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GROUND-AIR-GROUND (GAG) MODELLING AND TESTING OF DISBONDED HONEYCOMB AIRCRAFT SANDWICH PANELS

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1. ABSTRACT

On March 2005, an Airbus A310-300, experienced separation of its rudder in-flight (see Fig. 1). The investigation ruled out that the most probable root cause of the rudder loss was a sandwich disbond grown during the flight This incident together with a few other similar cases triggered extensive research into disbond fracture in honeycomb core sandwich composites [1, 2]. The presented experimental work here is part of an industrial partnership between AIRBUS and DTU in order to investigate disbond damages in aircraft honeycomb sandwich structures.

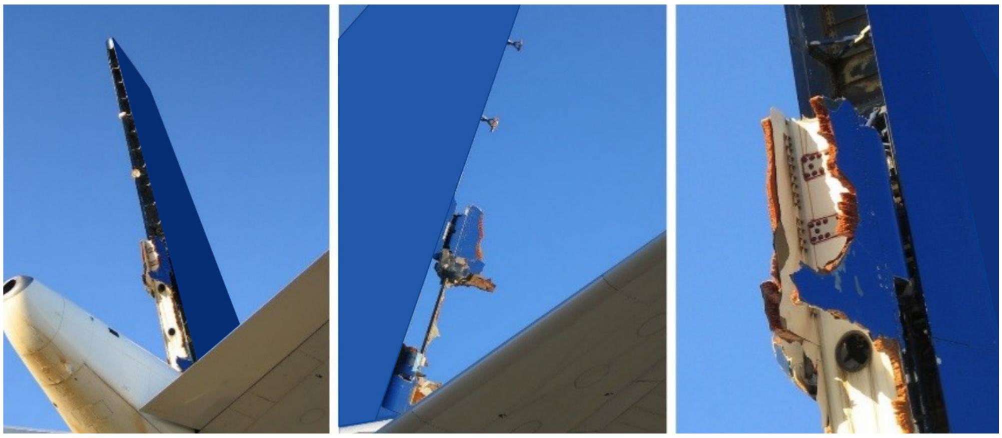

Fig. 1: Airbus A310-300 rudder failure.

Aircraft honeycomb sandwich structures are subjected to Ground-Air-Ground (GAG) loading cycles along their operation, as the relative pressure of the air inside their unvented honeycomb core varies due to different pressure at sea level and flight altitude. Cyclic change in relative internal pressure leads to fatigue loading and propagation of disbonds which may have been introduced during service or manufacturing process. This highlights the necessity of investigation of static and fatigue disbond propagation. To this end, CFRP/Nomex sandwich composite panels with circular disbond in centre were manufactured. A state of the art vacuum chamber was utilized to impose the cyclic pressure together with in-plane compression loading (see Fig. 2).

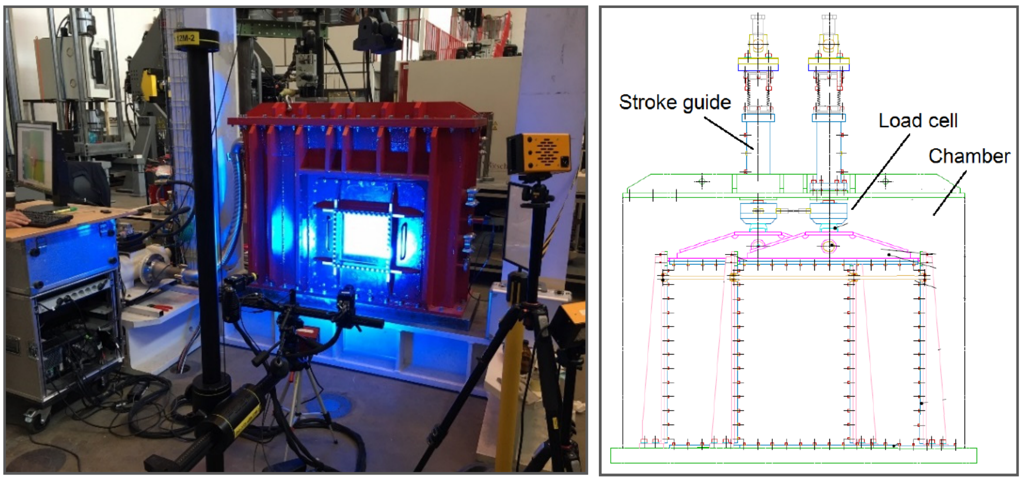

Fig. 2: Test setup using vacuum chamber and DIC.

The crack growth rate was measured for different load conditions. The sandwich panels were tested both in pure cyclic pressurization and also with cyclic in-plane compression. The disbond growth has been monitored using Digital Image Correlation (DIC) and the results have been compared with numerical analysis using Abaqus. Fig. 3 shows the out-of-plane displacement measurement of a vacuum loaded sandwich panel with an artificial circular disbond. The DIC revealed the accurate position of the Teflon film. The FE model was constructed accordingly.

