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Compressive Behavior of Composite Support Column for Aircraft Cabin Floor

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ABSTRACT

Composites are widely using in automobile, marine and aircraft industry. Most of the aircraft interiors are made using composites due to its high strength to weight ratio property and this interior component are using composite beams and columns as support structures. Most of these columns will undergo compression load due to withstanding heavy loads. The omega section is fabricated using wooden tools. Finite element analysis is carried out using Midas NFX to predict the test load and compression test have been done. The present study has been conducted to understand the compressive and buckling behaviour of the column.

Keywords — Strength To Weight Ratio, Carbon Fiber, Compression, UDM testing

I. INTRODUCTION

Components of aircraft are gaining serious attention in replacing the synthetic fiber with natural fiber The composite laminate before being fabricated for conducting experiments was modelled using MIDAS NFX Finite Element Analysis (FEA) Software to find if the problem statement and the assumed hypothesis are correct. The hypothesis put forth is to find if there is an effect in composition and concentration on the mechanical properties of the composite laminate. This chapter explains the process of modelling in FEA and the results obtained.

In this paper, author Zuhair, Hamden and Irfan explaining about the interior composite material. And reviewing the potential of natural fiber in the aviation industry. The evolution in aviation industry continues to evolve with the creation of space shuttle which launched into orbital space, and the industry still evolving until this current era. The natural fibers materials are being used from the early ages, such as for shelters and clothes but slowly decrease since the introduction of synthetic fibers. The hybrid composites exceeded full Kevlar's consistency efficiency and demonstrated better mechanical properties than the full kenaf composites. The material of the aircraft itself along with its design needs to be able to meet the required standard according to proper authority, which the use of natural fiber in some equipment may reduce the overall cost.

The equine this paper evaluates the feasibility of replacing the honeycomb and fiberglass skin layers core with rigid polyurethane foams and thermoplastic polymers. The result showing that structural composites have higher mechanical performances than the proposed sandwich composites, but they are compatible with non-structural applications. The work that the PN1 honeycomb is replaced by the 3 lb. The better mechanical performance is obtained with the GF/HC/GD panel which is attributed to the intrinsic mechanical properties of the honeycomb structure and the molecular compatibility between the aramid in the HC and the epoxy resin compared to the HC. Based on the results, it is possible to suggest that the core acts actively more than the panels with GF prepreg in panels with ABS as face sheets. The structural composites formed with HC and fiberglass showed higher mechanical properties than the proposed sandwich composites. The vacuum forming process proposed and analysed in this work was feasible for developing non-structural panels.

II. MIDAS NFX FEA SOFTWARE

This work evaluates the feasibility of replacing the honeycomb core and fiberglass skin layers with rigid polyurethane foams and thermoplastic polymers. The result shows that the structural composite materials have higher mechanical performance than the proposed sandwich-type composites, but are compatible with non-structural applications. The work that replaces the PN1 comb with the 3lb. The best mechanical performance is obtained with the GF/HC/GD panel, attributed to the intrinsic mechanical properties of the alveolar structure and the molecular compatibility between the aramid in the HC and the epoxy resin compared to the HC. Based on the results, it can be assumed that the core of the panels with ABS as top layer is more active than the panels with GF prepreg. The sandwich composites were converted into complex V-shaped panels. The structural composites formed with HC and fiberglass showed better mechanical properties than the proposed sandwich composites. The vacuum forming process proposed and analyzed in this work was suitable for the development of non-structural panels.

III. TOOLING CONCEPT AND DESIGN

The construction of the mould tools can be done in different methods. There are wooden tools, aluminium tools and composite tools are available in the market. Irrespective of those methods the moulds are made using wood which is the cost effective and easily available. If the parts need to be a good surface finish, then aluminium tool is most likely preferable. Whereas composite tools are difficult to make but it can use many numbers of times. The periodic maintenance is cheaper for aluminium and composite whereas for wooden tool it is one-time use. The male and female parts are shown in Fig. 4-1 and 4-2. After the tool design, the wood is given to CNC to carve out the material to get the mould tool. Since the wood is rough smoothing.

