Functionalized carbon reinforcement structures with optical fibre sensors for carbon concrete composites

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Here we are presenting our latest efforts in the development of functionalized carbon reinforcement structures (FCSs). FCSs are textile based carbon structures that are functionalized with optical fibre sensors and are designed for the reinforcement as well as structural health monitoring (SHM) of concrete composites. A schematic of a FCS is shown in Fig. 1a. In this example the FCS contains an optical glass fibre to measure distributed strain profile using the Optical Frequency Domain Reflectometry (OFDR) technique as well as two Fiber Bragg Grating (FBG) sensors to determine punctual strain and strain direction. The fabrication technique to manufacture FCS has been developed at the Saxon Textile Research Institute (STFI) in Chemnitz, Germany, and the fabrication of the FCS involve the embroidering the carbon fibre filaments and optical glass fibres simultaneously on a polyvinyl alcohol (PVA) nonwoven substrate [1]. PVA was chosen as a embroider substrate since it can be easily removed by dissolving it in hot water and the dissolved PVA further stabilizes the FCS. A manufactured FCS that is embedded in a custom made concrete block in order to evaluate the performance of the integrate optical fibre sensors is illustrated in Fig. 1b. After the concrete was set the concrete blocks containing the FCS were installed in a three point bending test (Fig. 1c) and the load transfer from the concrete to the FCS, respective, optical fibre sensor was evaluated. In Fig. 1d the response of the FBG sensor inside the FCS to applied load is illustrated for three consecutive load cycles. As can be seen, the FBG sensor is able to detect the load cycles with a sensitivity of 0.44 nm/% as well as a relatively low hysteresis of 0.011% [2]. Moreover, as indicated in Fig. 1e four strain peaks were detected using the OFDR during the three point bending test. The four strain peaks are due to the integration of the optical fibre of the OFDR in a meander shape (see Fig. 1a) and thus the same optical glass fibre experiences along its length the same load at four different positions. Furthermore, the different magnitudes of the four strain peaks at different time stamps correspondent to the increasing applied load of the three point bending test [2]. Therefore, the experiments verify that the developed FCS can be applied to monitor spatial strain profiles with a relative high sensitivity and low hysteresis.

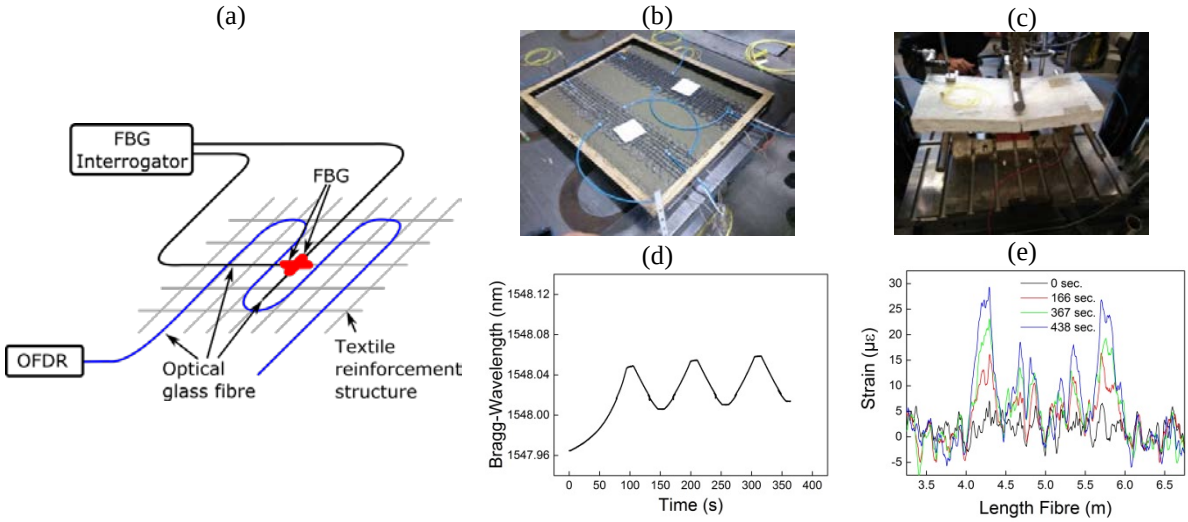

Fig. 1: Schematic of the FCS containing optical fiber sensors (a). Fabrication of a concrete blocks containing a FCS (b) as well as evaluating the sensor performance using a three point bending test (c) and the corresponding sensor response of a FBG (d) as well as OFDR (e) [2].

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References

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