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Distributed fibre optic sensors for advanced structural health monitoring of FRP composite bridge

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1 Abstract

Considering the worldwide recognized advantages of fibre optic sensors as measuring devices in structural health monitoring (SHM) of bridges and the unique ability to measure the long range distributed strain and temperature along the entire bridge superstructure, the distributed fibre optic sensors (DFOS) technology was chosen for the advanced SHM system of the first Polish FRP composite bridge. To develop an understanding of the long-term performance of the FRP bridge, a monitoring scheme utilizing DFOSs was implemented to assess any changes in the bridge structural behaviour in service. The monitored FRP bridge is a simply supported structure with four U- girders bonded with sandwich deck panels. The initial results of the SHM with the DFOS technology are the main subject of the paper. Analysis of the results obtained under proof tests in the field proved the effectiveness of the distributed fibre optic sensors for the SHM purposes. Wide range of practical problems related to sensor installation, fibre connection and data processing were successfully solved in the pilot field application. The smart Rayleigh sensors can ensure an acceptable measurement accuracy, thereby providing reliable strains referring to time-dependent behaviour of the FRP bridge span to assess the safety and serviceability of the FRP bridge.

Keywords: Distributed fibre optic sensors, Rayleigh scattering, FRP bridge, monitoring.

2 Introduction

The FRP composites have been used in bridge engineering for almost 35 years. Since the beginning of the XXI century, a great number of the FRP manufacturers have developed and successfully implemented many FRP composite systems for bridge construction. Many of these bridges are still being monitored to evaluate service performance of this emerging technology and, simultaneously, many of the next FRP construction products are being tested in various research projects worldwide. Fibre optic sensors (FOSs) in general have been often proposed to substitute the traditional electronic sensors in SHM applications [1], [2].

Many types of sensors have been developed with various characteristics. Common approaches use interferometry, fibre Bragg gratings (FBG), scattering mechanisms, and fluorescence [3]. They all benefit from the low profile and low loss of optical fibre. The sensors can be placed in difficult locations and the information can be sent over long fibre tubes. This results in a permanent, flexible capability of non-destructive testing. Moreover, by incorporating sensing devices, the development of such structurally integrated FOSs and intelligent sensing has led to the concept of smart structures.

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