EAN 2019
57th conference on experimental stress analysis

Testing of C/PPS structural element for aircraft

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Keywords: Composite, Fabrics, Thermoplastics, Aircraft structural element

Abstract. Presented work deals with testing and FE evaluation of composite structural element manufactured from C/PPS 5H satin fabric [1,2] used for junction of rib with keel beam lower panel in aircraft construction. Tested composite version should replace titanium one which is used nowadays. Loading of composite special element (bracket) was simulated in FE software Abaqus and it was proved that it should withstand the load without failure. After the manufacturing of three specimens an experiment was done to confirm the FE results.

Introduction

Many crucial connecting components in aircraft are manufactured from titanium because of the fact, that electrochemical corrosion can occur between steel and composite. Typical titanium part is analysed bracket used for junction of rib with keel beam lower panel. Its shape requires a variety of machining operations which are expensive, and they leave a lot of waste material. Therefore, composite version of the bracket was designed and manufactured from C/PPS 5H satin fabric by thermoforming technology and this version was simulated and tested.

Finite Element Computation. In Fig. 1 you may see the results for failure index according to maximal stress theory for given load of the bracket which is described in Table 1. Maximal failure index is equal to 0,3934 which means that the safety factor is around about 2,54. This means that composite bracket can replace titanium one without failure and with saving 58 % on the weight - Ti version weights 0,308 kg, composite one 0,129 kg.

Table 1: Load of the bracket

Location	F_x [N]	F_y [N]	F_z [N]
1	-276,1	-411,9	3 496,9
2	-345,6	-618,9	3 007,8
3	-168	-415,7	2 846,1

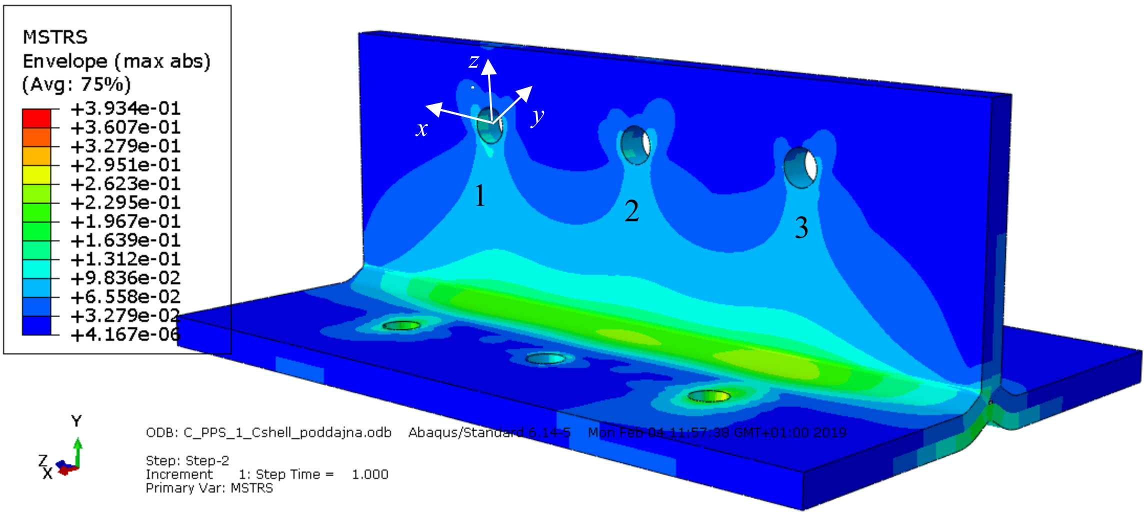

Fig. 1: Failure index according to the maximal stress theory for given load

Experiment. Experiment was done on TIRA 2300 universal testing machine with loading speed of 1 mm/min (respectively 2 mm/min). Tensile load was realized through the screws in the web of the element jointed with the jaws of the machine, just in the *z* direction (direction of the profile´s web) – when we look in Table 1, we may see that the load in this direction is much more higher than the load in. *x* and *y* direction. Specimen in the jaws can be seen in Fig. 2. Relationship between loading force and displacement for three tested specimens can be seen in Fig. 3. Comparison of failed specimen with FE prediction of failure index (according to maximal stress theory [3]) can be seen in Fig. 4.

