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Health Monitoring of Composite Pile Construction Using Fiber Bragg Gratings Sensor Arrays

Authors : B. Atli-Veltin, A. Vosteen, D. Megan, A. Jedynska, L. K. Cheng

Abstract : Composite materials combine the advantages of being lightweight and possessing high strength. This is in particular of interest for the development of large constructions, e.g., aircraft, space applications, wind turbines, etc. One of the shortcomings of using composite materials is the complex nature of the failure mechanisms which makes it difficult to predict the remaining lifetime. Therefore, condition and health monitoring are essential for using composite material for critical parts of a construction. Different types of sensors are used/developed to monitor composite structures. These include ultrasonic, thermography, shearography and fiber optic. The first 3 technologies are complex and mostly used for measurement in laboratory or during maintenance of the construction. Optical fiber sensor can be surface mounted or embedded in the composite construction to provide the unique advantage of in-operation measurement of mechanical strain and other parameters of interest. This is identified to be a promising technology for Structural Health Monitoring (SHM) or Prognostic Health Monitoring (PHM) of composite constructions. Among the different fiber optic sensing technologies, Fiber Bragg Grating (FBG) sensor is the most mature and widely used. FBG sensors can be realized in an array configuration with many FBGs in a single optical fiber. In the current project, different aspects of using embedded FBG for composite wind turbine monitoring are investigated. The activities are divided into two parts. Firstly, FBG embedded carbon composite laminate is subjected to tensile and bending loading to investigate the response of FBG which are placed in different orientations with respect to the fiber. Secondly, the demonstration of using FBG sensor array for temperature and strain sensing and monitoring of a 5 m long scale model of a glass fiber mono-pile is investigated. Two different FBG types are used; special in-house fibers and off-the-shelf ones. The results from the first part of the study are showing that the FBG sensors survive the conditions during the production of the laminate. The test results from the tensile and the bending experiments are indicating that the sensors successfully response to the change of strain. The measurements from the sensors will be correlated with the strain gauges that are placed on the surface of the laminates.

Keywords : Fiber Bragg Gratings, embedded sensors, health monitoring, wind turbine towers
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