FIBER OPTIC SENSOR FOR RIVER LEVEE MONITORING

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Fiber Bragg Gratings (FBGs) were exploited in a laboratory scaled-levee demonstrating the feasibility of fiber optic sensors to detect deformations of the levee body in response to water infiltration.

Keywords: FBG sensors, fiber optic sensor, levee monitoring

Abstract

In the last decade, there has been a growing interest to employ novel sensing techniques able to guarantee a real-time monitoring of embankments conditions and detect in advance hydrological risks. In this frame, geo-electrical techniques, such as Electrical resistivity tomography (ERT), are typically being exploited, recovering changes of soil composition and water saturation by measuring the soil resistivity. The acquisition of resistivity data by means of resistivity meters requires the injection of current into the ground via multiple electrodes and the measurement of the resulting potential field through other electrodes [1]. In order to cover a wide area, such as a river levee, with a sufficient spatial resolution, many electrodes are thus needed, drastically increasing the complexity and the cost of the whole measurement system which, therefore, is typically installed only temporarily to perform periodic measurements. In this contest, fiber optic sensors can prove to be an interesting alternative for river levee monitoring, offering the possibility of a permanent, real-time and minimally invasive system, able to provide, with a single fiber, multiple measurement points of temperature and deformation along the entire sleeve length.

To prove the feasibility of the proposed approach, a scaled-levee (1:12) was realized in a laboratory using the clay taken from the embankment of an irrigation canal (Fig.1). Two cracks, crossing perpendicularly the levee, were filled by sand in order to emulate real scenarios of potential points of water filtration. Two Fiber Bragg Gratings (FBGs), protected by a $900\mu m$ plastic tube to guarantee mechanical strength, were placed on the levee side not in contact with water, in correspondence of the upper and lower part of one crack. A further FBG was buried in the clay far away from the area of potential infiltration and considered as a reference.

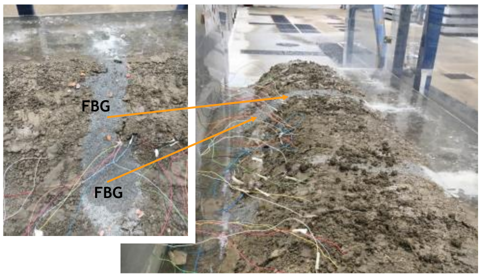

Fig. 1 Right: small-scale clay levee. Left: FBG positions placed on one sandy-filled crack subject to water infiltration.

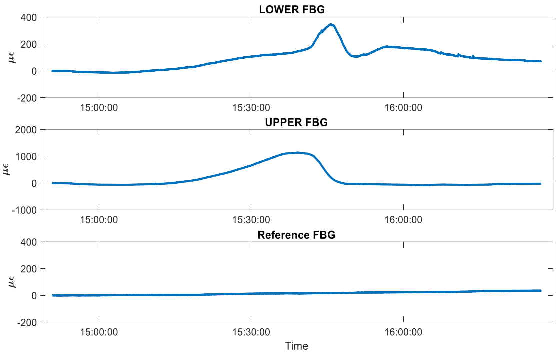

Fig. 2 Strain temporal profiles measured by the two (upper and lower) FBGs placed on the sandy crack and by the reference FBG in the clay.

Fig. 2 shows the temporal behaviour of the strain measured by the FBGs caused by the water passage through the sandy crack. As the temperature difference between the levee soil and the water in the river side was negligible, the marked changes observed by FBGs could be ascribed only to levee structural deformations caused by water infiltration through the sand. The larger deformation was recorded by the FBG positioned on the upper part of the sandy-filled crack as the water filtered first through the top, causing an expansion of the structure. Then, when the sand was saturated with water, the soil covering the FBG collapsed and the FBG got back to its initial state of "free strain". The same behaviour was observed, delayed, for the lower FBG, yet with smaller deformations due to less and slower water infiltration at this level of the levee. The reference FBG instead, not affected by water infiltration, remained almost constant.

Moreover, the temporal evolution of levee water content, resulting from ERT measurements carried out on the same scaled-levee, proved in perfect agreement with FBG data in Fig. 1, demonstrating fiber optic sensor feasibility in monitoring the integrity of levee structures.

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