Fig. 2: Specimen loaded in the testing machine

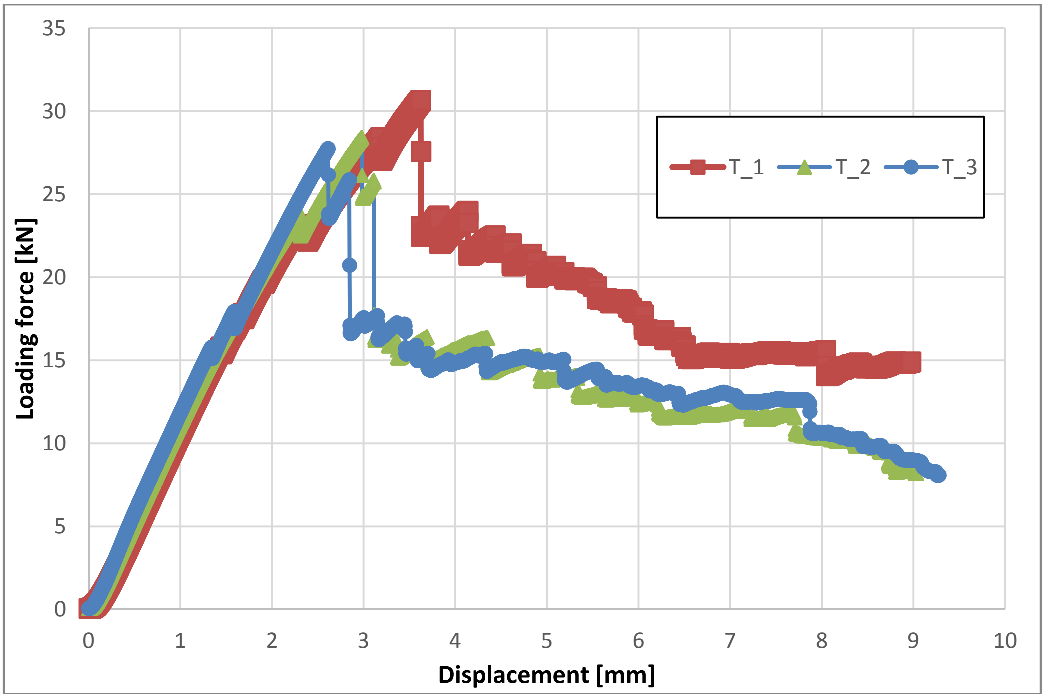

Fig. 3: Relationship between loading force and displacement for three tested specimens

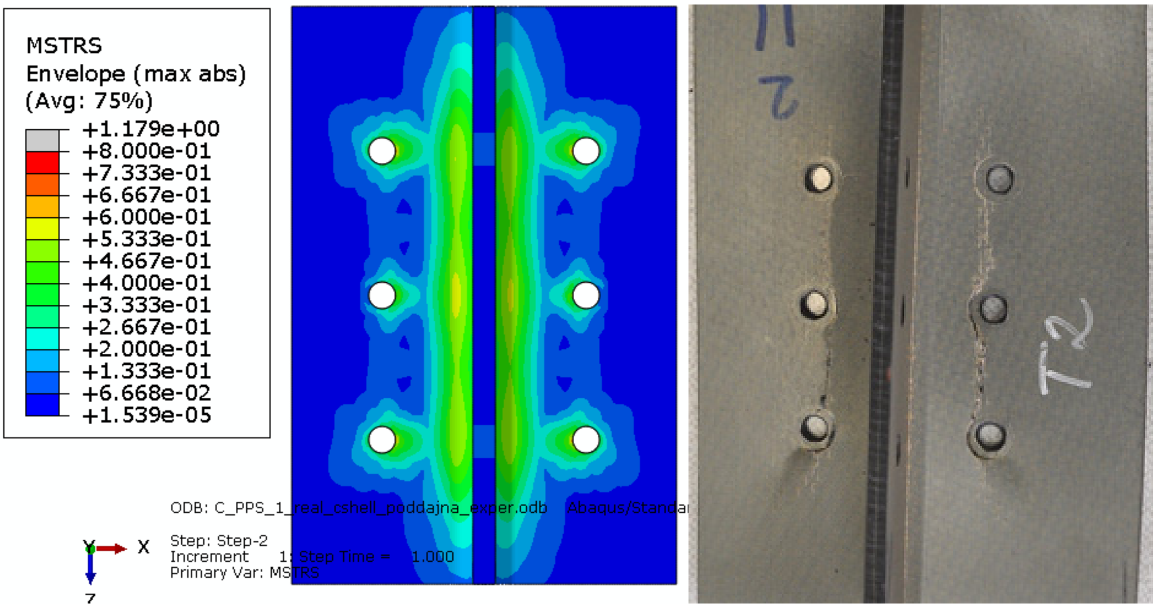

Fig. 4: Comparison of predicted failure index with real failure of the specimen

Conclusions

Three specimens of composite bracket were tested with achieving average maximal force 28,94 ± 1,25 kN.

Comparison of FE and experimental results shows that FE model predicts well areas of failure which are around the bolt holes and on transition radius between lower flange and web of the profile.

Future work will focus on re-design of composite bracket geometry, its testing and FE simulation and comparison with this geometry and original titanium solution.

Acknowledgements

This work has been supported by project FV30033 of the Ministry of Industry and Trade of the Czech Republic and by the Grant Agency of the Czech Technical University in Prague, under grant No. SGS18/175/OHK2/3T/12.

References

[1] AIMS05-09-002, Airbus Material Specification Carbon Fabric, 285 g/m2 fibre area mass with 43% PPS Resin or Equivalent resin Material Specification.

[2] ABS5045, Aerospace Series, Carbon Fibre Fabrics Reinforced PPS, Laminates w/ or w/o Lightning Protection, w/ or w/o Anti-Corrosion Protection, Structural Material.

[3] https://classes.engineering.wustl.edu/2009/spring/mase5513/abaqus/docs/v6.6/books/usb/default.htm?startat=pt05ch17s02abm04.html.