ISSN 2277 – 5528
Impact Factor- 4.015

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES &MANAGEMENT

ADAPTIVE DESIGN AND FINITE ELEMENT ANALYSIS OF FUSELAGE FLOOR BEAM OF AN AIRCRAFT

Shreepannaga[1], Mr Vishwash B[2] and Dr. Mallikappa[3]
[1]Mtech Scholar, MechanicalDepartment, NMAMIT, Nitte
[2&3]Faculty, Mechanical Department, NMAMIT, Nitte

ABSTRACT

The study has been carried out on aircraft systems, then type of aircraft system and on different aircraft parts. Then the study has been continued with the basic directions of aircraft and basic materials used in the aircraft systems. The study has been carried out on fuselage pressure bulk head and it is continued with the study of fuselage flight station for transport. The study has been carried out on aircraft structures. Study has been continued with the Shear force diagram and Bending moment diagram which was required for the analysis of floor beam. The literature reviews has been carried out from the journals. The calculations have been carried out using basics of mechanics of materials in order to get the maximum bending moment and maximum shear stress. The same has been carried out to get the maximum deflection. Study has been carried out on MAT Lab. Using MAT lab deflections has been varied and the best has been selected. The study has been carried out on beam theory. The calculations has been done using beam theory. Best deflection value has been collected. As soon as the analytical part has been finished then using Ansys10 analysis has been carried out on fuselage floor beam, which was the main intension of our mini project. The answers have been compared and the best results has been concluded.

Keywords: *Fuselage, Ansys, Floor beam*

1. INTRODUCTION

An aircraft is a machine that is able to fly by gaining support from the air. It counters the force of gravity by using either static lift or by using the dynamic lift of an air foil, or in a few cases the downward thrust from jet engines.Aircrafts can be classified based on Category and Usage.Aircrafts based on Category are classified as, lighter than air,heavier than air.Aircrafts based on Usage are classified asCivil Transport Aircraft, Military Aircraft and Space Vehicles. [1]The fuselage, or body of the airplane, is a long hollow tube which holds all the pieces of an airplane together. The fuselage is hollow to reduce weight. As with most other parts of the airplane, the shape of the fuselage is normally determined by the mission of the aircraft.It contains, cylindrical shape for containing pressure, streamlined to reduce Drag, nose houses Radar, carries a part of the fuel, it is the main structure or body of the aircraft. Types of fuselage structure contains, truss structure, monocoque, semi monocoque. The fuselage is fully Monocoque structure made of high strength aluminium alloy. It also includes other high technology materials such as titanium, corrosion resistance steel and carbon composites for primary structures, fiberglass and Kevlar for the secondary components. Elements of Fuselage section contains, Frames / Bulkheads,skin, Stringers &longerons.[1]The first aircraft had two wings made of light weight wood frames with cloth skins, held apart by wires and struts. The upper wing and the struts provided compression support while the lower wing and the wires supported tension loads. In the 1920s, metal began to be used for aircraft structure. A metal wing is a box structure with the skins comprising the top and bottom, with front and back formed by I-beams called spars, interior fore-aft stiffeners called ribs, and in-out stiffeners called stringers. . Rivets are the preferred fastening method in bridges and buildings mainly because such joints provide some structural damping via internal friction in the rivet-hole and plate-plate interfaces. This damping reduces vibrations and oscillations. [2]Comparing with conventional airliner, the length of fuselage for flying–wing configuration is dramatically less. The structure weight of outer wing can be reduced. It means for the same wing span, the weight penalty for the flying-wing is less than the conventional one. However, there are many challenges for flying-wing. At the beginning, it is thought that this configuration can have enough capability to carry more passengers, and also have enough room for more fuel tanks.The auxiliary structures for skin are the stringers and frames. Stringers just sustain the axial loads from bending moment in the ideal condition. The function of frames is the shape containing of the fuselage and the length reduction of stringers. Reinforced frames (bulkheads) can distribute the concentrated forces from the heavy load such as wings and landing gear. [3]The design process starts with a sketch of how the airplane is envisioned. Weight is estimated based on the sketch and a chosen design mission profile. A more refined method is conducted based on calculated performance parameters to achieve a more accurate weight estimate which is used to acquire the external geometry of the airplane.The wing is the part that provides an essential asset for heavier than air flight, the lift. Sadly this lift is not free; the price of drag is a cumbersome one that accompanies lift. [4]

ISSN 2277 – 5528
Impact Factor- 4.015

2. ADAPTIVE DESIGN & FE ANALYSIS

Based on Mechanics of Material

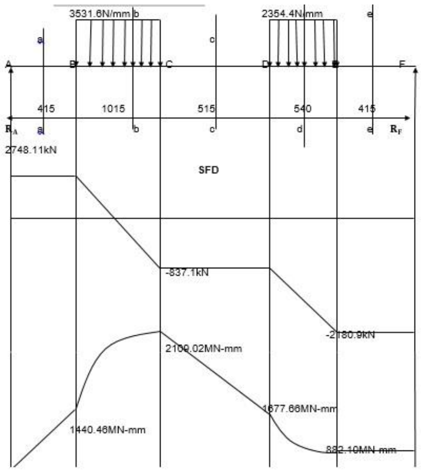

Fig.1. Schematic of the load variations.

