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Implementation of an Embedded Sensor Based on Electrical Resistivity to Monitor Drying in Thick Concrete Structures

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1 Introduction

The determination of the concrete water content using electrical resistivity method has been the subject of several studies (Millard, 1991; Andrade *et al*., 2007). Due to the limitations of the surface electrical measurements, Badr *et al.* (2019) developed an embedded sensor as a printed circuit board (PCB), which measures profiles at the centimeter scale through the entire thickness of a concrete structure. The main aim of this study is to characterize the PCB sensor in two reinforced concrete slabs, one reinforced with carbon steel bars (HA), and the other one with fiberglass bars (an electrically insulating material) (FV).

2 Experimental Program

The PCB sensor consists of 28 electrodes and presents two measurement configurations: the Transmission configuration where the current is transmitted through two metallic grids placed on both sides of the sensor and a potential drop is measured between all pairs of consecutive electrodes located on the same side of the PCB sensor (E1E3, E2E4, …, E26E28), and the Wenner configuration mode where the quadrupole measurements C1C2P1P2 (electrodes C1 and C2 are used for current injection and electrodes P1 and P2 are used for potential drop measurements) are successively E1E7E3E5, E2E8E4E6, ..., E22E28E24E26 (Figure 1).

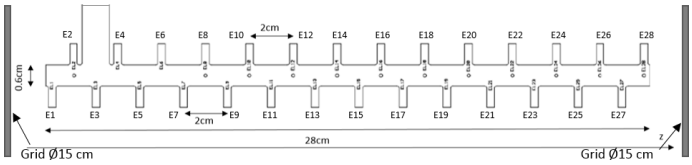

Figure 1. Schematic diagram of the PCB sensor with 28 electrodes.

Two concrete slabs measuring 75x75x30 cm3, equipped with 12 mm diameter reinforcement

were cast. In one of the two slabs, the reinforcements are made from fiberglass (FV), and in the other, from high-adhesion steel (HA). Two PCB sensors are placed on the right (Ed) and on the left (Eg) hand side relative to the surface of the slab exposed to drying.

3 Characterization of the PCB Sensors

The repeatability of the apparent resistivity measurements is verified under both saturated and unsaturated conditions. In addition, the reproducibility between the sensors located on the right and left sides of each slab is verified. The differences obtained can be related to the variability of the concrete. Moreover, the responses of the sensors between the HA and FV slabs are compared. Small differences are observed and can be attributed to the difference of the materials between the two slabs. Therefore, the presence of steel reinforcements does not significantly affect the response of the sensors placed in the center of the reinforcement mesh.

4 Monitoring of the Resistivity Profiles

The monitoring carried out during the drying of the FV slab at 45 °C indicates a resistivity gradient (Figure 2) between the surface exposed to drying (z = 0 cm) and the protected surface (z = 30 cm). Surface resistivity values increase gradually during 372 days of drying, and is consistent the expected trend.

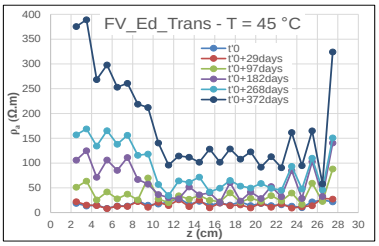

Figure 2. Monitoring of the apparent resistivity profiles measured with the sensor during drying of the FV slab.

5 Conclusion

In this paper, a PCB sensor is used to evaluate the resistivity profile of two 30 cm thick reinforced concrete slabs, one reinforced with carbon steel bars (HA) and the other with fiberglass bars (FV). The repeatability and reproducibility of the measurements are verified. During the monitoring of the concrete drying, measured apparent resistivities increase over time, showing the sensitivity of the sensors to the expected evolution of the concrete hydric state. Further work is needed to quantitatively validate the developed PCB sensor which is felt to be a promising tool for applications on real concrete structures.

References

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