ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 1 – No.1, September 2014

A Study on the Skin-Stringer Panel of an Aircraft

Amandeep Singh Sivia
Student (B.tech, Aeronautical)
Gurukul Vidyapeeth Institute of Engineering and Technology
amansivia93@gmail.com

Jaspalpreet Singh Grewal
Student (B.tech, Aeronautical)
Gurukul Vidyapeeth Institute of Engineering and Technology
gr3walboy@gmail.com

Amritpal Singh Bhinder
Student (B.tech, Aeronautical)
Gurukul Vidyapeeth Institute of Engineering and Technology
amritpalsingh160@gmail.com

Rajkamal Singh Saini
Student (B.tech, Aeronautical)
Gurukul Vidyapeeth Institute of Engineering and Technology
rajkamalsingh97@gmail.com

ABSTRACT

The design of skin-stringer panel forms an important and major portion of the wing-box design. The lift generated by the wing opposes the weight of the aircraft and thus generates bending. Depending on their location and type of stringers, stiffened panels that make up the wing are therefore mainly loaded in compression and tension. Upper skin-stringer panels are typically subjected to compressive load while the lower panels subjected to tensile loads. The ability to resist the compressive load is assessed through a stability study to complete the critical buckling load. But the main object is here to design the different types of stringers in CATIA in more rapidly way. Repeating the design process at different configurations of stringers along wing skin complete the preliminary design of aircraft wing stringers.

Keywords

Skin,Stringers,Panel,Aircraft,Buckling.

1. INTRODUCTION

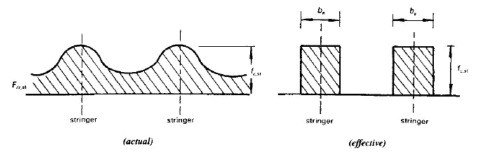
Aircraft wing consist of a collection of basic element like stringers running along the wing-spam, ribs and spars. Each component acts like beam and a torsion member a whole. A wing-box beam consist of stringers (axial members of wing) that are located at the maximum allowable distance from the neutral axis to achieve the most bending capacity to prevent buckling and skin, which enclosed a large area to provide a large torque capacity. Load on skin-stringer panel is provided in the form of air-pressure and skin as little bending stiffness to resist the air-pressure. To avoid incurring large deflection in the skin various shapes and sizes of longitudinal stringers can be used in this design to find which shape of stringer can take more load and resist buckling.

2. MATERIAL SPECIFICATION

Mostly aluminium-2024-T3 is used for skin-stringers and frames. Airframe designers still demand strong, stiff material at an acceptable weight and cost .So alloys of aluminum, steel and titanium will probably used for airframe design. Other aluminum alloys i.e. aluminum-iron-molybdenum-zirconium, function well enough at high temperature to be competitive with titanium up to near 600^{O}F.

3. TYPES OF BUCKLING MODES OF SKIN-STRINGER PANEL

Buckling is the general term frequency used in aircraft analysis to describe the failure of a structural element when a portion of the element moves normal to the direction of primary load application. For thin skin supported by sturdy stiffeners, the initial buckling stress can usually be calculated assuming that the skin buckles between stringer, while the failing stress can be calculated by considering the stringers together with an "effective width" of skin to fail in flexure as an Euler strut.

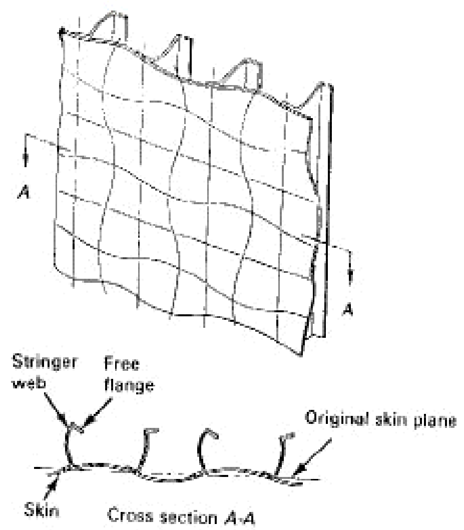


Effective width of skin stress distribution.