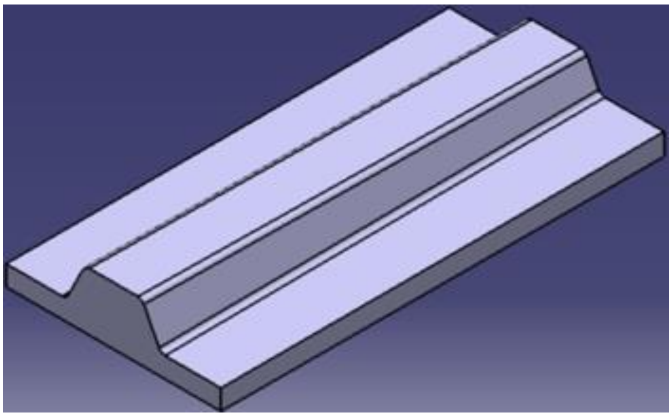


Figure 0-1: Male tool

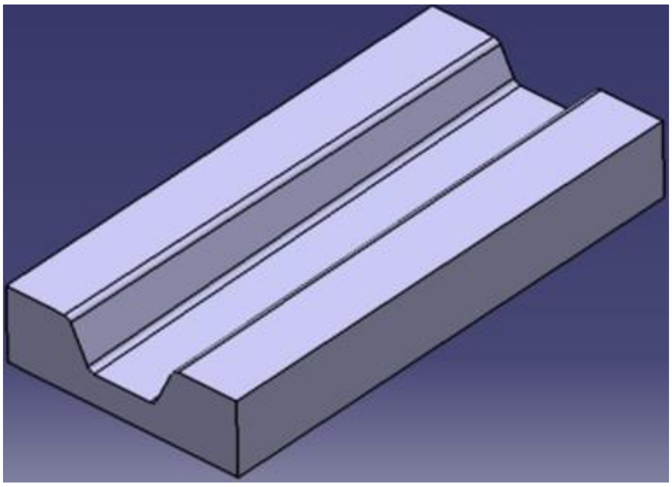


Figure 0-2: Female tool

Figure 0-3: Mould Tools after CNC

IV. MANUFACTURING AND FABRICATION PROCESS

It is necessary to list the fabrication materials and items needed for the layup. The materials used are carbon fabric. There are many types of fabrics available in the market based on the manufacturer requirement the fabrics should be selected. It is also important that the supplier should mention whether the fabric is a unidirectional or bi-directional and it's GSM so that the manufacturer would know the cured ply thickness. Bi-directional fabric is used to fabricate the omega section. The unidirectional fabrics offer the ability to place fibre in the component exactly where it is required, and in the optimum quantity these fibres are straight and uncrimped. Bidirectional fibres are called as plain fabric and twill. Both the fabrics have unique strength, properties and applications. The items such as resin, hardener, mylar film and wooden molds are also required for the fabrication.

Epoxy resin and hardener used is araldite LY556 and abrader HY951. Totally 4 layers of carbon is used and the GSM of per layer is 1 mm. Mylar film is used to debulking the part after curing. Two omega sections are fabricated and attached on each side to use as column support. M5 bolt and nut is used to attach the flange. Before adding bolt and nut the flanges are well bonded using araldite and the holes are drilled. The fabricated and assembled part after drilling is shown. The fabrication process is shown in the flowchart.

