# *Design and analysis of fuselage door cut-out panel*

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*Abstract :*

*Aircraft is made up of the several complex machines designed by mankind. It takes lot of complex calculation, assumption and evaluation for designing and manufacturing. Fuselage is the back bone of any aircraft. It is necessary to calculate the load distribution and shear stress distribution on the surface of fuselage while on flight. Cut-outs are unavoidable in all pressurized aircraft fuselages. Especially large cut-outs, like those for doors, remain very fatigue sensitive. They are usually unsuitable to carry many of the loads that are present on the surrounding structure. The direct load paths are interrupted and as a result the structure around the cut-out must be reinforced to maintain the required strength. In this project the cutout section of a fuselage is designed by using CATIA software. And then this cutout section will be meshed for analysis work. For analysis I used NASTRAN/PATRAN software. In PATRAN the preprocessing and post processing work will be done. NASTRAN gives the solved results for the input properties given through PATRAN. In this project I have taken Aluminum and E- Glass composite materials. After analyzing the results for Aluminum and E- Glass composite materials are compared. In both materials the Von - Mises stress value is not exceeding the allowable stress value.*

***Keywords: Fuselage;Cut-outs; Material selection; E-Glass composites; Analysis.***



## 1.INTRODUCTION:

The fuselage is almost invariably built-up as a stiffened shell. Disturbances in the perfect cylindrical shell (fuselage), such as doors and windows, are called cutouts. They are usually unsuitable to carry many of the loads that are present on the surrounding structure. The direct load paths are interrupted and as a result the structure around the cut-out must be reinforced to maintain the required strength. Cutouts are unavoidable in all pressurized aircraft fuselages. Especially large cut-outs, like those for doors, remain very fatigue sensitive. This fatigue sensitivity is due not only to the fact that the cut-out causes a large stress concentration, but also due to the use of the door in service. This increases considerably the chance for accidental damage. When a small dent or other damage has occurred, a fatigue crack is only a matter of time. Fatigue damage can endanger safety, or at the very least leads to expensive repairs. For these reasons stress levels must be kept below carefully defined maximum values.

### 1.1 Cut- outs:

Cutouts in airframe structures disfavor to engineers because the necessary reinforcements of the cutout increases the cost. In addition, the design and sizing of cutouts is a difficult process since it is an area of stress concentration, a problem area for both static and fatigue strength and there is insufficient design data.

Cutouts are essential in aircraft structure to provide the following:

- Lightening holes in webs are frequently used to save structural weight in cases of minimum gage thickness requirements.
- Passes for wire bundles, hydraulic lines, control linkages, fluids etc.
- Accessibility for final assembly and maintenance
- Inspection for maintenance.

While access holes are necessity, they should be kept as small as possible to meet the minimum requirements.

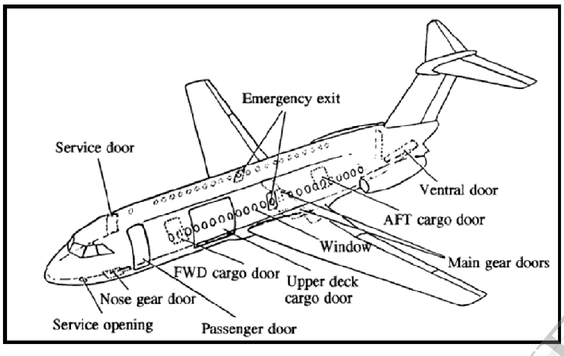


Figure 1 Cutouts on a Commercial Transport Fuselage

## 2. DESIGN CONSIDERATIONS:

In this project the upper deck of a transport fuselage made from aluminum alloys section is taken to find out the stress concentration near the cut-out section. The dimensions for the design are referred from AIRFRAME STRUCTURAL DESIGN Hand book of practical design information and data on aircraft structures. Based on the dimensions the design is drawn using CATIA V5 R17 software.

