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TESTING OF COMPOSITE STIFFENED PANELS MADE BY RESIN INFUSION

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ABSTRACT

The present work deals with the experimental testing and numerical analysis of an aerospace stiffened panel made by resin infusion. This one-shoot manufacturing procedure avoids the specific bonding step between the stringers and the skin, which is always a critical location for failure initiation. The final objective of the work is to investigate if the behaviour of the stiffened panel under compression loads, and subsequent induced postbuckling, is improved or not.

For that aim, some so-called "Level-2" tests have been carried out to try to determine the experimental allowable values of the potential failure between the stringer and the skin. These tests include: interlaminar mode-I fracture toughness, unfolding, compression after impact, pull-out bending, and 7-point bending tests (in both symmetric and antisymmetric configurations) (see Blázquez et al. [1]).

Mode I Interlaminar Fracture Toughness tests were performed using a laminate with the stacking sequence of skin+stringer to determine the G_{IC} value of a potential crack running along the interface. Take into account that no adhesive is being used, so the interlaminar strength properties between the two laminates (skin and stringer) may have no difference with respect to any other interlaminar location of the laminate. As the skin and the stringer laminates are not equal, a non-symmetric configuration was tested, with the subsequent mixed mode being obtained (see Figure 1a).

a) b)

Figure 1. a) Interlaminar Fracture Toughness test, b) Pull-out bending test.

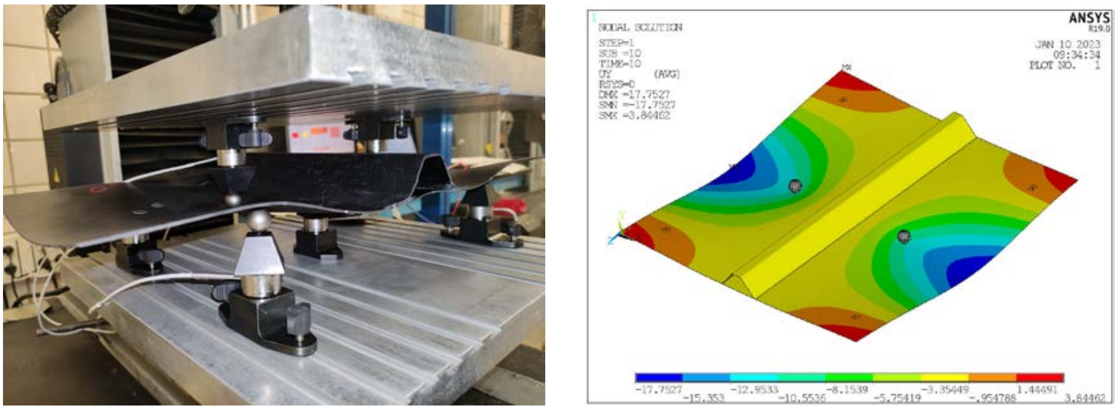
Compression After Impact test were also carried out to try to stablish a compression allowable value under barely visible impact damage situations. Take into account that the final aim of the project is to characterize the global behaviour under compressive loads of a curved stiffened panel, the compression strength being of major importance.

Unfolding tests in 90º L-shape specimens with the stacking sequence of the stringer were done to determine the potential failure in the curved parts of the stringer under bending loads.

Pull-out bending tests using the real skin and omega stringer configurations were also performed using a specifically designed device to force the failure between the stringer foot and the skin laminate to appear and to determine an allowable value of the bending moment per unit width in the skin-stringer junction (see Figure 1b).

Finally, 7-point bending tests, using both symmetric and anti-symmetric configurations were done, to induce in the stiffened panel a loading configuration similar to that that might appear after instabilities under compression would occur in the complete stiffened panel. This test is typically used in this type of characterization with stiffened panels (see for example [2]). For that test a specific device was conceived and manufactured with 5 supporting points in the bottom plate and 2 loading points in the upper plate (Fig. 2a) all points including a load cell to make measurements during the test. Due to the low thickness of the skin panel, and to avoid penetration of the loading points through the thickness, an aluminium plate was placed between the loading point and the skin panel.

In parallel, numerical simulations of some particular tests were carried out (Figure 2b) in order to be able to determine allowable stress values at certain loading situations. Numerical simulations included contact conditions for all supporting and loading points.



a) b)

Figure 2. a) 7-point bending test, b) Numerical simulation of the test.

The correlations between experimental testing and numerical simulations have made it possible to determine the allowable values for subsequent failure initiation prediction in the global compression test of the complete curved stiffened panel.

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