The effective width concept accounts, in a simple way, for the interaction between the skin and the stiffener. The skin-stringer panel construction can develop several separate type of buckling which are given below:-

3.1 Initial buckling or skin buckling

This generally involves waving of the skin between stringers in a half-wavelength comparable with the stringers pitch.



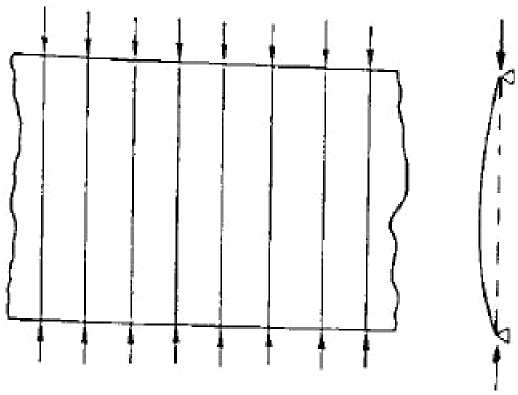
Initial buckling of skin stringer panel

3.2 Local Instability

A secondary short Wavelength buckling may take place in which the stringer web and flange are displaced out of their planes in a half-wavelength comparable with the stringer depth. There will be smaller associated movements of the skin and lateral displacements of the stringer free flange.

3.3 Flexural instability

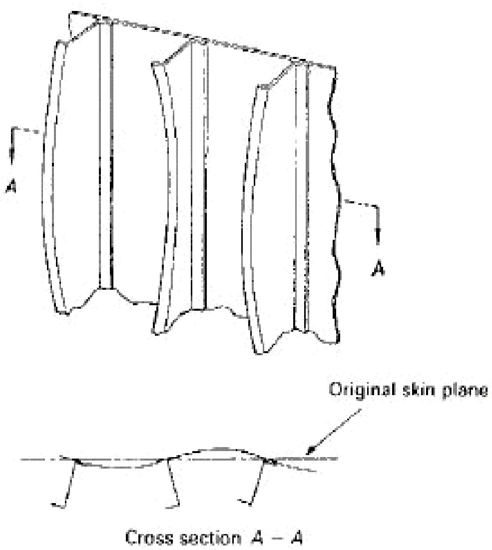
Simple strut instability of the skin-stringer construction in a direction normal to the plane of the skin. There may be small associated twisting of the skin. The half-wavelength is generally equal to the rib or frame spacing.



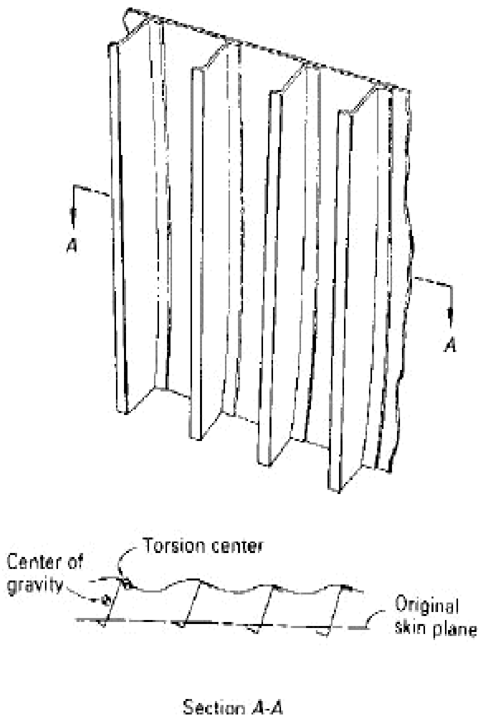
Panel instability of a skin-stringer panel.

3.4 Torsional instability

The stringer rotates as a solid body about a longitudinal axis in the plane of the skin, with associated smaller displacements of the skin normal to its plane and distortions of the stringer pitch.



