



CECAM Bulletin C05-02

August 2, 2005

"Effect of Repair Procedures Applied to Composite Airframe Structures"

Principal Investigators:

Dr. John Tomblin, Executive Director, NIAR and Sam Bloomfield Distinguished Professor of Aerospace Engineering; Lamia Salah, Manager, Fatigue & Fracture Lab.

Overview:

With the increasing use of composite materials in aircraft structural components, it has become essential to answer not only the fundamental questions related to the proper repair methods/systems to restore the aircraft part structural integrity but also the question of the performance of the repair under repeated loadings and what are the most critical factors affecting the static performance and the durability of the repair.

New challenges created by the growing use of composites will continue to be high on the priority list of concern topics as more and more aircraft make use of composites. These challenges will be primarily focused towards the migration of repairs, of which the majorities were previously in control surfaces and fairings, to the fuselage, wings and other safety critical primary structure. As most repair depots around the world prepare for this migration, the standards and training necessary to ensure the quality and durability of these repairs will continue to increase. These repairs will affect the new general aviation business jet aircraft and smaller piston driven planes as well as large commercial transport aircraft such as the Airbus A380 and the Boeing 787.

The ultimate goal of a bonded repair is to achieve a good level of confidence in bond strength as well as the ability to avoid service failures of these joints. Typically, most repairs being accomplished on composite structures consist of removing the damaged area and applying either an external or a flush patch repair. Flush repairs (scarf) require sanding to prepare the parent material with a constant taper before application of the

patch. Problems may be encountered in this process due to surface contamination of the scarfed region and the tendency to reduce the taper ration in moderately thick laminates or face-sheets in order to reduce the size of the repair and the removal of good material.

Furthermore, the current NDI methods fail to assess the quality of the bond (i.e., fail to detect a weak bond due to poor surface preparation, pre-bond moisture, under or over-cure, surface contamination, etc.). As a consequence, a bad repair is not detected until it actually disbonds, leading to a possible failure of the repaired part. It is therefore essential to quantify the performance of these weak joints and draw attention to the need for appropriate training within the repair community. This will help identify the degree of criticality of the different steps within a bonded repair and subsequently lead to more rigorous and standardized repair procedures.

Objective:

The objective of this research program is to assess the effects of different variables on the static and repeated load performance of scarf repairs applied to composite laminate and sandwich structures especially when a faulty process has been implemented and was not detected by NDI. This program is divided into different tasks.

The purpose of the first task is to generate baseline repair data for both laminate and sandwich composite coupons. Baseline repair data will be generated for Original Equipment Manufacturer (OEM) or factory repairs as well as field repairs. Variables considered for laminate repairs include different substrate stiffnesses, repair materials, lap lengths, laminate thicknesses and temperatures. The only loading mode considered for these repairs will be tension for both static properties and repeated load performance. Constant amplitude loading at a predetermined strain level will be conducted on the coupons and residual strength will be measured after 165,000 cycles. This type of procedure will be used to gage the durability of the repair as well as couple with common procedures typically used during certification of the full-scale element and components.

Variables considered for sandwich repairs include different repair materials and configurations. External patch repairs will simulate field repairs and scarf repairs with different taper ratios will simulate depot repairs. Static properties and repeated load performance for these repairs will be addressed using a four point flexure coupon with the repair patch in compression.

The purpose of the second task is to evaluate the durability of "poor" bonded repairs that passed NDI (undetected weak bond repairs). Factors such as poor surface preparation, surface contamination, pre-bond moisture, and improper cure (over-cure/under-cure) will be investigated. The goal is to evaluate the static and repeated load performance of these poor repairs in comparison with the baseline configurations.

The goal of this task is to evaluate existing SAE Commercial Aircraft Composite Repair Committee (CACRC) standards as related to technician skill level using different repair geometries and establish the value of existing CACRC standards for composite repair technician qualification and suggest modifications if deficiencies are found. This task will

utilize data generated in tasks 1 and 2 to assess the degree of criticality different repair segments evaluated during the repair process. This task will provide quantitative data for validation of safety standards for use by inspectors.