TESTING OF SANDWICH SPECIMENS FOR SPACE APPLICATIONS

Robert ZEMČÍK[1], Jan KRYSTEK[1], Tomáš MANDYS[1], Vladislav LAŠ[1], Petr PRŮCHA[2]

[1] NTIS – New Technologies for the Information Society, Faculty of Applied Sciences, University of West Bohemia, Technická 8, Plzeň, Czech Republic, corr. author: zemcik@kme.zcu.cz

[2] LA COMPOSITE, s.r.o., Beranových 65, 199 02 Prague 9, Czech Republic, prucha@lacomposite.com

1. Introduction

This work focuses on the mechanical testing of sandwich structures for space application made mainly of composite skins, aluminum honeycomb core, and joints in the form of inserts. The tests are conducted mainly according to ESA (European Space Agency) specifications (ECSS Standards and Requirements) [1] with the aim to participate in its future projects jointly with LA COMPOSITE company [3].

Structures for space applications must undergo a specific set of mechanical tests that will guarantee that all components of the structure will survive the harsh conditions during launch, in orbit and during landing. During launch the structure is exposed to broad spectrum of strong vibrations caused by the rocket engines or pyrotechnic devices. During the mission, e.g. in orbit, the structure is exposed to vacuum (i.e. no atmospheric pressure), and heat flux and temperature gradients caused by the orientation of the surfaces to Sun or its shadow. The landing phase exposes the structure again to strong oscillations and extreme temperatures.

2. Materials and specimens

All specimens were manufactured in LA COMPOSITE [3] from materials complying with ECSS Structural Materials Handbook [2]. The skins were made of prepregs consisting of carbon fibers and cyanate ester resin. The core was made from perforated aluminum honeycomb. The core and skins were glued with epoxy film adhesive. The insert were made of blind threaded aluminum inserts with Helicoil (M5 and M8 size). Some skin lay-ups contained also a copper mesh within the epoxy film adhesive on the outer surface. The skins were also tested for connecting with flush head blind rivets. One sandwich specimen with insert is shown in Figure 2 before and after testing.

3. Apparatus and testing

The mechanical testing performed in the labs of University of West Bohemia can be separated into three phases (see Table 1 and Figure 1). The first one was used to verify the properties of the prepreg material in form of unidirectional specimens. The second one concerned the skin (quasisotropic layup) and sandwich specimens. The third phase concerned the same specimens as in the second phase but after their exposure to thermal–vacuum cyclic conditioning (5 cycles, ±100 °C, gradient 2-3 °C per minute).

Table 1. Summary of main tests performed.

Phase	Test description	Standard / Specs.
1, 2, 3	Interlaminar shear strength test (ILSS)	DIN EN 2563
1, 2, 3	Lap-shear strength test of adhesives	EN 2243-1, EN 1465
1, 2, 3	Tensile test (various material orientations of unidirectional and quasiisotropic lay-ups)	DIN EN 2561, EN 2597, CSN EN 14129
1, 2, 3	Compression test	EN ISO 14126-2
1, 2, 3	DSC and DMA tests to assess the glass transition temperature	EN ISO 11357:1, EN 6032/A
2, 3	Sandwich flatwise tension test	ASTM C297
2, 3	Sandwich edge compression test	ASTM C 364
2, 3	Sandwich 4-point bending test (4PB)	ASTM D7249
2, 3	Insert pull-out, shear and compression tests	ESA PSS-03-1202, ECSS-E-HB-32-22A
2, 3	Rivet joint bearing and pull-through tests	ASTM D5961, ASTM D7332

