

4.2.11. INNOVATIVE USE OF ADHESIVE INTERFACE CHARACTERISTICS TO NONDESTRUCTIVELY QUANTIFY THE STRENGTH OF BONDED JOINTS

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Advances in structural adhesives have permitted engineers to contemplate the use of bonded joints in areas that have long been dominated by mechanical fasteners and welds. Although strength, modulus, and toughness have been improved in modern adhesives, the typical concerns with using these polymers still exist. These include concerns over long-term durability and an inability to quantify bond strength (i.e., identify weak bonds) in adhesive joints. Bond deterioration in aging structures and bond strength in original construction are now critical issues that require more than simple flaw detection. Whether the structure involves metallic or composite materials, it is necessary to extend inspections beyond the detection of disbond flaws to include an assessment of the strength of the bond. Use of advanced inspection methods to measure the mechanical properties of a bonded joint and associated correlations with post-inspection failure tests have provided some clues regarding the key parameters involved in assessing bond strength. Recent advances in ultrasonic and thermographic-based inspection methods have shown promise for measuring such properties.

Specialized noise reduction and signal enhancement schemes have allowed thermographic interrogations to image the subtle differences between bond lines of various strengths. Similarly, specialized ultrasonic (UT) inspection techniques, including laser UT, guided waves, UT spectroscopy, and resonance methods, can be coupled with unique signal analysis algorithms to accurately characterize the properties of weak interfacial bonds. The generation of sufficient energy input levels to derive bond strength variations, the production of sufficient technique sensitivity to measure such minor response variations, and the difficulty in manufacturing repeatable weak bond specimens are all issues that exacerbate these investigations. The key to evaluating the bond strength lies in the ability to exploit the critical characteristics of weak bonds such as nonlinear responses, poor transmission of shear waves, and changes in response to stiffness-based interrogations. This paper will present several ongoing efforts that have identified promising methods for quantifying bond strength and discuss some completed studies that provide a foundation for further evolution in weak bond assessments.