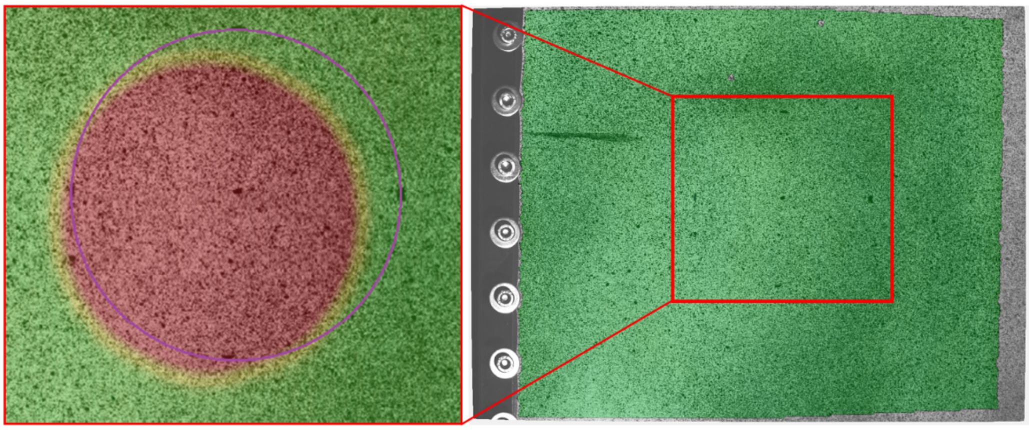

Fig. 3: Disbond front monitoring using DIC.

Pilot sandwich specimens were tested to validate the pressure control inside the vacuum chamber. Fig.4 shows the command and actual pressure versus time for a single cycle on left and for multiple cycles on right. The pressure was cycled between 1000 hPa corresponding to the see level air pressure and 150 hPa corresponding to the environment pressure at flying altitude.

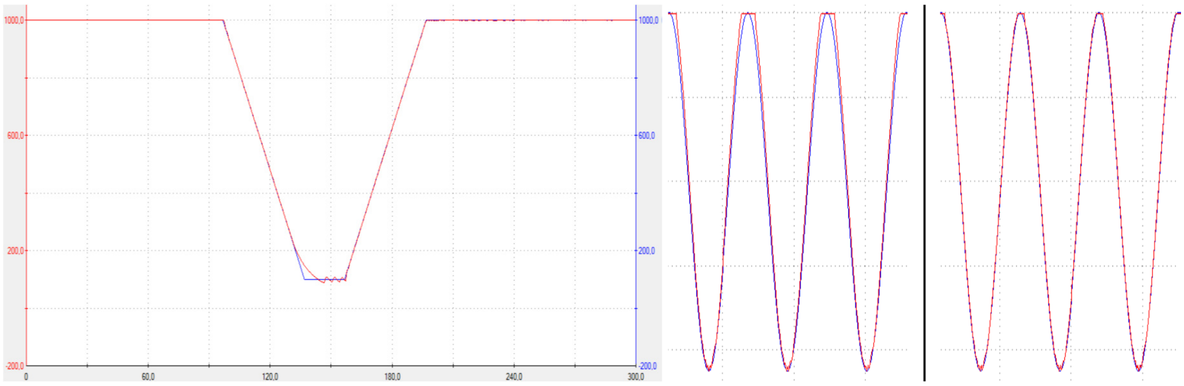

Fig. 4: Command pressure (blue) and actual pressure (red) for single (left) and multiple (right) cycles.

An advanced 3D model of disbonded panels subjected to Ground-Air-Ground (GAG) and in-plane loading was also constructed using the Abaqus software (see Fig. 5). The CSDE method and a sub-modeling technique as well as the cycle-jump method [3] were employed to handle arbitrary shape disbonds (i.e. not necessarily a circle or an ellipse) subjected to various fatigue loading scenarios (i.e. any combination of cyclic GAG, in-plane and out-of-plane loadings). Numerical results were validated against experiments carried out using the vacuum chamber facility.

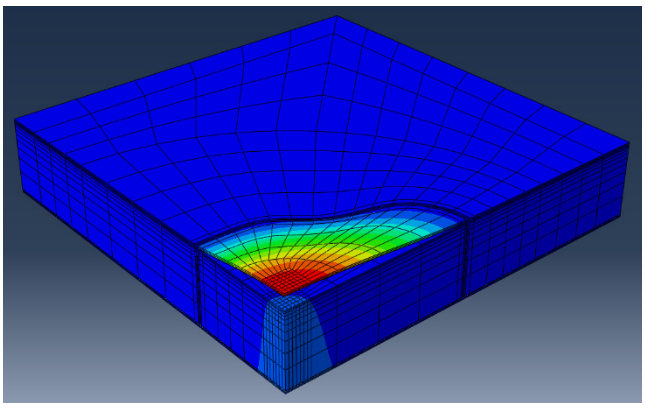

Fig. 5: Global model of the advanced 3D disbond model.

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