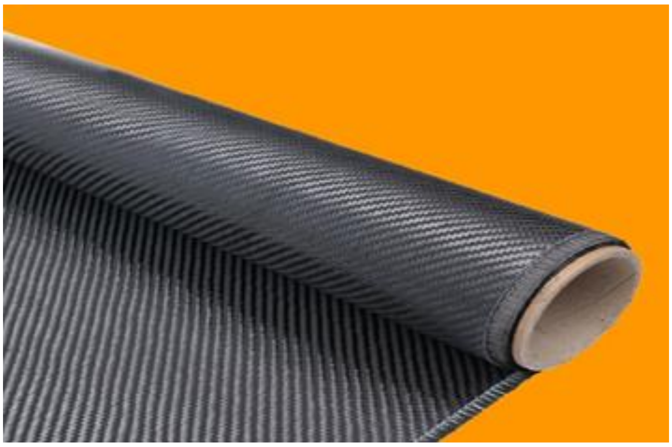


Figure 0-4: Carbon Fibre

Figure 0-5 :Fabricated section after debulking

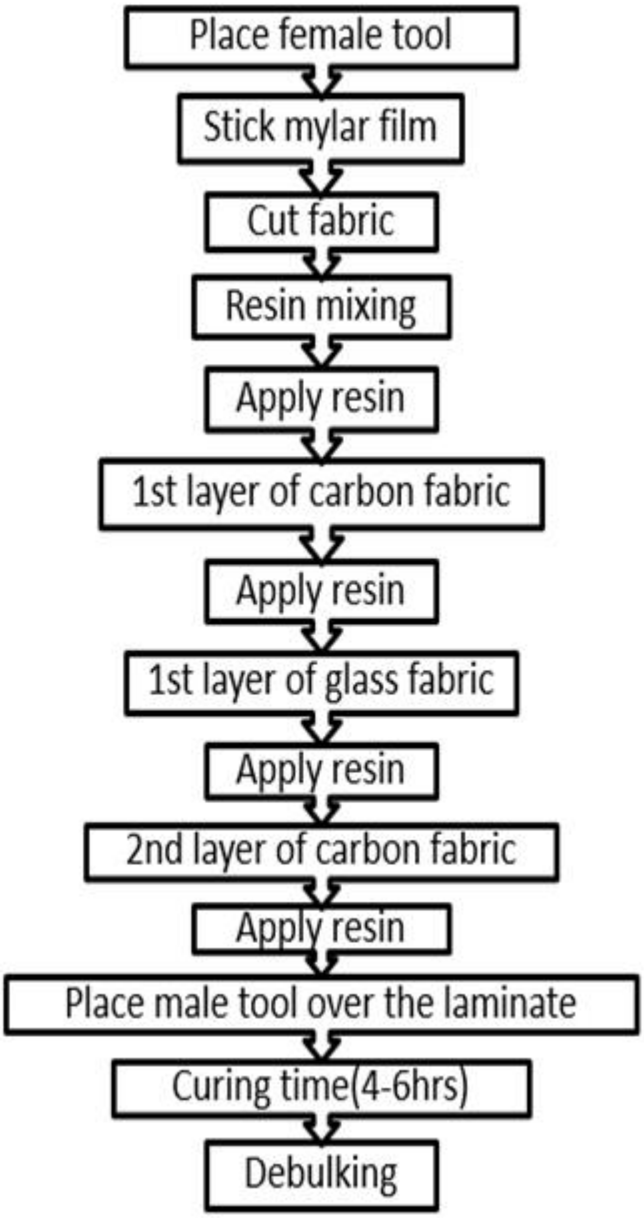


Figure 0-6: Fabrication process

V. FINITE ELEMENT ANALYSIS

In this section, the finite element analysis of omega section is carried out using Midas NFX. The column (Omega section) is idealised as 2D surface element and bolt as 1D element. Two cases were analysed for the following assumptions. First case is fixed the flange by sticking using Ana bond. Second case is using M5 bolt and nut to fix the flange. By assuming the boundary condition and load condition are carried out for pure compression. The length and width of the flange are 340 mm and 30 mm which will be same on either side of the column. The element length and width of average element is 4*4 mm.

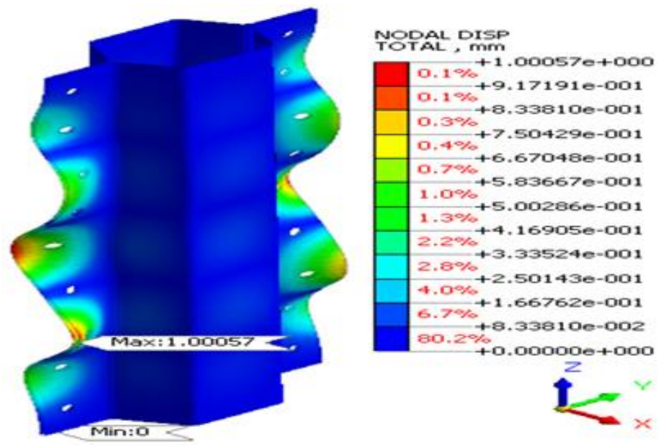
The material property used for the column is taken from Hexcel prepreg technology datasheet. Therefore, the idea is to find the test failure load using finite element analysis.

Linear Static		**Buckling**	
Model No	**Description**	**Model No**	**Description**
M100	Rigid - All Carbon - 1000N	M105	Bolted - All Carbon - 1000N
M200	Rigid - All Glass - 1000N	M205	Bolted - All glass - 1000N
M300	Rigid - Hybrid - 1000N	M305	Bolted - Hybrid - 1000N
M101	Rigid - All Carbon - 218224.3521N	M106	Rigid - All Carbon - 21870N
M201	Rigid - All Glass - 125627.8251N	M206	Rigid - All glass - 66820N
M301	Rigid - Hybrid - 86872.36885N	M306	Rigid - Hybrid - 18920N
M102	Bolted - All Carbon - 218224.3521N	M107	Bolted - All Carbon - 21870N
M202	Bolted - All Glass - 125627.8251N	M207	Bolted - All glass - 66820N
M302	Bolted - Hybrid - 86872.36885N	M307	Bolted - Hybrid - 18920N

