ISSN (O): 2393-8609
International Journal of Aerospace and Mechanical Engineering
Volume 5 – No.4, August 2018

ANALYTICAL METHOD TO DETERMINE THE NUMBER OF STRINGERS IN A DOOR OF A CARGO AIRCRAFT

Umang Rawal
B.Tech in Aerospace Engineering
UPES, Dehradun-248001
Uttarakhand, India
umangrawal1296@gmail.com

Mohit Sharma
B.Tech in Aerospace Engineering
UPES, Dehradun-248001
Uttarakhand, India
mht.shrm15@gmail.com

ABSTRACT
The primary principle for designing a plane is safety, low cost and less weight. In order to achieve this, different components must be designed in a way that they are efficient enough to carry the payload safely. The current work includes an analytical approach to determine the number of stringers that should be used in a door of a cargo aircraft so as to withstand the differential pressure load acting at the altitude of 20,000 ft. with a considerable factor of safety. The pressure loads are one of the most critical load acting on an aircraft structure and therefore stringers are required to increase the overall strength. The optimum thickness of the cargo door skin will also be determined.

General Terms
Extrapolation, stringer, cargo aircraft, aluminum-2024-T6

Keywords
Analytical, Dimension, Stringer, Aircraft door.

1. INTRODUCTION
Strength and weight are the most crucial parameters when designing an aircraft structure because the flight performance depends on them. For a structure to be efficient it has to tackle the adverse pressure gradient, adverse stress conditions and has to be less in weight with less manufacturing cost. It must be constructed in such a way that if the component fails, the failure should not cause loss of life i.e. the design must be fail safe. Success of a cargo aircraft depends on its range and payload capacity so the structure must be designed in a way which fulfills the criteria.

A typical cargo door aircraft door has four major components and they are stringers, ribs, spars and skin. Stringers takes care of bending loads acting on the structure. They generally have a Z, L or T shape because most cargo doors have rectangular cross section so the attachment to the skin is easy. The paper follows an iterative approach to find out the optimum number of stringers that should be used to withstand the differential pressure acting on the aircraft with a considerable factor of safety. This is achieved by assuming the number of stringers and the skin thickness to obtain a rectangular panel on the aircraft door and then further calculating the pressure load factors and the corresponding stress.

The paper aims to give a generalized method that can be used to find the optimum number of stringers that should be used in a door of a cargo aircraft. The paper also includes the approach in selecting the optimum skin thickness so as to reduce the overall weight and increase the strength of the structure. Experimental data of Pressure load Coefficient and their corresponding deflection derived from high speed wind tunnel are used for the stress calculations.

2. MATERIAL SPECIFICATION
Mostly aluminum-2024-T6 is utilized for skin-stringers and edges. Airframe designers still request solid, hardened material at an adequate weight and cost .So composites of aluminum, steel and titanium will likely utilized for airframe outline. Other aluminum composites i.e. aluminum-press molybdenum-zirconium, work all around ok at high temperature to be aggressive with titanium up to close to 600ºF.

3. METHODOLOGY
Step I
The first step is to assume the number of ribs and stringers required to support the skin sample.

Let the length of the sample = L

Breadth of the sample = B

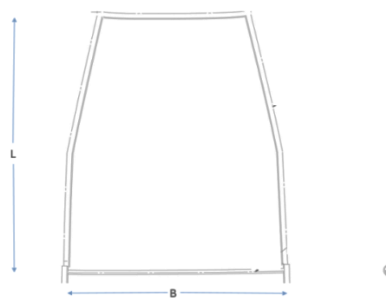

Fig 1: Door Frame

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 5 – No.4, August 2018

Stringers are installed length wise.

Thus stringer spacing = $\frac{B}{No.\ of\ stringers}$

Similarly

Ribs are installed breadth wise

Rib spacing = $\frac{A}{No.\ of\ ribs}$

Step II

The structure of the sample is divided into smaller panels whose length and breadth is stringer and rib spacing respectively.

Assume it as 'a' and 'b' respectively.

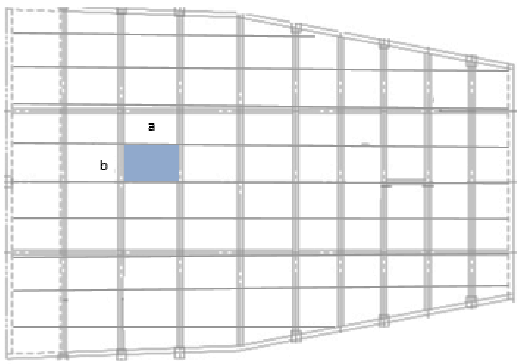

Fig 2: Segmented door frame

The sample structure is converted into segments. This is done to make the calculations easy. If the stringer and rib spacing is selected with reference to the component geometry then panel with the largest area is selected for iteration. This is done to get a better estimate of pressure loading on the sample.

Take panel a x b and calculate the amount of stress that it can bear.

Calculate the Pressure Load factor of this segment.

i.e. Pressure load factor = $\frac{p}{E}\left(\frac{b}{t}\right)^4$

Where p = pressure that is exerted on the segment

E = Modulus of elasticity of the material used

b = shorter side of the segment

t = thickness of the skin

The above equation is iterated by using various values of thickness one by one and is checked if it is able to support the structure or not. The thickness is varied according to the component at hand.

