given below in the table.

Speed	125-175 Kmph
Maximum Altitude	32000 Feet
Operating Altitude	20000 Feet
Maximum Speed	225 Kmph
Stall Speed	110 Kmph

Table 1: Important Parameters of RUSTOM 2.

1.3 Wing of the Unmanned UAV

Wing of the RUSTOM UAV is designed on the concept of two spar wing configuration and it's a high wing.

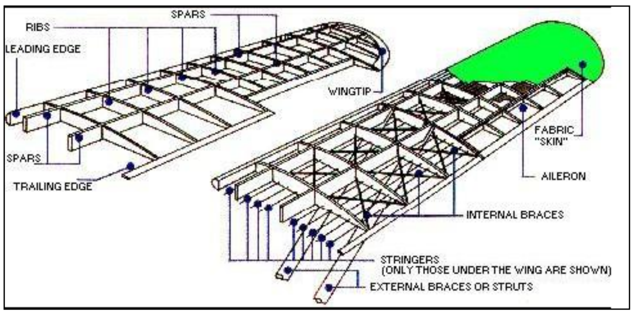

Fig 1: Two Spar Wing Configurations

2. ANALYSIS PROCEDURE

The procedure there were adopted has been described in detailed in this chapter. It includes design of the sandwich constructed composite in CATIA V5 and analyzing it in MSC Nastran. It also includes analysis of sandwich constructed composite by two methods.

1. Three point bending method
2. Linear static analysis

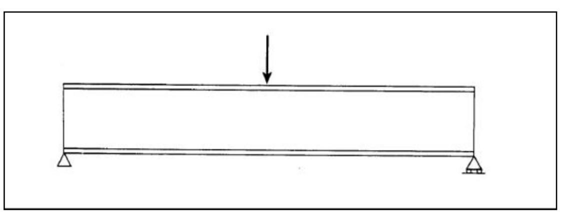

Fig 2: Sandwich Beam is analyzed using Three Point Bending.

To demonstrate the potentials and drawbacks of obtainable sandwich theories, here I am explaining the sandwich beam using three point bending load. The overall behavior and local behavior nearest to the load applied and also considered the support in the beam. And I have to find overall behavior and local behavior for two various sandwich core thicknesses.

2.1 Core Thickness: 5mm, 10mm

The core thickness with 5mm and 10mm is analyzed and compared with the classical theory and superposition approach theory.

As per classical theory is considered in this example, the faces thickness is less compared to sandwich thickness and the core is weaker than that of the faces. The deformations are considered are the combination of two quite individual parts. The initial deformation happens because of the deformation as per the ordinary beam theory. The next deformation is happens because of deformation as per the shear deformation in the core. By considering these above points the differential equations are derived as follows.

$$D_S \cdot \frac{d^4 w_b}{dx^4} = 0 \text{ (ordinary beam theory)}$$

$$\frac{dw_s}{dx} = \frac{-F/2}{A_s G_c} \text{ (shear deformation)}$$

Where,

$$D_s = \frac{b_s E_f d_f E_f d_b d^2}{E_f d_t + E_f d_b}$$

$$A_s = b_s d$$

$$d = \frac{d_t}{2} + 2 + \frac{d_b}{2}$$

$$c = h_s - (d_t + d_b)$$

In these equations w_b and w_s are the perpendicular displacements because of bending respectively shear deformations. D_S can be referred as flexural rigidity and $A_S G_C$ is referred as sandwich beam shear stiffness. No apply boundary conditions as x=0 and x=l/2 is:

$$\varphi_b(x = 0) = 0$$

$$w_b(x = l_s/2) = 0$$

$$D(x = l_s/2) = {-F}/{2}$$

$$M(x = l_s/2) = 0$$

$$w_s(x = l_s/2) = 0$$

After applying boundary condition rotation of the beam is referred as φ_b, shear force is referred as D and the bending moment is referred as M. Deflection due to bending and shear can be solved by using analytical method by applying boundary conditions, the equation can be written as follows;

$$w_b(x) = \frac{F}{12D_s}x^3 - \frac{Fl_s}{8D_s}x^2 + \frac{F{l_s}^3}{48D_S}$$

$$w_s(x) = \frac{-F}{2A_sG_c}x + \frac{Fl_s}{4A_sG_c}$$

By using derived constitutive relations we can easily calculate the shear force, bending moment, shear stress and membrane stress in the core and faces.

