International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org Volume 3 Issue 8 ‖ August 2014 ‖ PP.37-43

Static and Normal Mode Analysis of Aircraft Avionics Compartment Door

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ABSTRACT : *The aircraft has the following fuselage doors like Passenger door, Galley service door two overawing emergency exits, Flight compartment overhead escape hatch, Cargo door, Avionics compartment door, aft equipment compartment door. The avionics compartment door is used to gain access to the equipment in the avionics Compartment. It is located on the centerline of the lower forward fuselage. The door opens inward and moves up on four spring--loaded roller arms. The door is an important part of the airplane, and the reliability of opening the door has a great effect on flight safety. The inadvertent opening could lead to terrible consequence during flight. In this present work a conceptual design of aircraft door is done using cad software meshing using FEM and analysis using MSc Nastran. The static and normal mode analysis of aircraft door frame and stiffeners is done using aluminum material.*

KEYWORDS: *Aircraft door, Static Analysis, Normal Analysis, Finite Element Model*

I. INTRODUCTION

Passenger door

The passenger door is located at the forward left side of the fuselage and is the main entrance and exit to the cabin area The passenger door incorporates integral stairs with a retractable lower step and folding handrails. The door is hinged at the cabin floor level and opens outward. A counter--balance mechanism with gas springs is used to take the weight of the door and to dampen the door movement at the fully open position, the door rests on a support wheel. Handrails are provided to assist passengers in boarding and disembarking. Mechanical linkages raise the handrails when the door is opened and collapse them when the door is closed. When a jet way is used, the handrails must be collapsed. Collapsing of the handrails is done by removing the forward and aft handrail quick--release pins (Refer to Lowering the Stair Handrails).Closing the passenger door from inside the aircraft is normally accomplished using the power assist system which is controlled from a DOOR ASSIST switch light on the forward flight attendants panel. The passenger door status is displayed on the EICAS primary page in the form of warning and caution messages and on the DOOR synoptic page. The DOOR synoptic page is displayed when selected from the EICAS control panel [1].

A. Static Analysis

A static analysis calculates the effects of *steady* loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. A static analysis can, however, include *steady* inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads (such as the static equivalent wind and seismic loads commonly defined in many building codes).Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects.

B. Normal Mode Analysis

We use Normal mode analysis to determine the vibration characteristics (natural frequencies and mode shapes) of a structure or a machine component while it is being designed. It also can be a starting point for another, more detailed, dynamic analysis, such as a transient dynamic analysis, a harmonic response analysis, or a spectrum analysis. The natural frequencies and mode shapes are important parameters in the design of a structure for dynamic loading conditions,

II. METHODOLOGY AND MATERIAL

The Finite Element Method

Finite element method is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Although originally developed and applied to the broad field of continuum mechanics. Because of its diversity and flexibility as analysis tool, it is receiving much attention in engineering schools and industry. In more and more engineering situation today, it is necessary to obtain numerical solutions to problem rather than exact closed from solutions. The resourcefulness of the analyst usually comes to the rescue and provides several alternatives to overcome this dilemma. One possibility is to make simplifying assumption to ignore the difficulties and reduce the problem to one that can be handled sometimes this procedure works but more often than not it leads to series inaccurate or wrong answers. Now that computers are widely available, a more viable alternative is to retain the complexities of the problem and to find an approximate numerical solution. A finite element model of a problem gives a piecewise approximation to the governing equations‟. The basic premise of the finite element method is that a solution region can be analytically modeled or approximated by replacing it with an assemblage of discrete elements since these can be put together in a variety of ways, they can be put together in a variety of ways, and they can be used to represent exceedingly complex shape. Two features of the finite element method are to be noted

a) The piecewise approximation of the physical field on finite elements provides Good precision even with simple approximating functions. Simply increasing the number of elements can achieve increasing precision.
b) The locality of the approximation leads to sparse equation systems for a discredited problem. This helps to ease the solution of problems having very large numbers of nodal unknowns. it is not uncommon today to solve Systems. Containing a million primary unknowns.

