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Experimental and numerical evaluation of composite part strength

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Presented work deals with the design, stress/strain analysis and testing of composite element for aircraft construction. Main idea of the work is replacement of titanium part with composite manufactured from C/PPS 5H satin fabric [1, 2] by thermoforming technology. At first loading of the composite was simulated in FE software Abaqus and it was proved, that it should withstand the load without failure.

Experiment was done after the manufacturing of testing specimens. Tests were 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. Relationship between loading force and displacement for three tested specimens can be seen in Fig. 1. Comparison of failed specimen with FE prediction of failure index (according to maximal stress theory [3]) can be seen in Fig. 2.

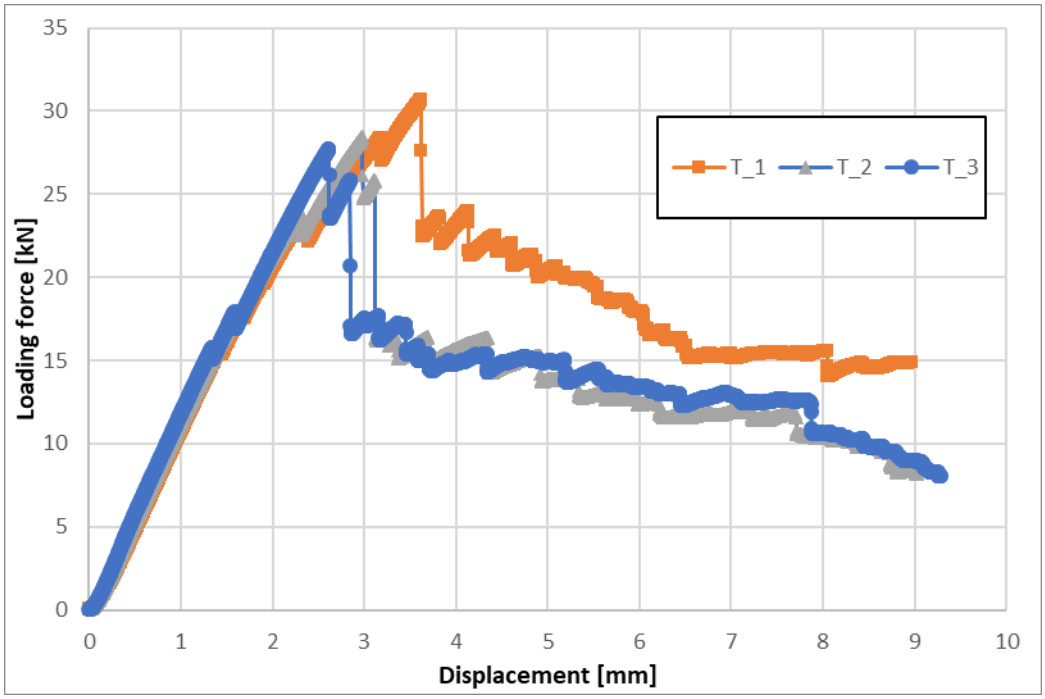

Fig. 1. Relationship between loading force and displacement for three tested specimens

