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Optimization of Longitudinal Stiffening Members of a Fuselage Structure

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Abstract **-Transport aircraft is a highly complex structure. The aircraft fuselage shell is composed of stressed skin, longitudinal stringers, and circumferential frames. The present work focuses attention on damage tolerance design of a fuselage structure of transport aircraft. The objective of this work is to design the longitudinal stiffening member and analyse with the different methods to determine the total deformation and equivalent stresses with different loading conditions and varying materials to obtain an optimum result.**

Keyword: SIF, CAD, COD, VCE

I. INTRODUCTION

Stiffeners are secondary plates or sections which are attached to beam webs or flanges to stiffen them against out of plane deformations. Almost all main bridge beams will have stiffeners. However, most will only have transverse web stiffeners, i.e. vertical stiffeners attached to the web. Deep beams sometimes also have longitudinal web stiffeners. Flange stiffeners may be used on large span box girder bridges but are unlikely to be encountered elsewhere.

A. Types of Stiffener

There are two principal types of stiffener:

- Transverse stiffeners, which are aligned normal to the span direction of the beam
- Longitudinal web stiffeners, which are aligned in the span direction.

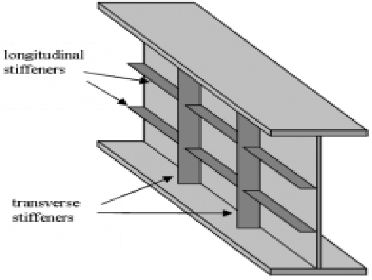


Figure 1.1 Different types of stiffeners

The web of plate girder is so thin that there is always tendency for diagonal buckling and vertical buckling. Therefore, stiffeners are provided. In welded plate girders, plates, angles, tees and closed sections are used as stiffeners. The outstand of the stiffener should not be less than that.

B. Connections to the Flange

Transverse web stiffeners are sometimes welded to the flange, and sometimes stopped just short of either or both flanges. The necessity for a connection to a flange depends on whether forces need to be transferred to the flanges. If there is a significant axial force to be transferred to the stiffener from one of the flanges it will be necessary to weld the stiffener to that flange.

C. Cope Hole

At the corner of a transverse web stiffener where the stiffener plate meets the web to flange weld, it will be necessary to shape the stiffener to avoid the weld.

There are two options, either snipe the stiffener to suit the web to flange weld and weld up all the interfaces, or provide a cope hole. Although the first option requires welding one weld on top of another, this detail may be easier to fabricate than the second, because it is difficult to satisfactorily complete continuous welds around cope holes and apply paint to all of the surfaces.

II. LITERATURE REVIEW

Fatigue loads in a pressurized fuselage are mostly due to pressure cycles that occur with each takeoff or landing cycle during flight. The most common fatigue crack orientation in a pressurized fuselage is a longitudinal crack along the direction of maximum hoop stress. Damage tolerant designs use fracture mechanics data and analysis to predict crack growth rates and critical crack lengths [1]. Cabin pressure results in radial growth of the skin and this radial growth is resisted by frames and stringers giving local bending along the fastener lines. Fuselage skin panels are curved and these panels are under biaxial tension loading due to cabin pressure. The objective of paper was to present a systematic investigation of the damage tolerance design capability of typical aircraft fuselage structure for longitudinal cracks using linear elastic fracture mechanics [2]. Damage tolerant fuselage is supposed to sustain cracks safely until it is repaired or its economic service life has expired. Strength assessment of the structures is necessary for their in service inspection and repair. Damage tolerance analysis should provide information about the effect of cracks on the strength of the structure. Damage tolerance evaluation must include a determination of the probable locations and modes of the damage due to fatigue, or accidental damage. The aircraft must be capable of successfully completing a flight during which likely structural damage occur as a result of bird impact as specified in Federal Aviation Regulations 25.631 [3].

The crack propagation stage is studied by using stress intensity factor. There are different methods used in the numerical fracture mechanics to calculate stress intensity factors (SIF). The crack opening displacement (COD) method and the force method were popular in early applications of FE to fracture analysis. The virtual crack extension (VCE) methods proposed by Parks[5] and Hellene[4]. Lead to increased accuracy of stress intensity factor results. The virtual crack extension method requires only one complete analysis of a given structure to calculate SIF. Both the COD and VCE methods can be used to calculate SIF for all three fracture modes. However, additional complex numerical procedures have to be applied to get results. The equivalent domain integral method which can be applied to both linear and nonlinear problems renders mode separation possible [6].