Solution Procedure Using FEM Software

All finite element packages require the user to go through these steps in one form to another

- **Specifying Geometry-** First the geometry of the structure to be analyzed is defined this can be done either by entering the geometric information in the finite element package through the keyboard or mouse or by importing the model from a solid modeler like Pro-ENGINEER.
- **Specify Element Type and Material Properties-** Next, the material properties are defined. In an elastic analysis of an isotropic solid these consist of the Young's modulus and Poisson's ratio of the material.
- **Mesh the Object-**Then the structure is meshed into small elements. This involves defining the types of elements into which the structure will be broken, as well as Specifying how the structure will be subdivided into elements.
- **Apply Boundary conditions and External Loads-** Next, the boundary conditions e.g. .location of supports and the external loads are specified.
- **Generate a solution-** Then the solution is generated based on the previously input parameters.
- **Post processing-** Based on the initial conditions and applied loads, data is returned after a solution is processed. This data can be viewed in a variety of graphs and displays.
- **Refine the Mesh-** Finite element methods are approximate methods and, in General, the accuracy of the approximation increases with the number of elements Used. The number of elements needed for an accurate model depends on the Problem and the specific results to be extracted from it. Thus, in order to judge the number of elements in the object and see if or how the results change.
- **Interpreting Results-** This step is perhaps the most critical step in the entire Knowledge of mechanics to interpret and understand the output of the model. This is critical for applying correct results to solve real engineering problems and in identifying when modeling mistakes have been made.

Thickness (mm)	**Proof strength (min)**	**Tensile strength (mm)**	**Elongation %(mm)**
Over 0.4 up to and include 0.8	350	415	7
Over 0.8 up to and include 1.6	350	420	8
Over 1.6 up to and include 6.0	370	420	9

Material Property: Aluminum Standard BSL 165

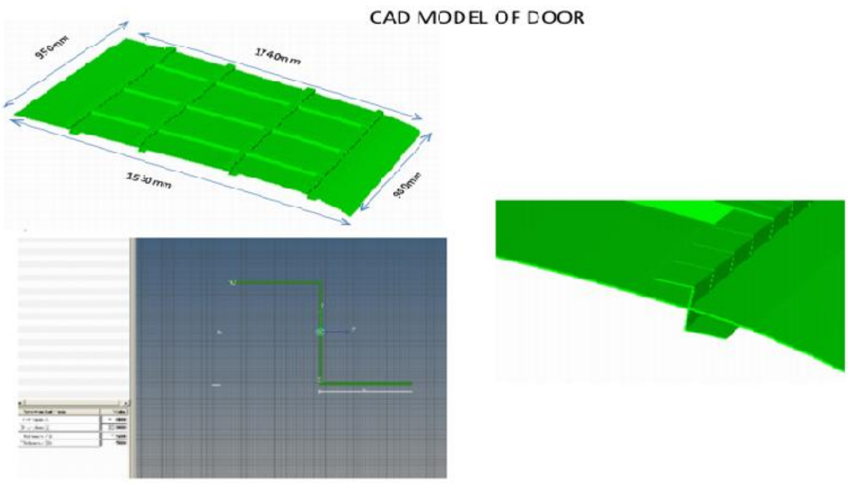
Physical property	Value
Density	2.80 g/cm^3
Melting point	640 °C
Thermal expansion	$22.8*10^{-6}$ k
Modulus of elasticity	73Gpa
Thermal conductivity	155 w/m.k
Electrical resistivity	40%IACS

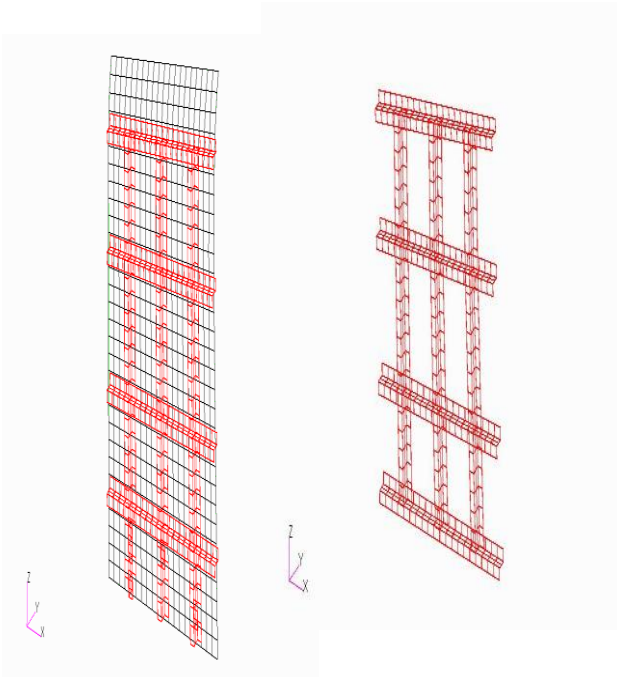
Physical Property: Aluminum Standard BSL 165