A 49" x45" cutout section with a radius r = 74" is shown in figure. All dimensions in the following figures are given in inches. Near the door cut-out

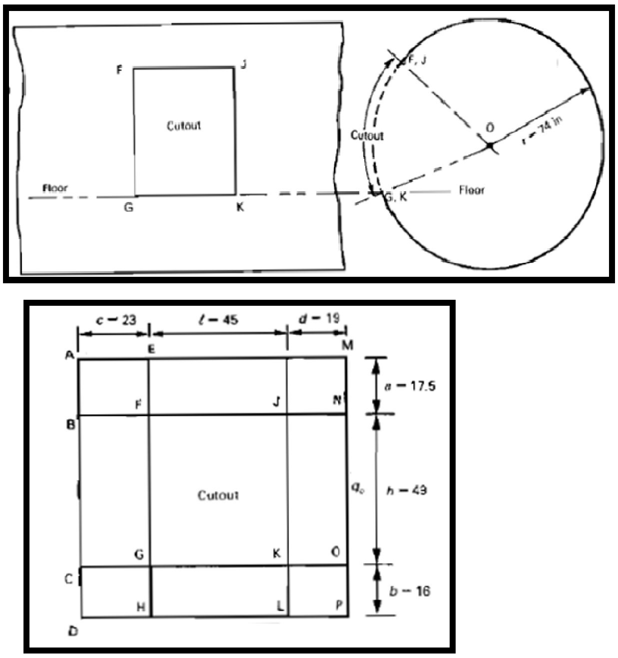


Figure 2 Dimensions for cut-out section

Based on the given dimensions the model is drawn in CATIA software.

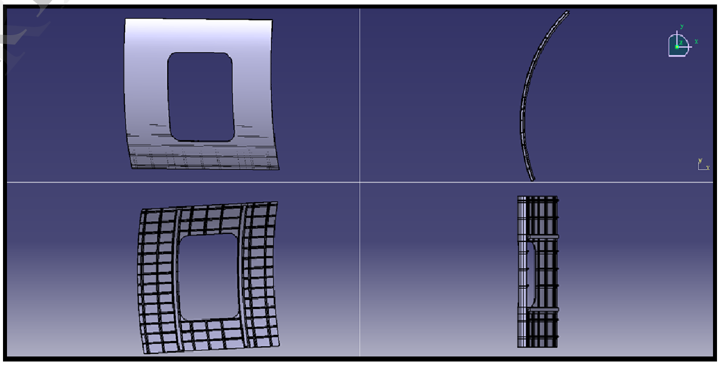

Figure 3 CATIA model

## 3. ANALYSIS WORK:

### 3.1 Preprocessing:

The CATIA IGES file is imported in to the Patran software, the preprocessing work starts from this step. After importing the IGES file the geometry cleanup part takes place. Then mesh the file using QUAD elements. The total part is meshed by QUAD elements.

The selected aluminum material properties are applied over the meshed model. The material properties are given,

| | |
|---|---|
| Elastic modulus | 70000 MPa |
| Poisson's ratio | 0.3 |
| Ultimate strength | 460 MPa |

Table 1 Aluminum material properties

3.2 analysis on aluminum:

3.2.1 Pressure load

The next step is boundary conditions for cabin pressurization. The wall areas are constrained by 123(ie..translation along x,y,z direction) constraints and the pressure load is 8.6 psi. The below figure shows the applied pressure load and the results due to that pressure load on the cut out section.

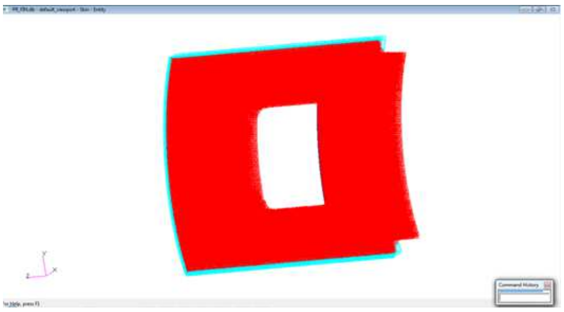

Figure 4 Load/ Boundary conditions –Pressure load (Al)

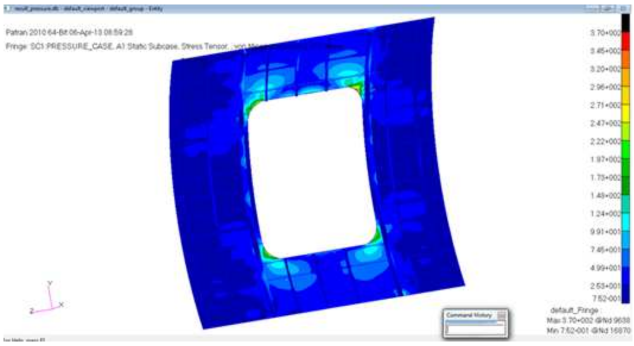

Figure 5 Von-Mises stress plot for Pressure load (Al)

3.2.2 Tensile load:

Tensile load of 500N is given in the skin area near the cut-out section. In this condition the upper and bottom wall areas are constrained with 123 constraints and the load is acting perpendicular to the constraints.