Sandwich beam stresses strains are found out by

Axial Strain:

$$\epsilon_{xx}(x,z) = -z\frac{d^2w}{dx^2}$$

Axial Stress:

$$\sigma_{xx}(x,z) = -zE(z)\frac{d^2w}{dx^2}$$

2.2 Bending Moment of the Beam

$$M_x(x) = \int z\,\sigma_{xx}dz = -\left(\int z^2E(z)dz\right)\frac{d^2w}{dx^2} = -D\frac{d^2w}{dx^2}$$

The quantity *D* is called the flexural stiffness

By considering the above equations and I can say the stress in the sandwich beam which is having core thickness *2h*, the modulus elasticity of core E^c , face sheet thickness of two numbers *f* the modulus elasticity of fiber E^f can be written as below equation.

$$\sigma_{xx}{}^f = \frac{zE^fM_x}{D}$$

$$\sigma_{xx}{}^c = \frac{zE^cM_x}{D}$$

$$\tau_{xz}{}^f = \frac{Q_xE^f}{2D}[(h+f)^2 - z^2]$$

$$\tau_{xz}{}^c = \frac{Q_x}{2D}[E^c(h^2 - z^2) + E^f f(f+2h)]$$

3. LINEAR STATIC ANALYSIS

When loads apply on a body, the body get deforms and the loads will be transmitting all the way through the body. The state of equilibrium induces when the external loads induce internal forces and reactions to render the body.

Linear Static analysis calculates the following;

1. Displacements
2. Strains
3. Stresses and
4. Reaction forces under the effect of applied loads.

3.1 Assumption of Linear Static Analysis

Static Assumption: To get full magnitude the loads should apply slowly and gradually. The loads remain constant (time-invariant) once after reaching their full magnitudes. Due to negligibly small accelerations and velocities the above assumption I can conclude inertial and damping forces are neglected. In many cases induces considerable inertial and damping forces that cannot be neglected due to dynamic loads change with time.

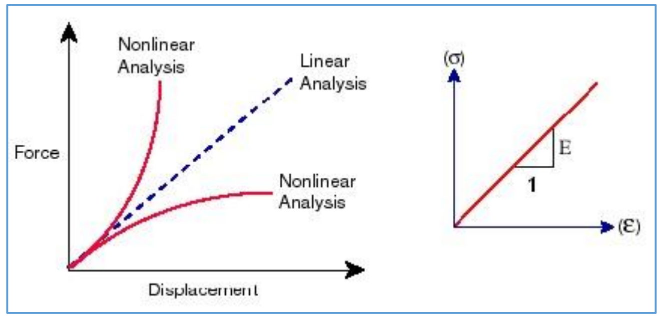

Fig 3: Assumption of Linear static analyses

Linear static analysis for this sandwich panel is done with the help of software package MSC nastran.

With the help of linear static method, ply stress in each ply is found. And ply stress for the various.

In this example a classical theory, a superposition approach theory is compared for the above two core thickness.

Deflection of sandwich panel along the x axis with separate deflection value accounting shear and bending with total deflection

3.2 Deflection of Sandwich Panel along the X Axis Core Thickness 5mm

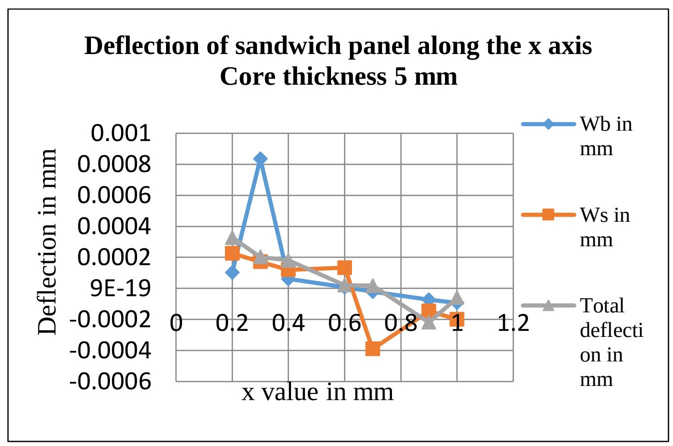

Fig 4: Deflection of Sandwich Panel along the X Axis Core Thickness 5mm.