III. RESULT AND DISCUSSION

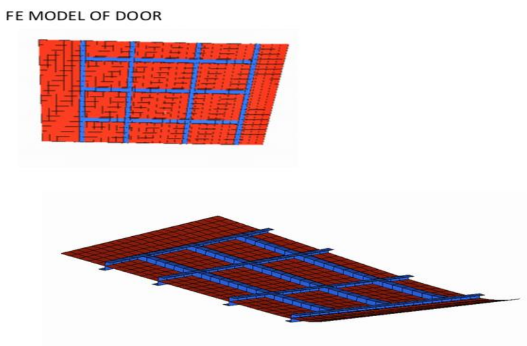
In this present work the door is analyzed by following iterations. In iteration 1 the door skin sheet is analyzed without any stiffeners and the result obtained are not in allowable range, so the work is further proceeded for iteration 2 by providing 4Z shape stiffeners placed horizontally along with the door skin sheet and the results obtained are above the allowable limit, so the work is further proceeded to iteration3 by providing 2Z shape stiffeners vertically along with 4Z shape stiffeners horizontally. By analyzing with these provided stiffeners the door results are well below the allowable limit. Stiffeners provided were well enough to withstand the applied loads. But still there was a chance of heavy displacement so the work is further proceeded to iteration 4 by providing one more additional vertical stiffeners at the center and the door is analyzed the results are well below allowable limit and the displacement is also less and the reserve factor is greater than one (RF>1) as shown in table 1 In this present work if the aircraft frequency matches with the obtained frequency then there is a cause of resonance formation .so to avoid this we have performed normal analysis .Generally the aircraft frequency is in the range of 10 to 15 hz, in this present work obtained frequency are well below the aircraft normal frequency so there is a no chance of forming resonance as shown in table 2 results

IV. FIGURE AND TABLES





Door skin with Z shape stiffeners



Final analysis result (iteration 4)