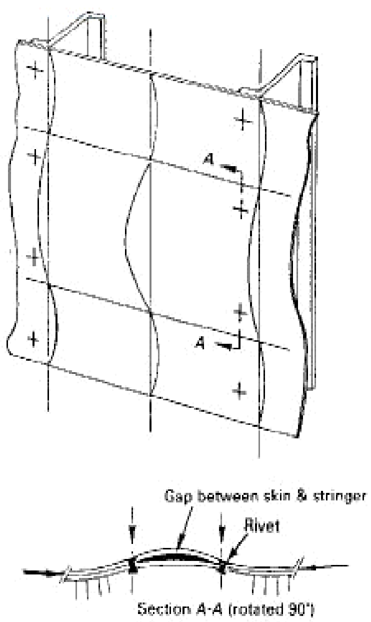
Torsional buckling of a skin-stringer panel.



Flexual and torsional buckling of a skin-stringer panel.

3.5 Inter-rivets buckling

Buckling of the skin as a short strut between rivets. This can be avoided by using a sufficiently close rivet pitching along the stringer.



Inter-rivet buckling and wrinkling of a skin-stringer panel.

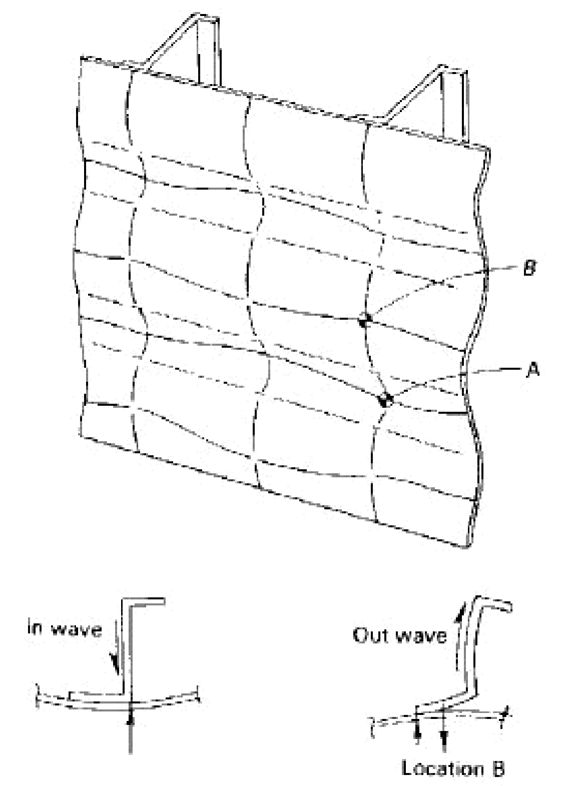
ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 1 – No.1, September 2014

3.6 Wrinkling buckling

A mode of stability similar to inter-rivet buckling in which the skin develops short-wavelength buckling as elastically supported along strut. For all practical skin-stringer construction it can be avoided by keeping the line of attachments very close to the stringer web.



Wrinkling of a skin-stringer panel.

4. VARIOUS CONFIGURATIONS

Typically Shapes for stringers are Z-section,Y-section,Hat-section,J-section,I-Section,L-section,U-section,Bulbed-section,T-section and so on.

