Electro-Mechanical Response Of Smart Concrete Block Corresponding To Different Humidity

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There have been many bridge collapse owing to premature deterioration, such as the Nanfangao Bridge in Taiwan (2019) and the Genoa Bridge in Italy (2018). One of the main reasons of premature deterioration is the loss of prestressing stress of prestressing steel tendons. Strain gauges, fiber bragg grating sensors, and accelerometers have been frequently used to monitor the prestressing stress of PS tendons. However, they have low durability and are sensitive to external environment. To overcome the aforementioned limitations, this study propose to apply a smart concrete block (SCB) capable of monitoring the loss of prestressing stress of PS tendons. However, the electrical resistance of SCB is much affected by external environment such as humidity and temperature. In this study, the effect of relative humidity (RH) on the electro-mechanical response of SCB was investigated. Smart ultra-high-performance concrete (S-UHPC), a material for SCB, contained fine steel slag aggregates with maximum diameter 0.39 mm and short smooth steel fiber with 0.2 mm diameter and 6 mm length. The dimension of the SCB is 200×200×50 mm^3 and the SCB contains a hole with 90 mm diameter. To measure the electrical resistance of SCB, eight electrodes were embedded with a 70 mm horizontal interval and a 20 mm vertical interval (gauge length). The electrical resistance of SCB was measured by using Bluetooth low energy (BLE) based wireless sensing systems (WSSs), and 2-probe method was used under direct current (DC). To investigate the effect of RH, four different RH conditions (20%, 40%, 60%, and 80%) were applied in a chamber. To minimize polarization effect, the electrodes are connected during 48h before the test. As RH increased from 20% to 80%, the initial electrical resistivity of SCB decreased from 6380.4 to 3884.8 kΩ-cm (39.1%). As RH increased, the water content of S-UHPC increased owing to penetration of water from the air into the pores of S-UHPC and the movement of ions in the pore system increased. Consequently, the electrical resistivity of SCB generally decreased as RH increased. The stress sensitive coefficient (SSC), a fractional change in electrical resistivity per stress, of SCB increased from 0.060 to 0.079 %/MPa as RH increased from 20% to 60%, while SSC decreased from 0.079 to 0.064 %/MPa as RH increased from 60% to 80%. In dry condition (RH= 20% and 40%), the electrical conductivity of the matrix between tunneling gap is low, thus it is difficult to form conductive networks in the SCB under external loads. However, SSC increased when RH was more than 60% because the electrical conductivity of the matrix between the tunneling gaps increased and tunneling barrier of the electron decreased. However, when RH was too high (80%), the conductive network was over-stabilized, thus it was difficult for the electrical resistance of SCB under loads to change.