III. FEATURE CREATION

"Feature" is an all-encompassing term that refers to all solids, bodies and primitives used in Pro/E Features are used to supply detail to the model in the form of standard feature types. These include blend, sweep, revolve and extrude. We can also create our own custom features using the User Defined option. All of these features are associative. Reference Features allow creating reference planes, reference lines and reference points. These references can assist in creating features on cylinders, cones, spheres and revolved solid bodies.

Assembly

Select all the components and make the assembly of the module for designing process of longitudinal stiffening member. Below figure shows the procedure for assembly of the longitudinal stiffening member

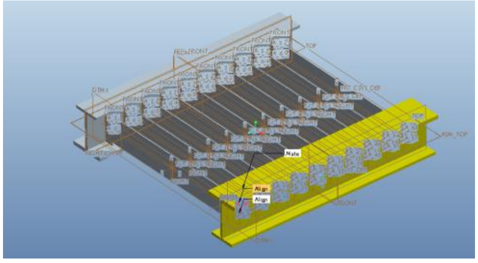


Figure 3.1 Longitudinal stiffening members with constraints

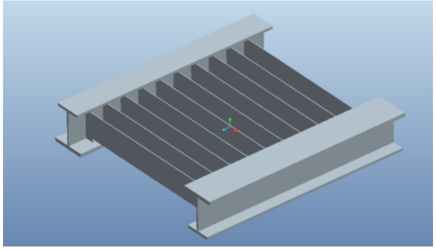


Figure 3.2 Assembly of the longitudinal stiffening members

IV. STRUCTURAL ANALYSIS

Using the design of arresting crack on a fuselage using longitudinal stiffening member, here we are only considering the longitudinal stiffening member and finding the analysis result with acting the different material and with different loads.

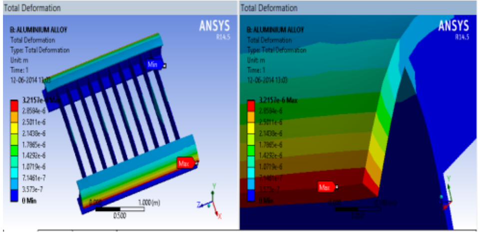
A. Analysis Results

Using the ANSYSR14.5 software we are finding the different analysis results of designed module with acting the different loads and material, below figure shows the procedure of finding the analysis results.

Results 1: Using material Aluminum Alloy

Load: 10kN

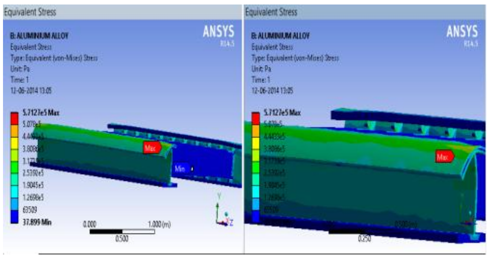
Total Deformation



B: ALUMINIUM ALLOY
Total Deformation
Type: Total Deformation
Unit: m
Time: 1
12-06-2014 13:03

Figure 4.1 Total deformations of Aluminum at load 10kN

Equivalent Stress

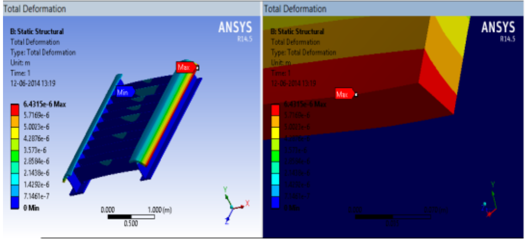


B: ALUMINIUM ALLOY
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: Pa
Time: 1
12-06-2014 13:05

Figure 4.2 Equivalent stresses of Aluminum at load10kN

Load: 20kN

Total Deformation



B: Static Structural
Total Deformation
Type: Total Deformation
Unit: m
Time: 1
12-06-2014 13:19