3.3 Comparison of Theories for Stress Due to Bending for 5 mm

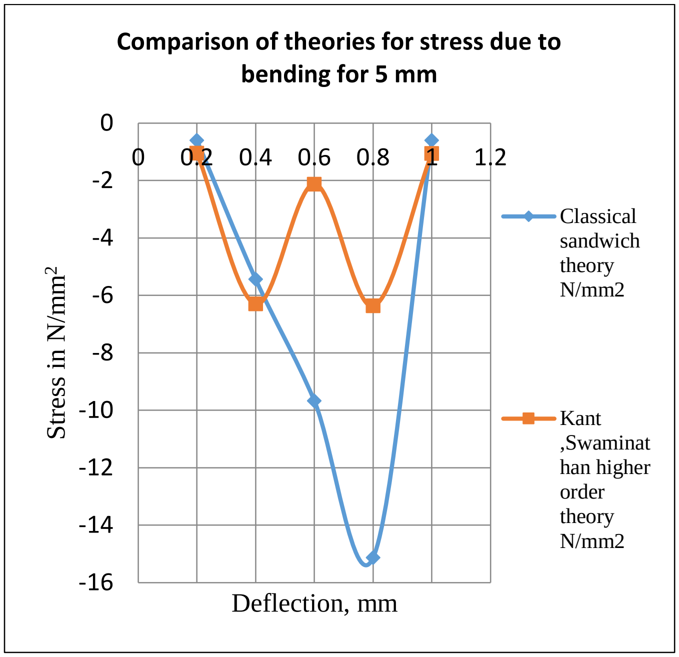

Fig 5: Comparison of Theories for Stress due to Bending For 5mm.

3.4 Comparison of Theories for Axial Strain for 5mm

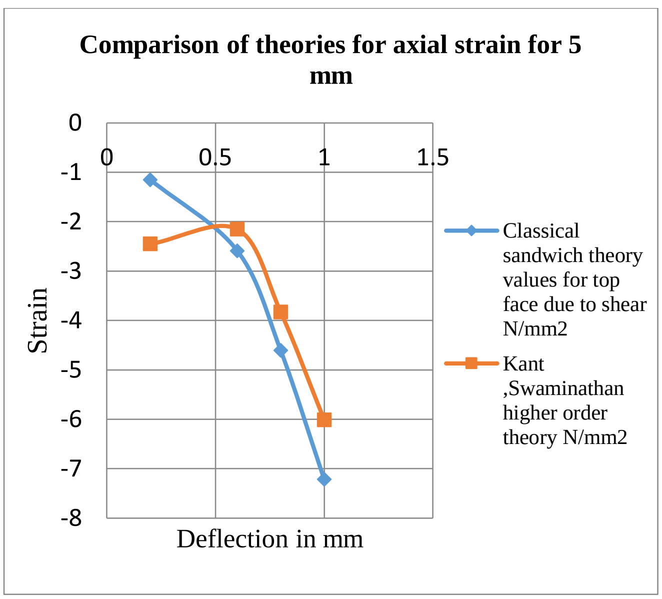

Fig 6: Comparison of Theories for Axial Strain for 5 mm.

3.5 Comparison of Theories for Displacement Due To Shear 5mm (Top)

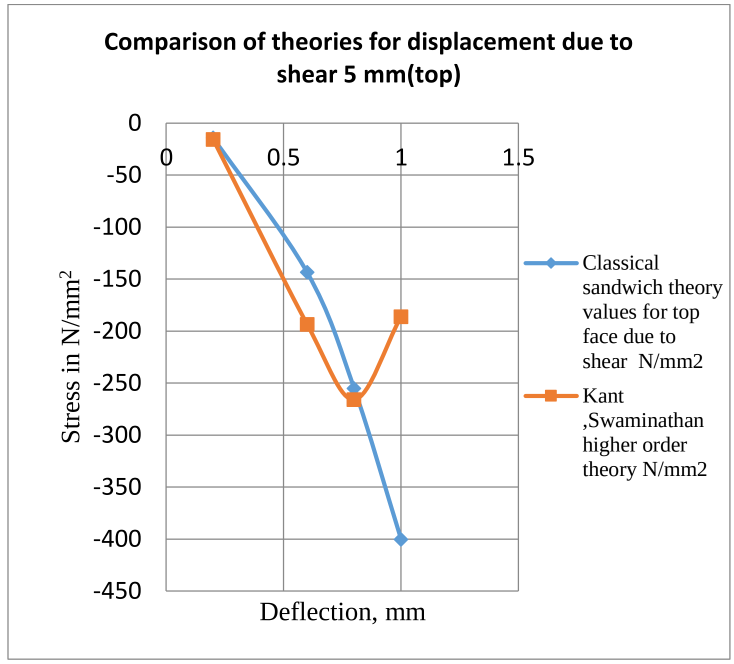

Fig 7: Comparison of Theories for Displacement due to Shear 5mm (top).