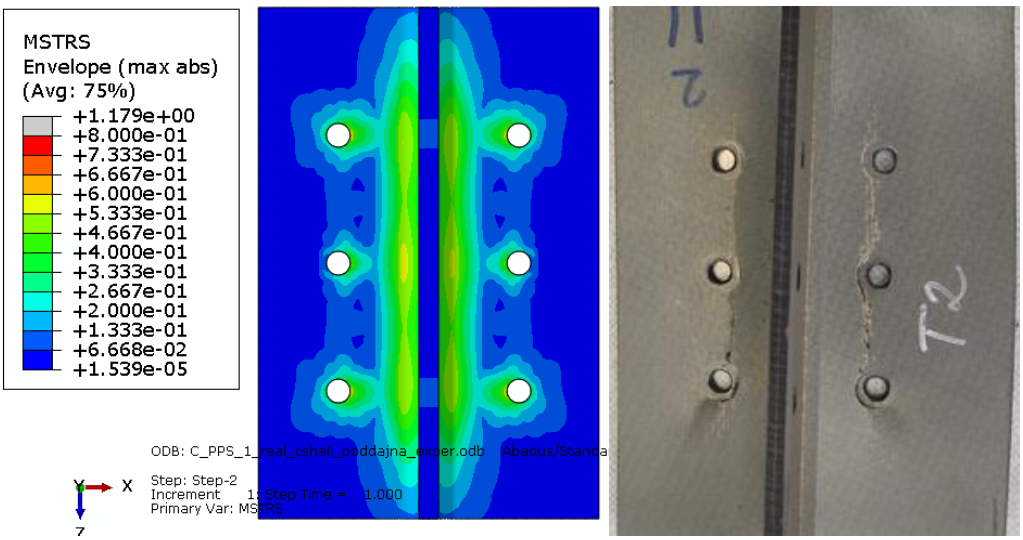

Fig. 2. Comparison of predicted failure index with real failure of the specimen

Next part of the work is comparison of interlaminar shear strength of our part (which is consolidated from two plates with 8 layers of fabric) with properties of plate manufactured from 16 layers of fabric. One set of specimens cut from 16 layers plate and two sets of specimens cut from profile with 2x8 layers were prepared for tests. Experiment and its evaluation is like single lap joint testing (according to ČSN EN 1465 standard for example). Tests were done on TIRA 2300 machine with loading speed 1 mm/min. Tested specimens can be seen in Fig. 3. Results can be seen in Table 1.

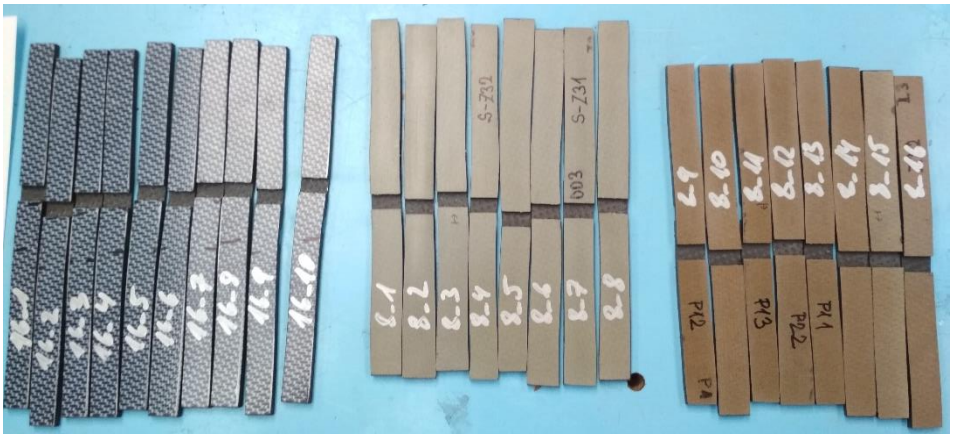

Fig. 3. Tested specimens

Table 1. Comparison of deflection/rotation for designed versions

	Average interlaminar shear strength [MPa]	**Standard deviation [MPa]**
Specimens 8_1 -8_8	22,63	0,86
Specimens 8_9 -8_16	20,17	0,66
Specimens 16_1 -16_10	19,01	1,49

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.

From the Table 1 can be seen that specimens cut from plate with 16 layers have lower average interlaminar shear strength and higher standard deviation then specimens cut from consolidated profile (2x8 layers). It means that the consolidated profile from 2x8 layers has similar or even better interlaminar shear properties then profile made from 16 layers.

Acknowledgements

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References

[1] ABS5045, Aerospace series, carbon fibre fabrics reinforced PPS, laminates w/ or w/o lightning protection, w/ or w/o anti-corrosion protection, structural material.
[2] AIMS05-09-002, Airbus material specification carbon fabric, 285 g/m2 fibre area mass with 43% PPS resin or equivalent resin material specification.
[3] https://classes.engineering.wustl.edu/2009/spring/mase5513/abaqus/docs/v6.6/books/usb/default.htm?start at=pt05ch17s02abm04.html