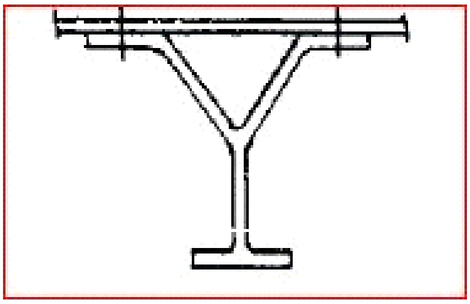


Fig. Extruded Y-Stringer

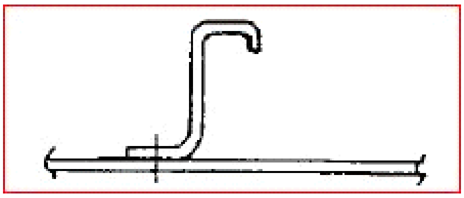


Fig. Formed Z-Stringer

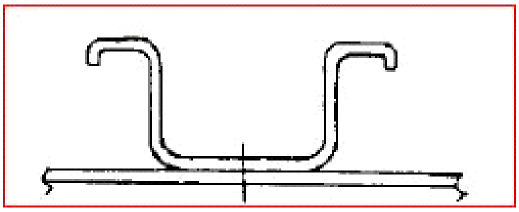


Fig. Formed Hat-Stringer

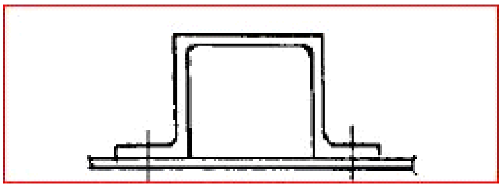


Fig. Extruded Hat-Stringer

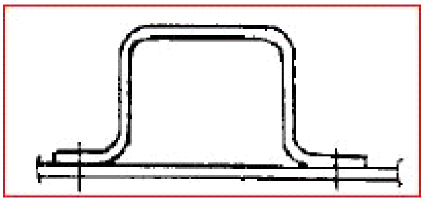


Fig. Formed Hat-Stringer

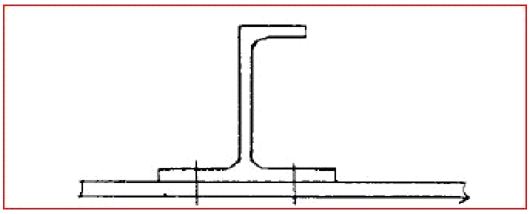


Fig. Extruded J-Stringer

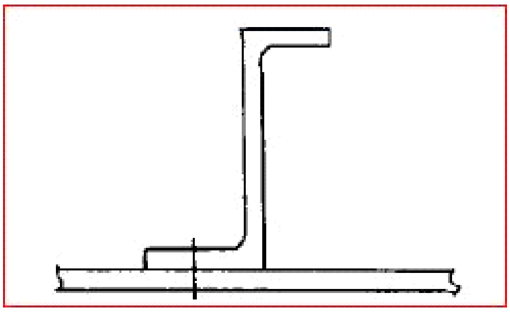


Fig. Extruded Z-Stringer

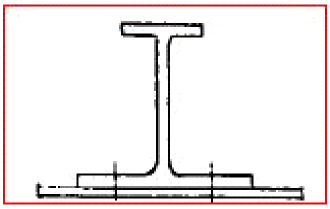


Fig. Extruded I-Stringer

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 1 – No.1, September 2014

5. PRELIMINARY DESIGN APPROACH

We used CATIA V5 Software to design different types of shapes of stringers and analyze which one of these have good configuration.

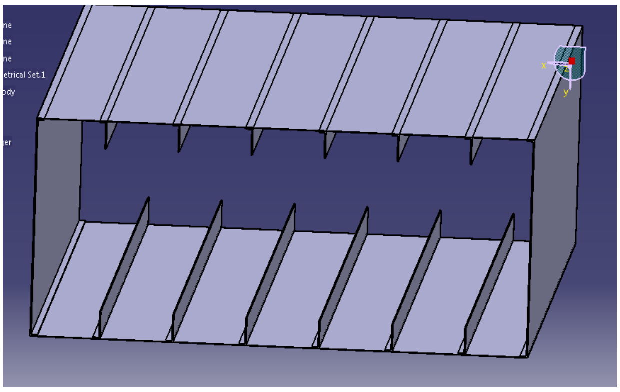


Fig 1. Skin-Stringer panel with Wing-Box. (L-section)