3.6 Deflection along Y Direction for 10mm Core Thickness

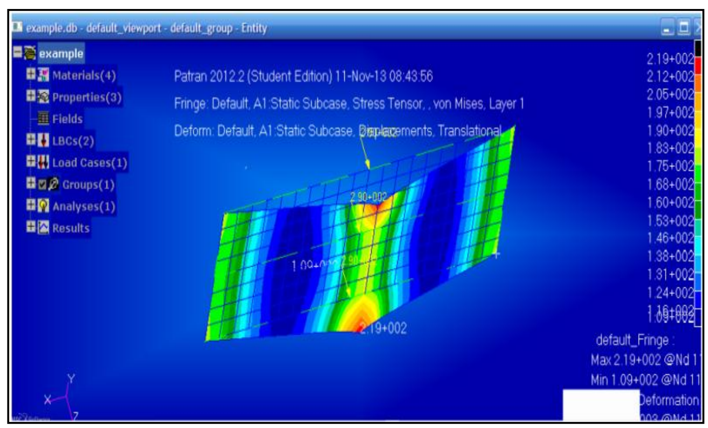

Fig 8: Deflection along Y Direction for 10mm Core Thickness.

3.7 Comparison of Theories with MSC Nastran for 5mm Displacement due to Bending

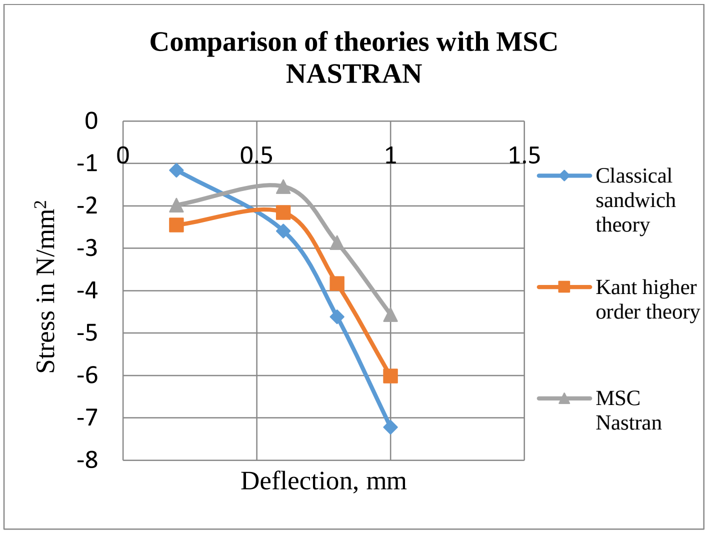

Fig 9: Comparison of Theories with MSC Nastran for 5mm Displacement due to Bending.

3.8 Stress Variation along Y Direction for 10mm Core Thickness

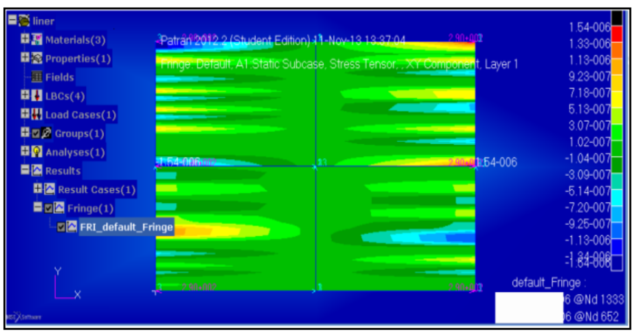

Fig 10 - Stress Variation along Y Direction for 10mm Core Thickness.

4. CONCLUSION

So, based on the classical theories to the highly advanced theories, we come to conclusion that sandwich panel with high core thickness has high stiffness and flexural rigidity. Moreover this is confirmed with the help of overall stiffness value from the theories.

This is further more that this phase of project work is concerned with the study of sandwich theories and a software package relates to sandwich constructed composites.

Since software package we concerned in this project gives exact results. So, it is worth to continue our project with the help of this software packages.

Moreover, from this observation sandwich panel with foam proves better than honey comb core.

Then the given two material ROAHCELL r51 and carbon t300 are highly efficient when compare with other combination.

REFERENCE

1. Torayca t300 data sheet "fiber, composite properties of carbon t300".
2. Msc/patran laminate modeler course pat 325
3. Paulkuhn, "*Analysis Of &Par Cantilever Wings with Special Reference to Torsion and Load Transference*".
4. Deshpande, "*The Design of Sandwich Panels with Foam Core*".
5. Ijsbrand j. Van straalen "*Comprehensive Overview Of Theories For Sandwich Panels*"
6. B. Woodward, M. Kashtalyan. "Bending response of sandwich panels with graded core: 3d elasticity analysis".
7. Salih n. Akour et al., "*Effect of core material stiffness on sandwich Panel behavior beyond the yield limit*".
8. T. Kant et al., "*Analytical Solutions For The Static Analysis Of Laminated Composite And Sandwich Plates Based On A Higher Order Refined Theory*"
9. Aditya kotikalpudi "aerodynamic analysis using xflr-5".
10. S.Rajagopal and Ranjan ganguli "*Multidisciplinary Design Optimization of Long Endurance Unmanned Aerial Vehicle Wing*".