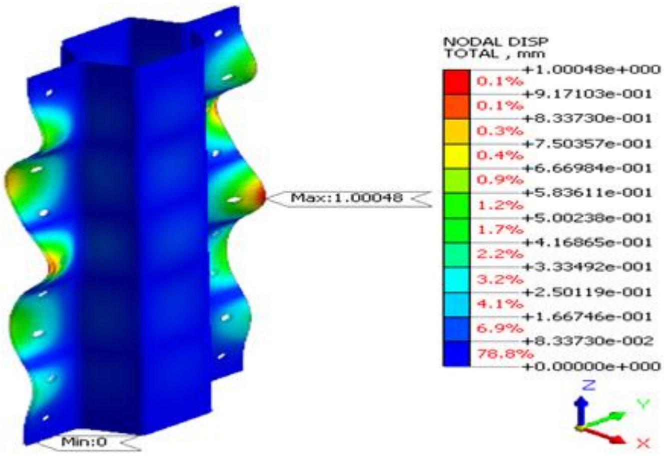
Table 0-1: Summary of loads

VI. BUKLING ANALYSIS

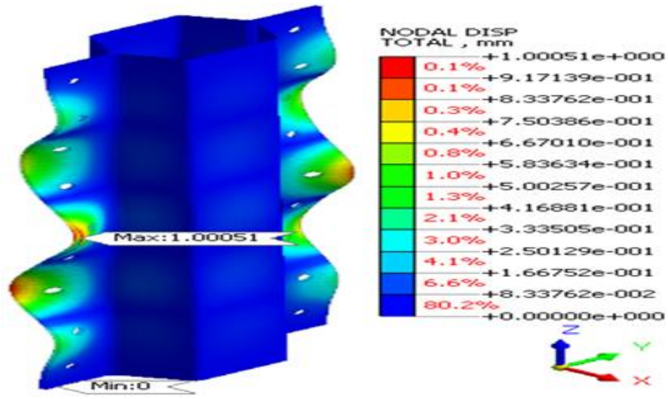
Here 1000N is used to predict the factored load for buckling analysis to find the reserve factor calculation which ultimate strength divided by yield stress. The allowable stress is taken from the Hexcel prepreg datasheet.



(a)-Carbon



(b)- Glass



(c)- Hybrid

VII. LINEAR STATIC

When applying compression load to a beam/column it will undergo buckling rather than compression due to the high shear load acting in the material. I our cases the models are ran under pure compression to predict the test load.

VIII. FEA SUMMARY

The aim is to predict the failure load of the specimen. It is important to assume certain conditions to undergo pure compression and buckling. From the FEA, 1000N load is used to predict the test load in both buckling and compression. The factored load for linear static for carbon, glass and hybrid are 218224.35, 125627.82 and 86872.36 respectively. The linear static is completed to understand the strength of the column/beam/specimen. Whereas the specimen will undergo buckling before compression is the actual fact. The factored load for buckling for carbon, glass and hybrid are 21870, 66820 and 18920 respectively. The predicted loads are used to do the experimental testing.

IX. TEST RESULT

From the finite element analysis, the predicted loads are used to do the compression test in universal testing machine. Therefore, the specimen is tested under compression until it gets failure. The test results are added below.

Load at Peak	Elongation at Peak	Compression Strength
29.260kN	70.430mm	13.300N/mm^2

Table Error! No text of specified style in document.-**1 :** Input data from experimental results

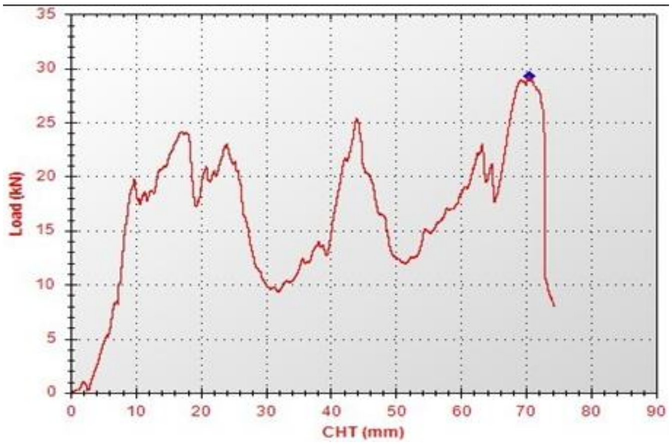


Figure 0-2: Load vs cross head travel

X. CONCLUSION

The study of cabin floor column beam in an aircraft is been understand using compression test in UTM. The peak stress and strain are located in the graph from the experimental results. It is also important to calculate the stiffness of the bolt due to the shear load acting on it while compression. Therefore, to make sure the bolt stiffness the flanges must be compacted tightly to avoid net-section failure in bolts. The main aim is to fail the omega section. But in the FEA results it understands that the assumption we made is not enough to fail the omega section. Whereas in the experimental tests the specimen is failed in along the width including the omega section. The behaviour of the CFRP column beam has been done.

XI. REFERENCES

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