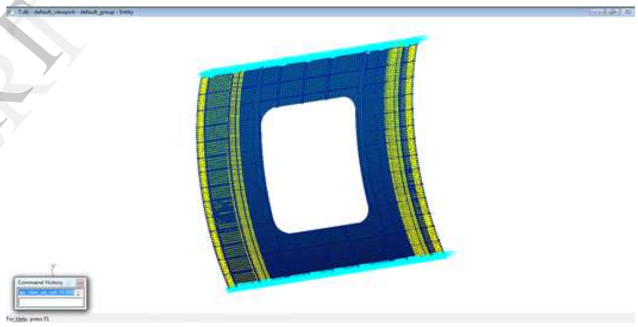

Figure 6 Load/ Boundary conditions –Tensile load (Al)

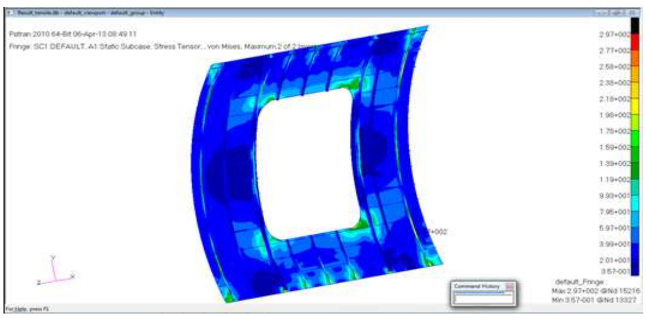

Figure 7 Von-Mises stress plot for Tensile load (Al)

### 3.3 ANALYSIS ON COMPOSITE MATERIAL:

The E-Glass composite material properties are taken for this analysis work. 12 layers of E- Glass composites are arranged in $0^0$ ply orientation. Each layer thickness is 0.3 mm the material properties of E-Glass composites are taken for the analysis work as given below

Table 2

| | |
|---|---|
| Elastic modulus | 25000Mpa |
| Poisson's ratio | 0.20 |
| Ultimate strength | 440 MPa |

Material Properties of E-Glass composites

#### 3.3.1 Pressure load

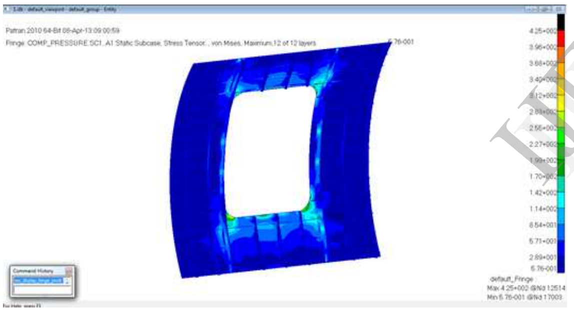

Figure 8 Von-Mises stress plot for Pressure load (E-Glass)

#### 3.3.2Tensile load

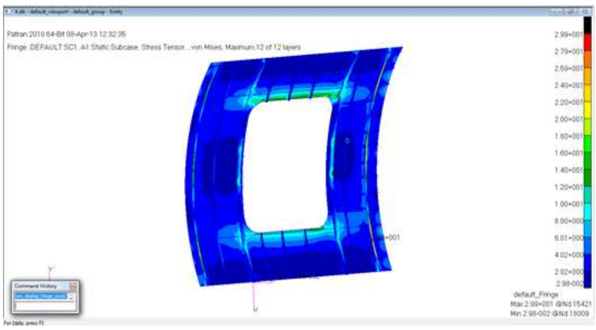

Figure 9 Von-Mises stress plot for Tensile load (E-Glass)

## 4. CONCLUSION:

The fuselage door cutout section For these conditions the stress values from the Von mises stress plot is not exceeding the ultimate strength of the Aluminum material and the E-Glass composite material. The Von mises stress for Aluminum is 370 Mpa and 297 Mpa for the pressure load and tensile load respectively. These stresses are comparatively lower than the ultimate strength of Aluminum material 460 Mpa. So the door cut- out model is in safe condition.

The same load conditions are given to E Glass composite material. For that the Von mises stress results are 425 Mpa and 29.1 Mpa for the pressure load and tensile load respectively. These stresses are comparatively lower than the ultimate strength of E Glass composite material 440 Mpa. So the door cut- out model is in safe condition.

## 5. ACKNOWLEDGEMENT:

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