After choosing the value of thickness pressure load coefficient is calculated.

Step III

Plot the value of pressure load coefficient in the given graph (Niu, 1999) and calculate the corresponding value of $\frac{f}{E}\left(\frac{b}{t}\right)^2$

Where f = total load on the skin.

If the values exceed the scope of the given graph then it can be extrapolated in MS Excel using the equation,

y *= 1E-06x³ - 0.0008x² + 0.201x + 1.719*

For the given value of pressure load coefficient calculate the value for ***"f"*** from the formula

$\frac{f}{E}\left(\frac{b}{t}\right)^2$.

The total force value on that segment of airplane structure is compared to the yield strength of material used to make the component. We generally use Aluminum Al2024-T6 which has yield strength of 45700 psi in aircraft industry.

ISSN (O): 2393-8609
International Journal of Aerospace and Mechanical Engineering
Volume 5 – No.4, August 2018

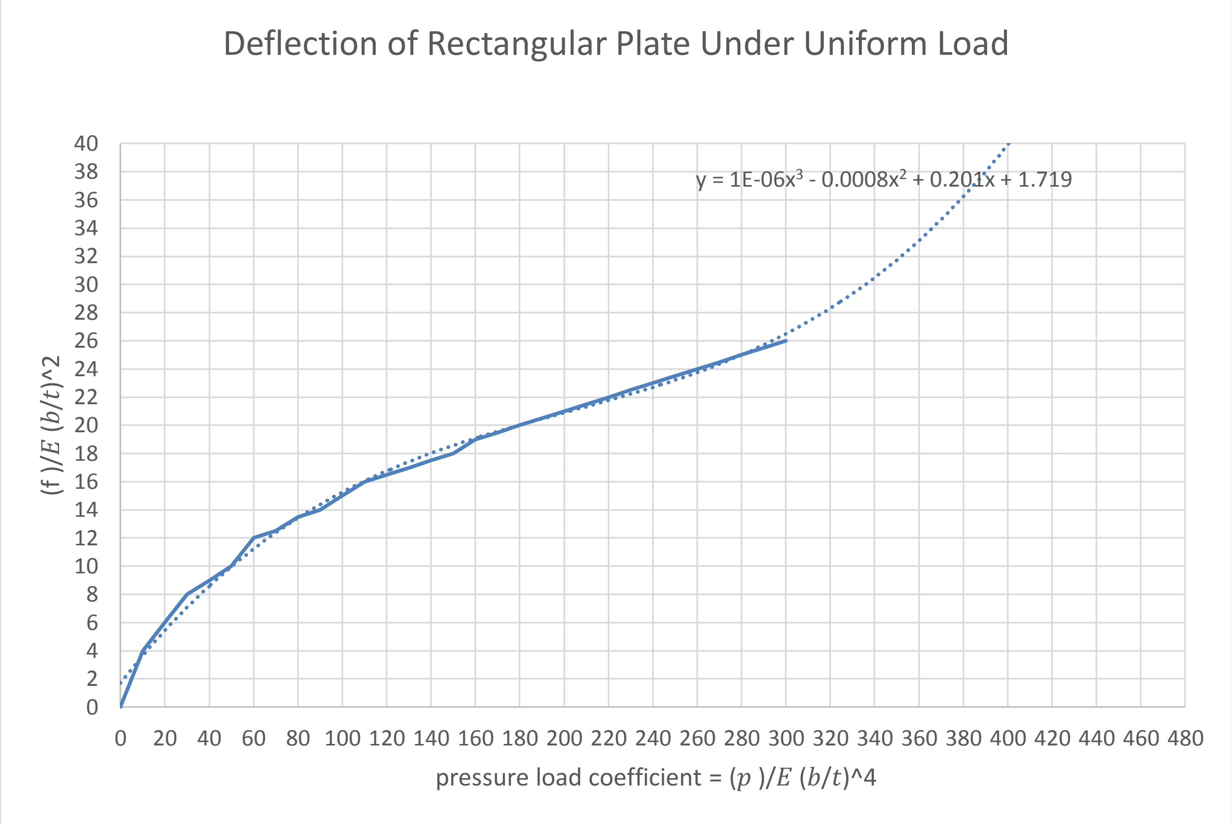

Fig 3: Graph representing deflection of rectangular plate under uniform load

Step IV

If the value of ***"f"*** is less than the yield strength of the material then the considered parameters i.e. stringer spacing, rib spacing, thickness of skin and a 1.25 factor of safety then the case is favorable and the number of assumed stringers are valid.

If the value of ***"f"*** is more than the yield strength or the factor of safety is less than 1.25 then increase the number of assumed stringers and do the calculations again.

4. CONCLUSION

The iterative approach is one of the basic but still less time consuming than computational approach in this case. Following the above four steps we can easily calculate the number of stringers required to support a structure. The technique can be used in initial stage of sizing for any component of this kind that is design of wing, design of fuselage structure and many more.

5. REFRENCES

[1]] Airframe Stress Analysis and Sizing, Niu, 1999.

[2] A. J. Morris. MOB A European Distributed Multi-Disciplinary Design and Optimization Project. AIAA Paper 2002-5444, Sept. 2002.

[3] Analysis and Design of Flight Vehicle Structures, E.F. Bruhn, 1965.

[4] Baolin Chen.Theory and algorithm of optimization[M].Beijing:TsinghuaUniversity Press,2004.