Summation of forces equal to zero. i.e. . I.e. sum of upward forces is equal to sum of downward forces. Since it is a uniformly distributed Load we have to multiply with distances to get point load.

$$R_A + R_F = (F_1 * L_1) + (F_2 * L_2)$$

$$= (3531.6*1015) + (2354.4*540)$$

$$\underline{R_A + R_F = 4855.95 \text{ kN.}}$$

Summation of moments about A is equal to zero, i.e. $\sum M_A = 0$.

$$R_F * L_5 = \left[(F_1 * L_2) * \left(L_1 + \frac{L_2}{2}\right)\right] + [(F_2 * L_4) * (L_1 + L_2 + L_3 + \frac{L_4}{2})]$$

$$R_F = (3.306*10^9 + 2.81*10^9)/2900$$

$$R_F = 2108.96 \text{ kN.}$$

Therefore, = 2746.99 kN.

i. SFD and BMD at section a-a:

Shear stress, $\boldsymbol{\tau} = R_A = 2746.99\text{kN}$.

Bending Moment, $M_x = (R_A * x)$, @ x=0 and x= 415,

$$M_0 = 0, M_{415} = 1140.46 * 10^6 \text{ N} - \text{mm.}$$

Since there is a sudden drop in shear force diagram from positive side to negative side there will be point of contraflexture. By substituting the Shear stress of the section b-b zero, we will get the value of point of contraflexture. Then by using that value we need to find out maximum bending moment.Maximum Bending Moment,

$M_{max} = 2746.99 * 10^3 \times 1192.83 - 3531.6(1192.83-415)$

$$M_{max} = 3273.94 \times 10^6 \text{ N} - \text{mm.}$$

Considering I section,

I section is symmetric and outer fibre will have more stress

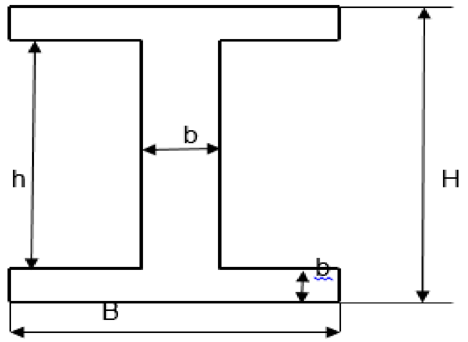

Fig. 2. Cross-section of I section

Let us consider the values for b, B, h, H.

b= 20mm, B= 450mm, h= 450mm, H=490mm.

Section modulus, $Z = (BH^3 - bh^3)/6H$……………………………….. (1)

$= \{(450\times490^3)-(20\times450^3)\}/6\times490$

$$\mathbf{Z= 17.38\times10^6 mm^3.}$$

Bending stress, $\boldsymbol{\sigma_b} = \frac{M_{max}}{Z}$**…………………………….(2)**

$= 3276.13\times10^6 / 17.38\times10^6$

$$\boldsymbol{\sigma_b} = \mathbf{188.5\ MPa}$$

Shear stress τ, $\tau = (F \times A \times y)/(b \times I)$………………. (4)

$= (2748.11\times10^3 \times 27000 \times 1399.62)/(20 \times 4.26 \times 10^9)$

$$\boldsymbol{\tau} = \mathbf{1218.9\ N/mm^2}.$$

Principal stresses,

$$\boldsymbol{\sigma_1, \sigma_2 = \frac{\sigma_x+\sigma_y}{2} \pm \sqrt{[(\sigma_x - \sigma_y)/2]\text{^}2 + \tau^2}}\text{……… (5)}$$

$$= \frac{188.5}{2} \pm \sqrt{\left(\frac{188.5}{2}\right)^2 + 1218.9^2}$$

$$\boldsymbol{\sigma_1 = 1316.78 N/mm^2, \sigma_2 = -1128.28 N/mm^2}.$$

According to distribution energy theory, Considering Al-T7351 material, yield strength$\sigma_y = 421$ MPa,

$$\sigma_c = \frac{\sigma_{yield}}{FOS}\text{……………….. (6)}$$

$$\sigma_c = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2}\text{….. (7)}$$

FOS= 2.5

The maximum deflection can be find out by using the formula,

$EIy = R_A \times \frac{x^3}{6} - (F_1 \times L_2) \times \left(\frac{x^3}{6} - 922.5\right) - (F_2 \times L_4) \times (\frac{x^3}{6} - 2215) + c_1 \times x)$

Deflection, **y= 9.674mm=0.0096m.**

Based on Beam theory: In beam theory, we can show the distribution in point load manner. It is the advantage of using Beam theory. The equation for shear force, bending moment, bending deflection for the freely supported beam with point load are given by

$$Q(x) = Pb/l \quad 0<x<a$$

ISSN 2277 – 5528
Impact Factor- 4.015

$$Q(x)=-Pa/l \quad a<x<l$$

$$M(x)=Pbx/l \quad 0\leq x\leq a$$

$$M(x)=(l-x)/l \quad a\leq x\leq l$$

$$fmax=-Pbx\ (l2-b2-x2)/6lEI \quad 0\leq x\leq a$$

$$fmax=-Pb\ [(l2-b2-x2)+lb(x-a)\ 3]/6lEI \quad a\leq x\leq l$$

Where, Q= Shear force, M= the bending moment.

