Bonded Repairs of Composite Wing Panel Structure

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The Federal Aviation Administration and The Boeing Company have been investigating the safety and structural integrity issues of bonded repair technology. Current efforts, under a Cooperative Research and Development Agreement (CRDA), are focused on testing and analyzing bonded repairs to representative composite wing panels using the Aircraft Beam Structural Test (ABST) fixture, a new structural test capability at the FAA William J. Hughes Technical Center. The program objectives are to characterize the fatigue and damage tolerance performance of bonded repairs subjected to simulated service load and to evaluate the limit load capability of a typical composite wing panel of transport category aircraft with a failed repair. In addition, this program investigates the methods and tools used for analysis and predictive performance of the repairs as well as those used for evaluating and monitoring the repair integrity over the life of the part.

In a phased approach, the initial baseline testing of this program characterized the material response of composite panels in the unnotched pristine and open hole configurations under constant moment loading. This baseline information provided verification of the test fixture loading and validation of analysis models, as well as an initial reference point for non-destructive inspections (NDI) and structural health monitoring (SHM) systems. Initial results from the baseline testing are summarized in Figures 1 and 2 for the unnotched pristine and open hole panels, respectively. In general, these panels were subjected to fatigue loading conditions that produce typical operational strain levels for transport category wing panels for three design service objectives (~165,000 cycles). During fatigue, panels were monitored for damage formation using high magnification cameras, strain gages, NDI and SHM, and a digital image correlation (DIC) system.

For the unnotched panel, structural integrity was maintained through testing with no signs of damage in the test section as shown in Figure 1. Measured strains in the test section were relatively constant and remained unchanged during fatigue. In the tab end sections, strain levels were higher than in the test section resulting in local delaminations of the taper region. Tab ends were redesigned with a high taper ratio to reduce peel stresses in subsequent panels. For the open hole panel, strain surveys revealed excellent correlation between test and analysis as indicted in Figure 2. Strain concentrations measured using DIC and strain gages matched finite element analysis results. Hole edge delaminations were detected during fatigue, which were monitored visually and using NDI including flash thermography and pulse-echo and phased array ultrasound.

The second phase of this program will support bonded repair size limit (BRSL) studies and methods used to predict the limit load residual strength for a failed scarfed repair in solid composite laminates and honeycomb panels. This paper/presentation will provide the ICAF community an overview and update of this multi-year collaborative program including test and analysis results of the first two phases and plans for future work.