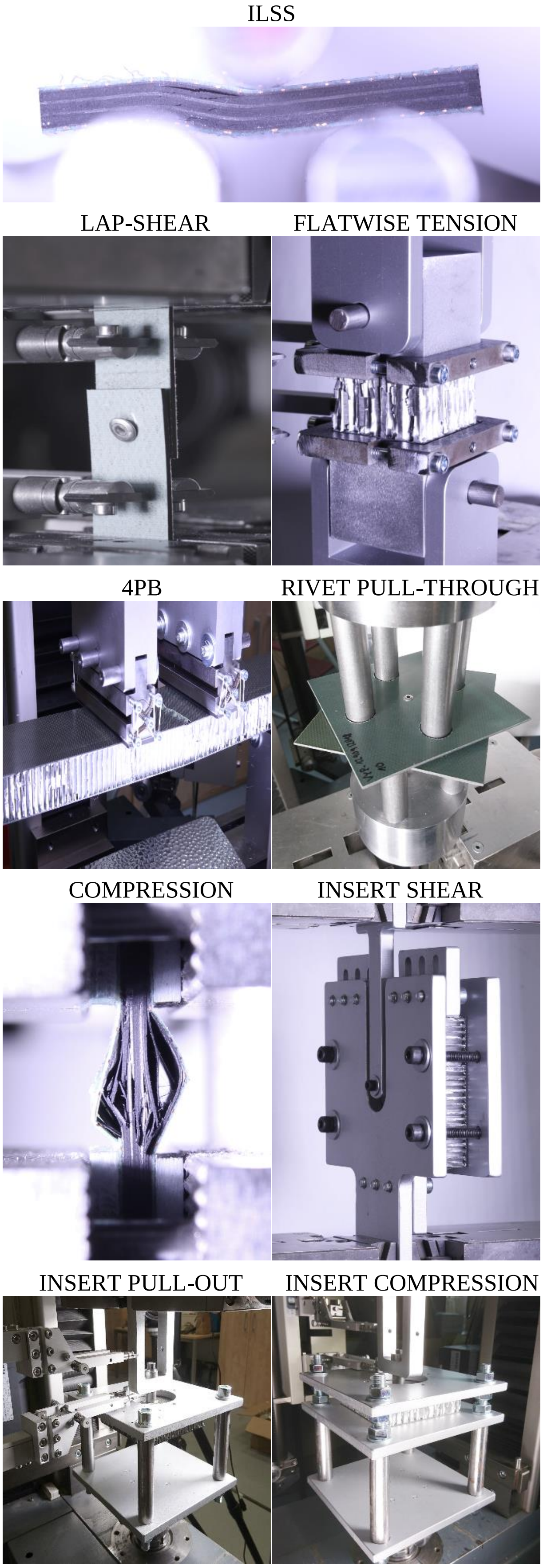

Fig. 1. Various specimens and apparatus used.

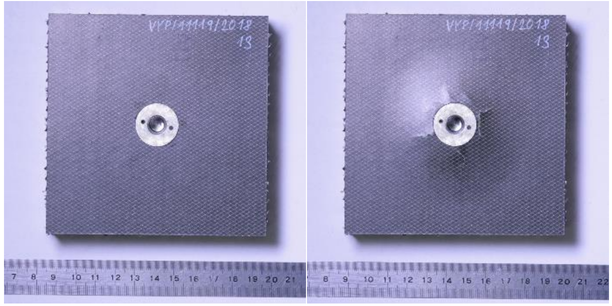

Fig. 2. Typical sandwich specimen (top view) with insert prior (left) and after (right) pull-out test.

Some testing fixtures needed to be designed and manufactured. The fixtures for flatwise tension, insert pull-out and compression were tweaked so that extensometer with arms could be used. This will help to obtain more data for future numerical models such as those in [4] compared to standard approaches where only the less accurate force–crossbar displacement dependency is normally available.

Further testing will concern the verification of sandwich panels with added mass at the inserts subjected to vibrations using a shaker device.

4. Conclusions

A successful cooperation between the manufacturer LA COMPOSITE and University of West Bohemia was established. The experience gained in this project will help both parties to participate in future space project of ESA and its subcontractors.

Acknowledgements

This work was supported by the project TRIO FV10400 “Development of processes applicable to development and production of components for the space industry” of Czech Ministry of Industry and Trade and by the project LO1506 of the Czech Ministry of Education, Youth and Sports under the program NPU I.

References

[1] ECSS-E-HB-32-22A, ESA Requirements and Standards Division, Netherlands, 2011.
[2] ECSS- E- HB- 32- 20 Part 1A, ESA Requirements and Standards Division, Netherlands, 2011.
[3] LA COMPOSITE, s.r.o., https://lacomposite.cz/.
[4] Mandys T., Laš V., Zemčík R., Krystek J. Testing of honeycomb sandwich panel with potted insert. In: Experimental Stress Analysis – Conference Proceedings, pp. 273-278, Luhačovice, 2019.