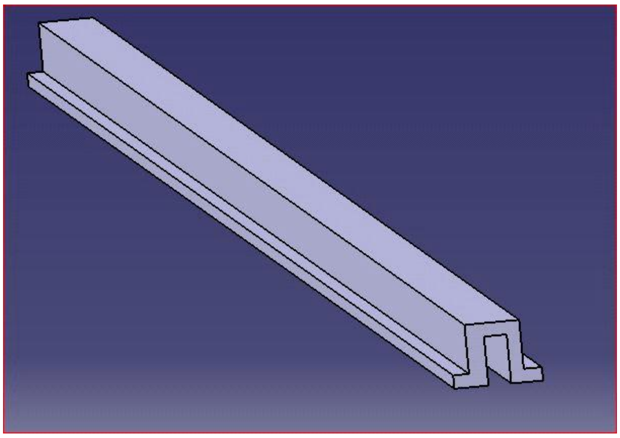


Fig 2. Hat type Stringer

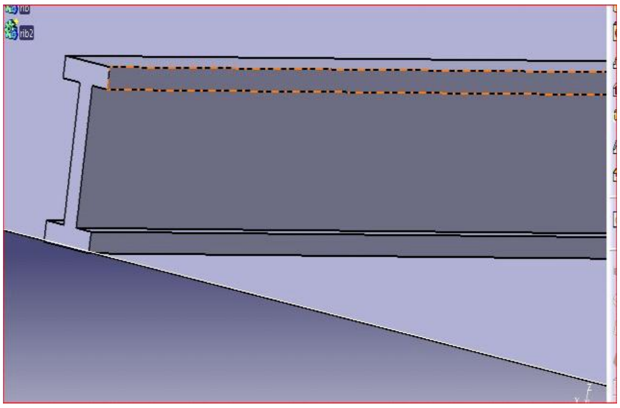


Fig 3. Stringer with I-section

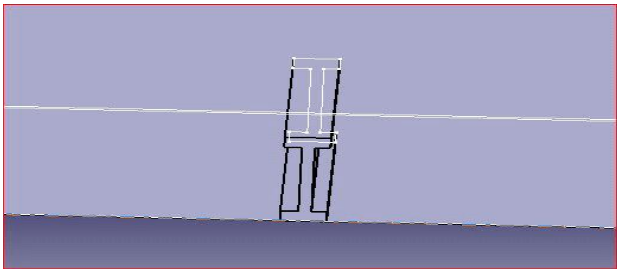


Fig 4. I-Section attached with skin

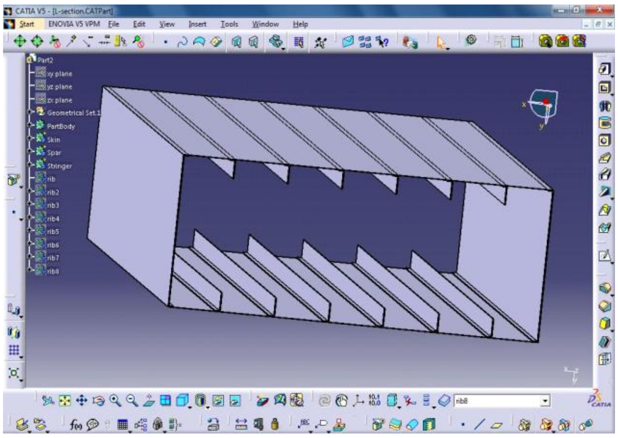


Fig 5. Skin-Stringer with L-section Stringers

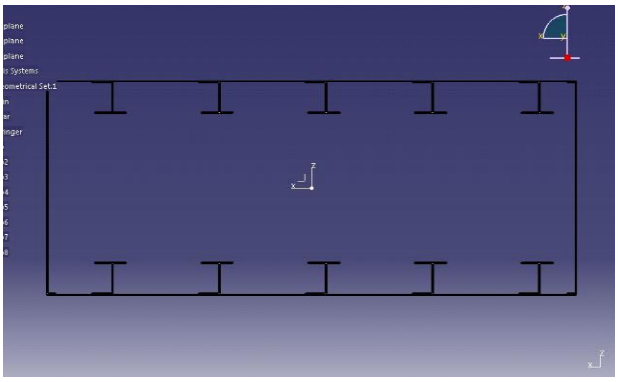


Fig 6. Skin-stringer with J-section

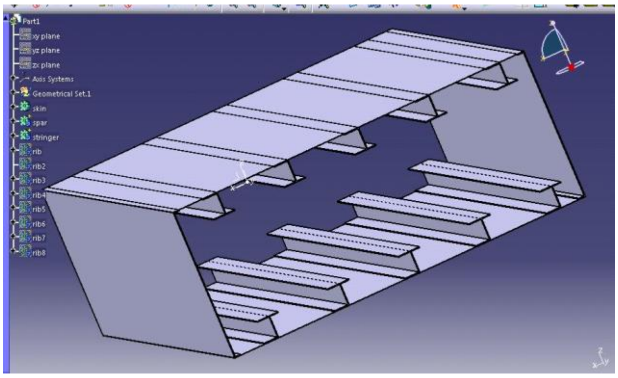


Fig7. Wing-box with j-section stringer

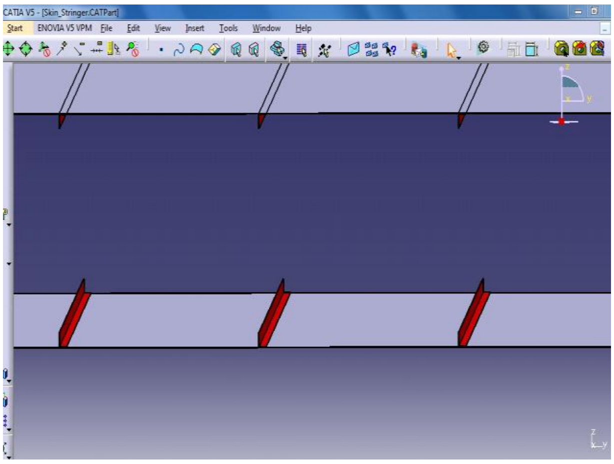


Fig 8. Skin-Stringers with L-section stringers

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 1 – No.1, September 2014

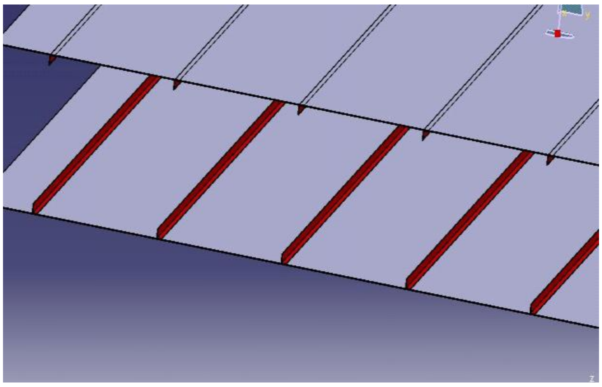


Fig 9.L-section stringers

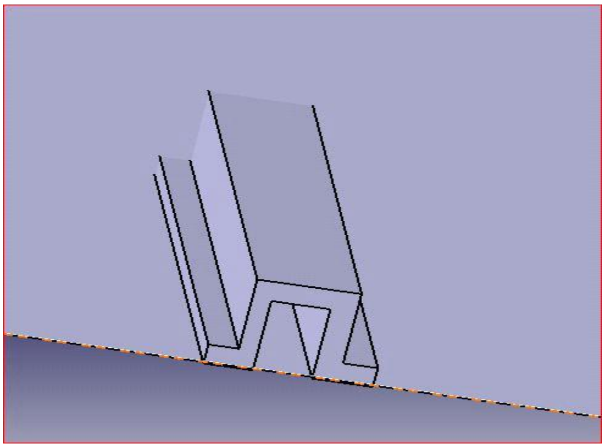


Fig 10. Hat-section stringer with rib

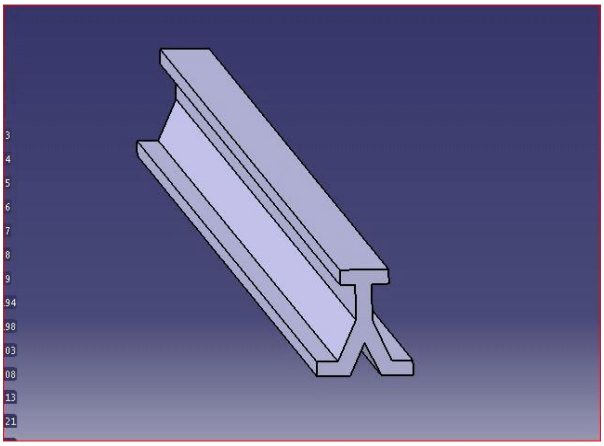


Fig 11. Y-Section Stringer

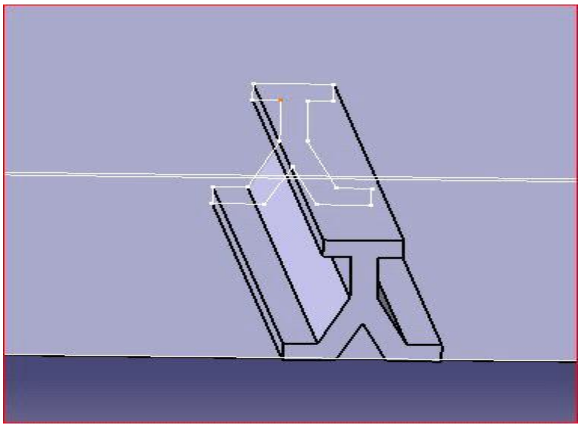


Fig 12. Y-section with skin

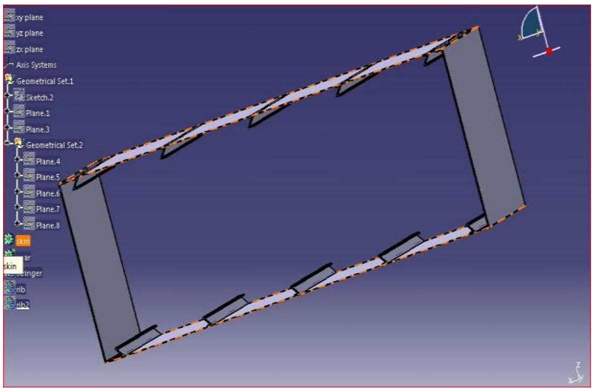


Fig 13. Skin-stringer with cross z-section stringers