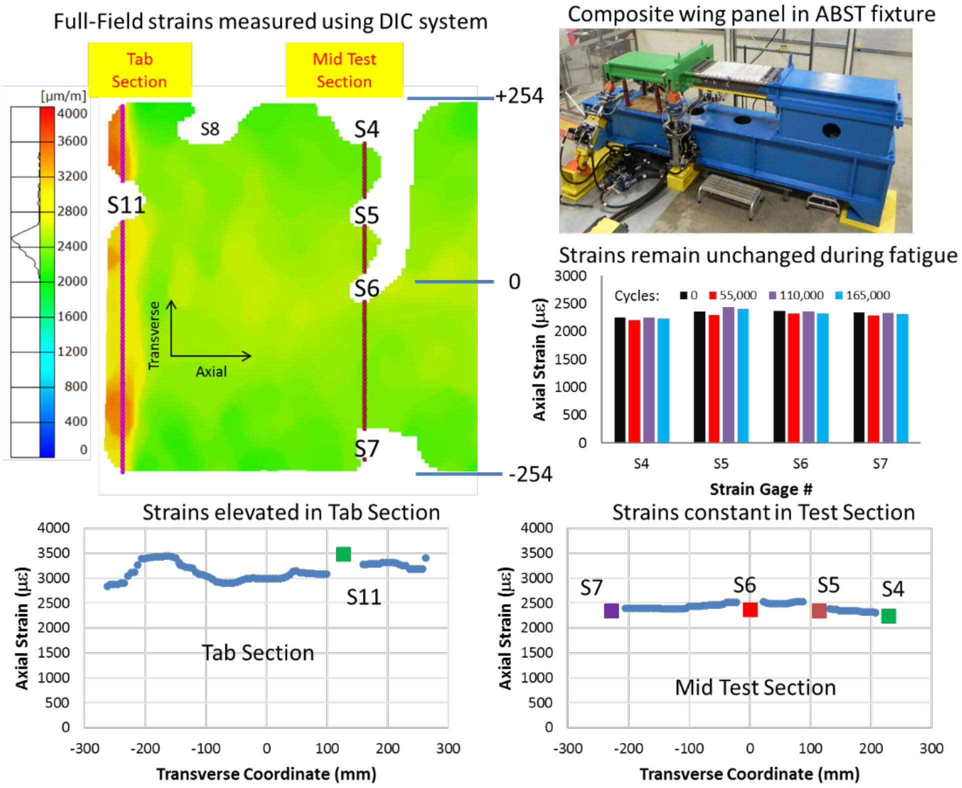

Figure 1: Baseline results for unnotched pristine panel

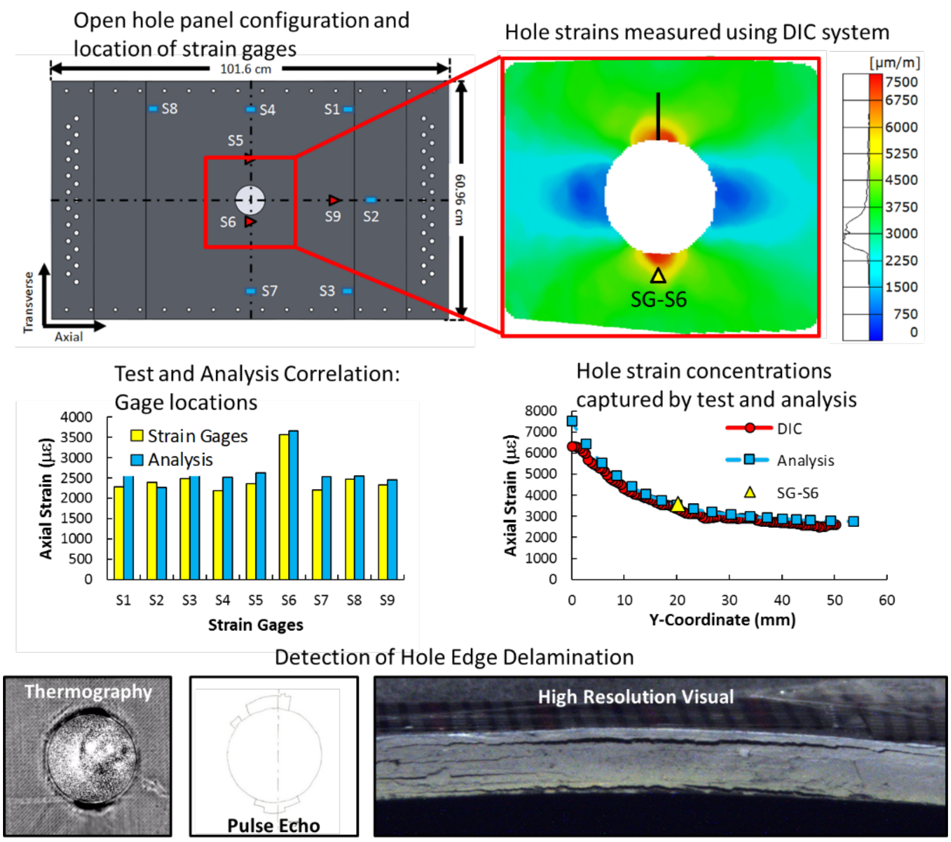

Figure 2: Baseline results for open hole panel