Fig 1: Displacement of color plot

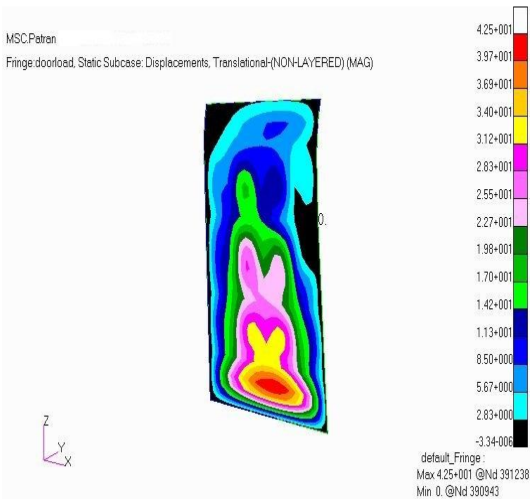


Fig 2: Maximum principal stress

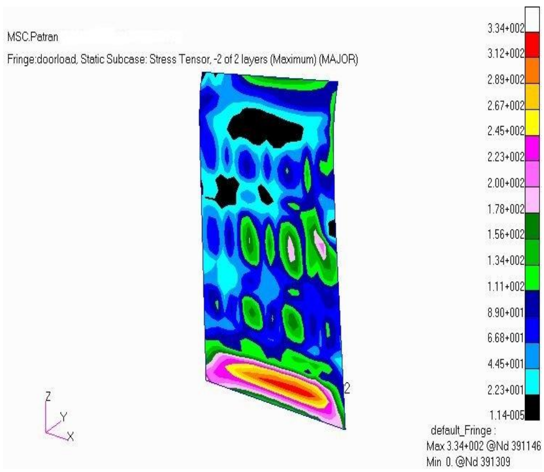


Fig 3: Minimum principal stress

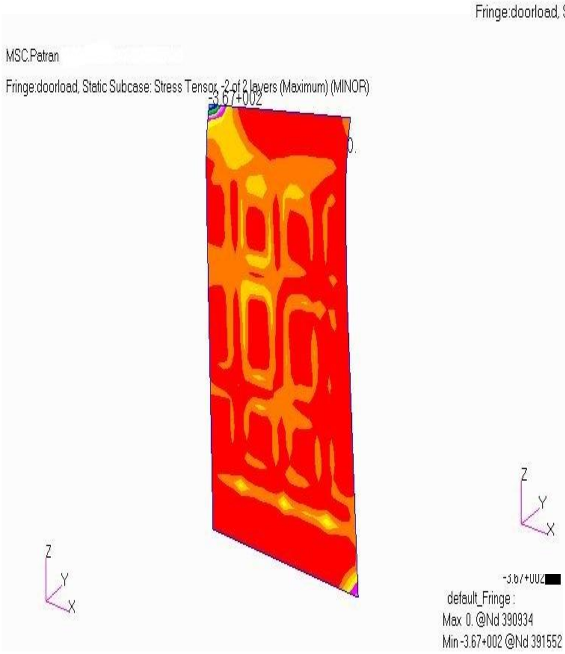


Fig4: Maximum shear stress

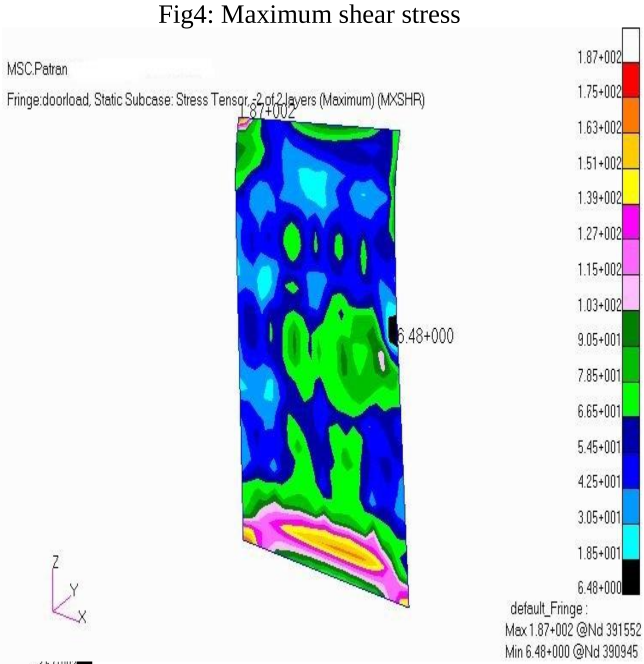


Fig 5: Vonmisses stress

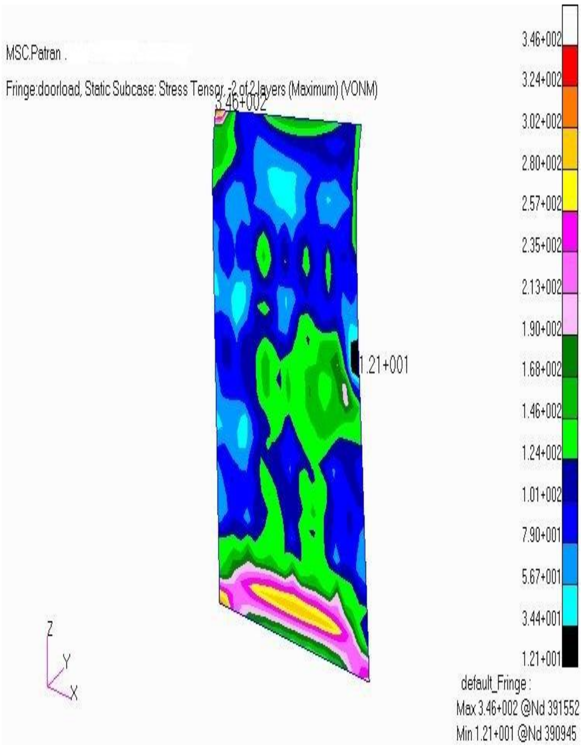


Fig6: Maximum combined at center

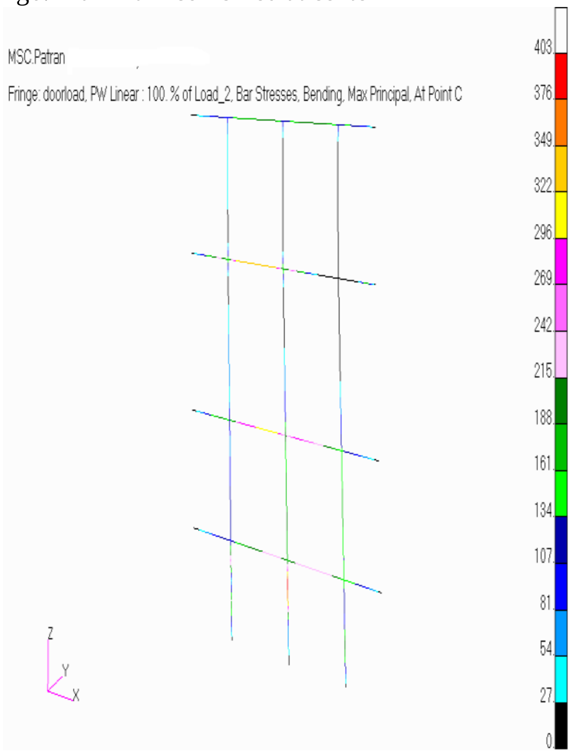


Table1: Conclusion for static analysis

SL.No	Structure component	Material Specification	Type of stress	Developed Stress(Mpa)	Allowable stress(Mpa)	Reserve Factor (RF)	Remarks
1	Door skin with stiffeners	Aluminum Standard: BSL 165	Max Principal Stress	334	415	1.24	RF>1 structure is safe
			Minimum principal Stress	367	415	1.13	RF>1 structure is safe
			Max shear stress	187	247	1.32	RF>1 structure is safe
			Vonmises stress	346	415	1.19	RF>1 structure is safe
			Max combined at center	403	415	1.02	RF>1 structure is safe

Table 2: Conclusion for normal mode analysis

MODE	FREQUENCY	DISPLACEMENT
1	2.9881	0.655
2	4.05	1.23
3	4.27	1.35
4	4.86	1.16
5	5.04	1.62

V. CONCLUSION

From the above static and normal mode analysis we have seen that stress, displacement and frequency are within the limit. In static analysis Z-shape stiffeners are provided for the door skin to provide resistance to the door and import strength to the door for the applied forces and pressure and for the normal mode analysis we have seen that the obtained frequency is in the range of 2-6 Hz less than that of the normal aircraft frequency i.e. 10-15 Hz. So there is no resonance which will not cause heavy vibration and catastrophic failure of the door structure.

VI. FUTURE SCOPE OF THE PROJECT