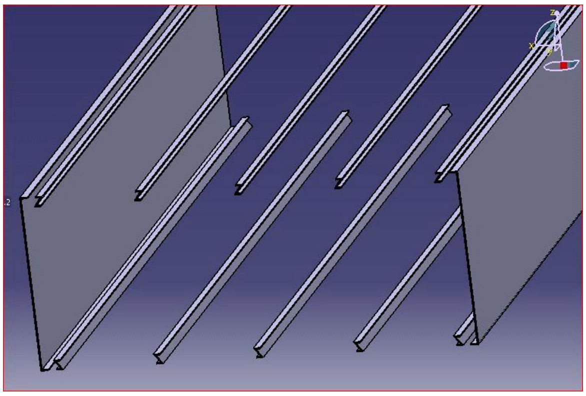


Fig 14. Cross z-section stringers

6. CONCLUSION

The most important conclusions and contributions from the current work are listed below:-

1. An effective Optimization routine has been developed to design a compressive skin-stringers panel for minimum while guarding against important failure made such as stringer buckling, compression in stringer outstanding and beam column eccentricity.
2. An optimization routine has been developed to design a lower skin-stringer panel subjected to tensile load.
3. The above optimization routines have been successfully used to design Wing stringers of different shapes by CATIA software. A good preliminary design of wing-box having different types of configuration was implemented by different stages of design process.

7. RECOMMENDATION FOR FUTURE WORK

Although most of the important aspects have been covered in this thesis work in designing a preliminary skin-stringer panel with wing-box, other important and interesting subjects for the future work are identified as follows.

1. Although the design of a lower wing panel for simple case of single straight crack is a good start, it can be extended to design for a case of multiple cracks. Instead of using adhesive material to join stringer with skin, it would be interesting to design by replacing adhesive material with rivets (fasteners).

2. The drag forces can also be included while generating the design load curves.

3. As the dimensions for spars and their corresponding web caps are taken with reasonable assumption, the design can be refined by taking actual dimensions for them.

ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 1 – No.1, September 2014

4. This design process can be repeated at different stations along the wing semi-spar to design a complete preliminary of wing box and stringers or skin-stringer panel.

8. REFERENCES

[1] Airframe- structural- design by Michael Chun –Yung Niu Lockheed aeronautical systems company Burbank, California.

[2] Bruhn, E. F. "Analysis and Design of flight vehicle