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Performance of Patch Repaired Composite Panels under Cyclic Loads

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Summary

The study in this paper was focused on evaluating the performance of bonded patch-scarf repairs of full scale laminated composite panels under cyclic load conditions. Nondestructive testing to characterize the quality of repairs and destructive testing to evaluate the performance of repaired panels were used in this study. All composite panels used in this research were fabricated at the Center for Composite Materials Research at North Carolina A & T State University. Carbon/Epoxy prepreg material was used to lay up six-ply (12 in.x 27 in.) ((-60/60/0)s) quasi-isotropic laminates. The repairing process started by removing an imposed damage from the center of a panel by drilling 1-inch hole. More material was removed by scarfing around the hole to reveal the six layers of the panel with a gradient of 0.5 inch per layer. The patching kit consisted of 7.5 inches diameter adhesive film, 1 inch diameter filler ply at 90o fiber orientation, and six plies (2 -7 inches diameter) with a similar lay-up as of the parent material. Patches were applied on different scarfed panels to finish the repairing process. A defective repair was also engineered by inserting 1 inch or 2 inches circular Teflon flaw between the fifth and sixth layers of the patch. A schematic diagram for a defective repair panel is shown in figure 1. For the purpose of this study, a total of 33 panels were prepared and divided into five categories: (1) Three pristine panels (undamaged parent material), (2) Three damaged panels (1-inch-centered-hole), (3) Nine good repair panels, (4) Nine defective repair panels (1 inch flaw), and (5) Nine defective repair panels (2 inches flaw). A good and defective repair panels are shown in figures 2 and 3 respectively. The nondestructive testing including the pulse echo C-scan and pseudo through- transmission air coupled and water coupled C-scan was performed at the Center for Nondestructive Evaluation at Iowa State University while the destructive testing was performed at the Center for Composite Materials Research at North Carolina A & T State University. The testing program included 15 static tensile tests and 18 tension-tension fatigue tests. Static tensile tests were performed on three panels of each category and an average ultimate load was recorded. The S-N curves for both good and defective repairs can be established by obtaining at least three data points for each category curve. Therefore, for each of the good and defective repair panels six fatigue tests were performed: two at 40% load, two at 50% load, and two at 60% or 75% load. All load percentages were taken with respect to ultimate load obtained from the tensile testing part. At each specified load the average number of cycles for two panels to break was recorded. Based on the results of the experimental evaluation of this study, good repaired panels have restored 95%

of the tensile strength while defective repair panels have shown 5% degradation in tensile strength compared to the good repaired ones. Under fatigue loading, panels repaired with a 1 or 2 inches flaw delamination within the patch layers have shown a major reduction in fatigue life compared to the good repair panels under similar loading conditions. According to this experimental study, bonded patch-scarf repair for composite laminates is an effective retrofitting technique through which repaired panels can restore up to 95% of their tensile strength. A defective repair panel with a delamination may experience a premature failure under severe fatigue conditions.