Adhesively Bonded Composite Repairs in Marine Applications and Utility Model for Selection of Their Nondestructive Evaluation

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During the last half century, the use of composite materials and structures has been increasing within many industries: aerospace, automotive, civil, marine, and railway engineering, wind power generation, and sporting goods, to name a few. There is, however, only a small open-literature base concerning adhesively bonded composite repairs, primarily originating from within the aerospace industry. Moreover, little work has been done toward the optimization of repairs on marine composite structures, despite a growing number of such applications. Few decision-making procedures leading to the undertaking of composite repairs have been articulated. Among these, the selection of the most appropriate nondestructive evaluation (NDE) scheme is acknowledged as an important aspect in determining the extent and the type of repair, and ultimately assessing its quality. Such selections of NDE technique(s) currently appear to be largely based upon qualitative engineering judgment, which is likely to lead to long-term sub-optimal remedies.

An open-literature review of various repair schemes and the parameters that affect their mechanical properties, is undertaken, and conclusions on adhesively bonded composite repairs for marine applications are summarized. Particular attention is given to the effects on the repaired composite of the mechanical and geometric properties of the adhesive and patch materials, fabrication procedures, as well as the environmental and loading conditions in which the repair is expected to function. It is thusly concluded that among the essential parameters for cost and reliability optimization of composite marine repairs are the following: NDE of the region under consideration for repair; adhesive thickness and spew fillet size; membrane and flexural stiffness, overlap length, and scarf angle of the repair patch; in-plane bondline length; repair curing and subsequent operating temperature; and moisture absorption. Accordingly, recommendations for further studies are based on these summaries and conclusions.

It is also determined that the selection of the optimal NDE techniques(s) for field inspection is a complex function of the structure's geometry, construction of the composite material (such as single skin, sandwich, or laminate), type and orientation of defect sought (such as interlaminar or intralaminar), accessibility of the site to be inspected (such as single-sided versus double-sided), and cost. To facilitate this multi-attribute decision-making, decision theory is used to generate a value model for the determination of the optimum NDE scheme in marine applications. The decision criteria for this multidimensional assessment of NDE methods are derived from the marine-related open literature. The reliability of such a value model will ultimately depend on the quality of the available data for its formulation.