Figure 4.3 Total deformations of Aluminum at load 20kN

Equivalent Stress

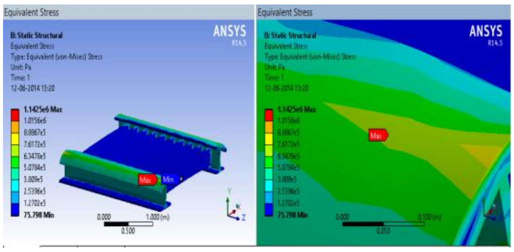


Figure 4.4 Equivalent stresses of Aluminum at load 20kN

Results 2: Using material Stainless Steel

Load: 10kN

Total Deformation

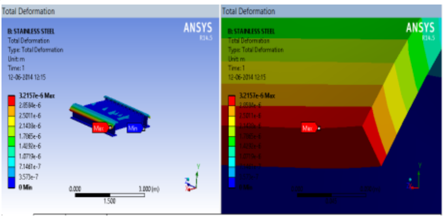


Figure 4.5 Total deformations of Stainless steel at load 10kN

Equivalent Stress

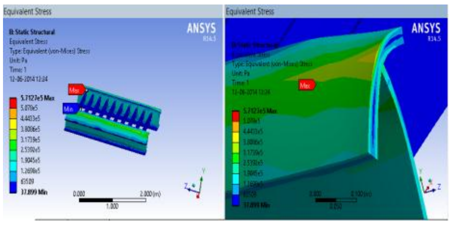


Figure 4.6 Equivalent stresses of Stainless steel at load10kN

Load: 20kN

Total Deformation

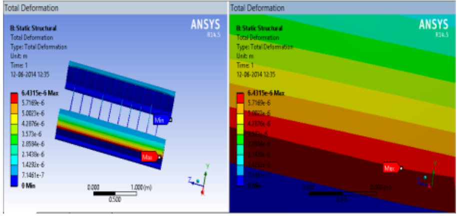


Figure 4.7 Total deformations of Stainless steel at load 20kN

Equivalent Stress

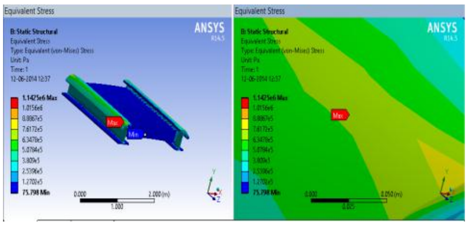


Figure 4.8 Equivalent stresses of Stainless steel at load 20kN

Results 3: Using material Structural Steel

Load: 10kN,Total Deformation

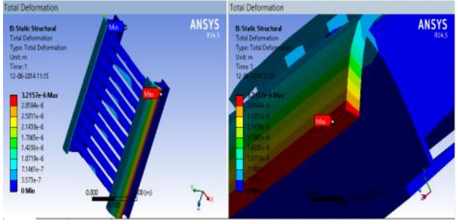


Figure 4.9 Total deformations of Structural steel at load 10kN

Equivalent Stress

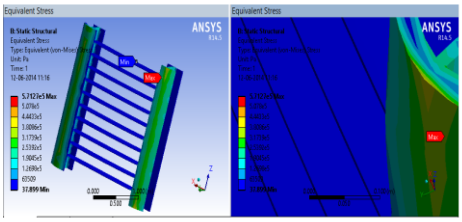


Figure 4.10 Equivalent stresses of Structural steel at load 10kN

Load: 20kN, Total Deformation

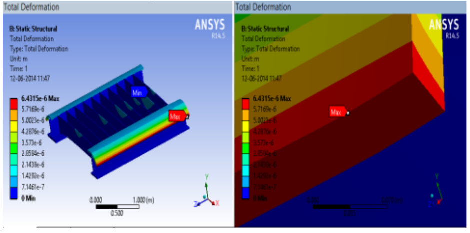


Figure 4.11 Total deformations of Structural steel at load 20kN

Equivalent Stress

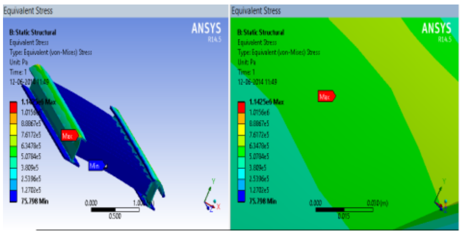


Figure 4.12 Equivalent stresses of Structural steel at load 20kN

V. RESULTS

In the area dynamic the aircraft structural component is very important to define the strength and property of the material.

TABLE 5.1 Analysis Result of Material Aluminum

S. No	Load(KN)	Equivalent Stress(Pa)	Total Deformation(M)
1	10	5.7×10^{5}	3.2×10^{6}
2	20	1.12×10^{6}	6.4×10^{6}

TABLE 5.2 Analysis Result of Material Stainless Steel

S. No	Load(KN)	Equivalent Stress(Pa)	Total Deformation(M)
1	10	5.7×10^6	3.2×10^6
2	20	1.14×10^6	6.4×10^6

TABLE 5.3 Analysis Result of Material Structural Steel

S. No	Load(KN)	Equivalent Stress(Pa)	Total Deformation(M)
1	10	5.7×10^5	3.2×10^6
2	20	1.42×10^6	6.4×10^6

CONCLUSION

Modeling and analysis was done over longitudinal stiffener by using two predominant software Pro-E(CREO) and ANSYS 14.5. CREO is the latest version of Pro-E which is advanced modeling software and by using this modeling of longitudinal stiffener was completed. ANSYS is the most important and predominant software which will use the FEM technique as its principle. For three materials and at two loading conditions results were achieved and tabulated. From those results comparison was done and the stainless steel is having better strength when compared with other materials.

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