In this project the door skin and stiffeners are analyzed using the metallic material .In order to reduce the cost of the door assembly and weight .further the door skin along with stiffeners are made of composite so that there is an overall cost reduction and weight of the door structure.

REFERENCES

[1] Bombardier CRJ-200; WWW2. Bombardie.com
[2] MICHAEL CHUN-YUNG NIU “Airframe structural design” practical design information and data on aircraft structures.
[3] Muniyasamy Kalanchiam and Baskar Mannai “Topology Optimization of Aircraft Fuselage Structure”.

[4] KHAIRI YUSUF, NUKMAN Y., S. Z. DAWAL,DEVI CHANDRA, N. SOFIA Conceptual Design of Fuselage Structure of Very Light Jet Aircraft".

[5] KANG JIANXIONG, GAO HANGSHAN, WANG FUSHENG, AND YUE ZHUFENG "Effect of Detail Design on Fatigue Performance of Aircraft Door Frame" Department of Engineering Mechanics, Northwestern Polytechnical University, Xi'an 710129, China

[6] UKADGAONKER, VG; AWASARE, PJ; GADE, SV "Stress analysis of door and window of a passenger aircraft"

[7] Z K Awad1, F Gonzalez2 and T Aravinthan "Advanced robust design optimization of FRP sandwich floor panels". 1 Centre of Excellence in Engineering Fibre Composite (CEEFC), University of Southern Queensland (USQ), Toowoomba QLD 4350, AU 2 Faculty of Built Environment & Engineering, Queensland University of Technology (QUT), Brisbane, AU

[8] SHAH, K., KANG, H., AND DESHMUKH, U., "Design of Dual Sliding Door for a Small-size Car and Its Validation Using CAE Tools," SAE Technical Paper 2007-01-0889, 2007, doi:10.4271/2007-01-0889.

[9] DARYL GRUAR "AUTOMATION PROCESS OF 'KING AIR' AIRCRAFT - CARGO DOOR DESIGN" C/o- Vaughn College of Aeronautics and Technology 86-01 23rd Ave Flushing, NY 11369

[10] BONNIE ROGERS, CHRIS HAMBLIN, & ALEX CHAPARRO "A Comparison of Two Evaluation Techniques for Technical Documentation" National Institute for Aviation