The value of maximum deflection at each point is tabulated below

Table 1: Maximum Deflection

Point	1	2	Aisle	3	4
Distance(m)	0.415	0.935	1.450	1.965	2.485
Max. deflection (m)	2.76×	8.73×	9.39×	8.73×	2.76×

3. RESULTS & DISCUSSIONS

FE analysis is done using ANSYS software for both uniformly distributed load and also for point loads using beam section.

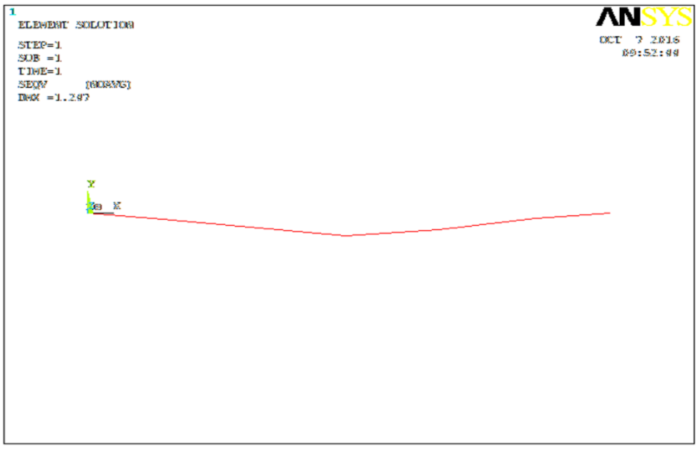

Fig.3 Ansys Solution for UDL

ISSN 2277 – 5528
Impact Factor- 4.015

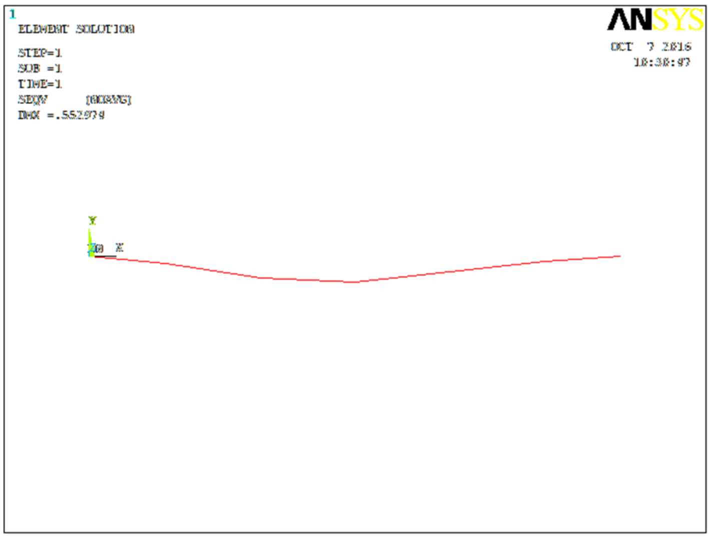

Fig.4 Ansys solution for point load

Floor beam analysis design is done using Ansys10.0. The value of displacement is obtained. When this Ansys displacement value is compared with the analytical value, it is found that the values are close to each other.

4. CONCLUSION

Floor beam analysis design is done using Ansys10.0. The value of displacement is obtained. When this Ansys displacement value is compared with the analytical value, it is found that the values are close to each other.

To find deflection using numerical method, we used two theories. They are "Based on basics of mechanics theory" and "Based on beam theory". While comparing the deflection values, we found that the calculated value of deflection using beam theory was lesser than that of the value calculated using basic of mechanics theory.

5. ACKNOWLEDGEMENT

I would like to thank all who supported me to carry this work. I would like to extend my heartful thanks to my guide Mr. Vishwash. B for his great support. I also thank our HOD Dr.ShashikanthKarinka foe his support.

REFERENCES

1. *T.H.G Megson, "Introduction to Aircraft Structural Analysis", 2013*
2. *YUN CHENG, "PRELIMINARY FUSELAGE STRUCTURAL CONFIGURATION OF A FLYING-WING TYPE AIRLINER ", 2012.*
3. *K. Sainath, "Reduced Order Modelling of Aircraft Structural Assembly using Spectral Finite Element Method", 2012.*
4. *Ghassan M. Atmeh, ZeaidHasan and FerasDarwish, "Design and Stress Analysis of a General Aviation Aircraft Wing", COMSOL Conference 2010 Boston.*
5. *J. Scherer, D. Kohlgrüber, F. Dorbath, M. Sorour, "A FINITE ELEMENT BASED TOOL CHAIN FOR STRUCTURAL SIZING OF TRANSPORT AIRCRAFT IN PRELIMINARY AIRCRAFT DESIGN", DeutscherLuft- und Raumfahrtkongress 2013, Document ID: 301327.*

51