Fiber Stiffness Detection of GFRP Using Combined ABAQUS and Genetic Algorithms

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Abstract : Composite structures offer numerous advantages over conventional structural systems in the form of higher specific stiffness and strength, lower life-cycle costs, and benefits such as easy installation and improved safety. Recently, there has been a considerable increase in the use of composites in engineering applications and as wraps for seismic upgrading and repairs. However, these composites deteriorate with time because of outdated materials, excessive use, repetitive loading, climatic conditions, manufacturing errors, and deficiencies in inspection methods. In particular, damaged fibers in a composite result in significant degradation of structural performance. In order to reduce the failure probability of composites in service, techniques to assess the condition of the composites to prevent continual growth of fiber damage are required. Condition assessment technology and nondestructive evaluation (NDE) techniques have provided various solutions for the safety of structures by means of detecting damage or defects from static or dynamic responses induced by external loading. A variety of techniques based on detecting the changes in static or dynamic behavior of isotropic structures has been developed in the last two decades. These methods, based on analytical approaches, are limited in their capabilities in dealing with complex systems, primarily because of their limitations in handling different loading and boundary conditions. Recently, investigators have introduced direct search methods based on metaheuristics techniques and artificial intelligence, such as genetic algorithms (GA), simulated annealing (SA) methods, and neural networks (NN), and have promisingly applied these methods to the field of structural identification. Among them, GAs attract our attention because they do not require a considerable amount of data in advance in dealing with complex problems and can make a global solution search possible as opposed to classical gradient-based optimization techniques. In this study, we propose an alternative damage-detection technique that can determine the degraded stiffness distribution of vibrating laminated composites made of Glass Fiber-reinforced Polymer (GFRP). The proposed method uses a modified form of the bivariate Gaussian distribution function to detect degraded stiffness characteristics. In addition, this study presents a method to detect the fiber property variation of laminated composite plates from the micromechanical point of view. The finite element model is used to study free vibrations of laminated composite plates for fiber stiffness degradation. In order to solve the inverse problem using the combined method, this study uses only first mode shapes in a structure for the measured frequency data. In particular, this study focuses on the effect of the interaction among various parameters, such as fiber angles, layup sequences, and damage distributions, on fiber-stiffness damage detection.

Keywords : stiffness detection, fiber damage, genetic algorithm, layup sequences
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