Water and Seawater Moisture Detection Sensitivity of Smart Cement

S. Bhatia[1] and C. Vipulanandan[1], Ph.D., P.E.
[1]Texas Hurricane Center for Innovative Technology (THC-IT)
Department of Civil and Environmental Engineering
University of Houston, Houston, Texas 77204-4003
E-mail: bhatiashivam399@gmail.com, cvipulanandan@uh.edu Phone: (713) 743-4278

Abstract: Sensitivity of Smart Cement (water to cement ratio 0.4) to detect moisture was studied. Smart Cement specimens (air cured for 28 days) were dipped in tap water and sea water (salt content 35g/L) upto different levels and changes in the resistivity values were measured. Initially, specimens were dipped upto 0.5 inches for four hours and then water level was increased to 2 inches for next 4 hours. Resistivity measured in vertical direction (combination 1-2) decreased by about 4% in 4 hours and 9% in 8 hours when immersed in tap water with moisture content changes of 2.6% and 3.3% respectively. Whereas, resistivity decreased by about 57% in 4 hours and 81% in 8 hours when immersed in sea water with moisture content changes of 7% and 14% respectively.

1. Introduction:

Salt-induced damage represents a serious problem which a significant number of buildings face (Skalny, 2002). Soluble salts can penetrate buildings easily with moisture which can further transport them (Haynes and Bassuoni, M.T., 2011). It has been found that different contaminants behave differently on bricks, stones, mortars, and wood, which seems to react differently to the damaging action of salts and pollutants (Morabito, 2013). Liquids will diffuse into various construction materials due to concentration gradient, capillary rise due to microstructure configuration and due to chemical reactions. Therefore, it is important to understand the problem thoroughly regarding all the porous building materials and salt contaminants (Morabito, 2013). Damage to modern concrete building foundations caused by salts has recently been the subject of litigation leading to multi-million-dollar settlements and judgments (Doehne, 2014). It is estimated that only the American and British transportation structures such as roads or bridges require approximately $450 billion and £616.5 billion, respectively, to repair the damage caused by salts (Broomfield, 2007).

2. Objectives:

The objective was to monitor and understand the changes in electrical properties of smart cement specimen due to the penetration of tap water and sea water.

3. Materials and Method:

In this study, smart cement samples were prepared with water to cement ratio of 0.4 and 0.05% of conductive filler. Samples were prepared by mixing conductive filler in tap water followed by cement being added by hand mixing. Specimens were prepared in cylindrical molds of height 4 inches in height and 2 inches in diameter. Wires were inserted in these molds about 2 inches apart. To determine the electrical resistivity, 2 probe method was adopted, and wires were used to measure the Resistance (R) using an AC measuring device. Resistivity (ρ) is related to resistance as (R / k) and the parameter k was determined by measuring the resistivity and resistance when cement was in early hours of curing. Samples used for this study were air cured for 28 days at room temperature. Initially samples were immersed upto 0.5” depth (see figure 1 (a)) and changes in the electrical properties were noted; followed by raising the water level to 2” depth (see figure 1 (b)). Similar tests were conducted for different specimens immersed in tap water and saline water.

Fig – 1(a) **Fig – 1 (b)**

Figure – 1 Schematic diagram of test setup: (a) water level up to 0.5” (b) water level up to 2”

4. Results and Discussion:

Effect of water infiltration on the electrical properties of smart cement and the weight change of specimen was monitored.

4.1 Tap water:

Initial Resistivity of the specimen was 15.34Ωm (Figure – 2). On first contact with tap water, resistivity of smart cement decreased by about 4% in 4 hours and by 9% in 8 hours along with increase in the weight of specimen by 2.6% and 3.3% respectively (Figure – 2).

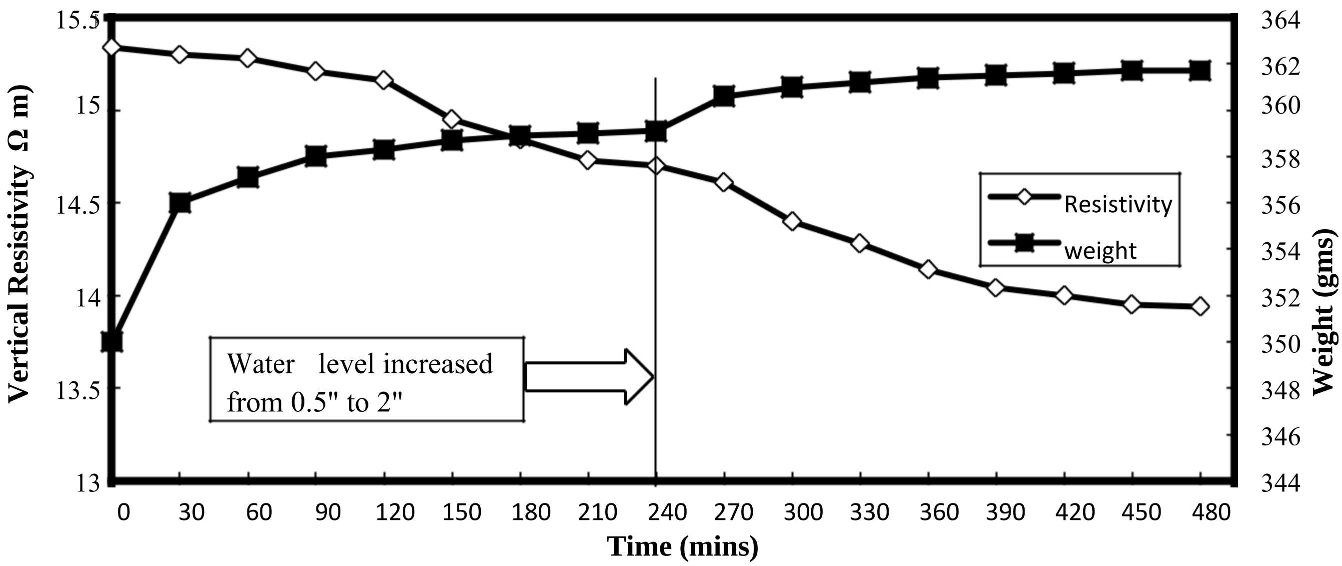

Figure – 2. Variation in Resistivity and weight with time for specimen dipped in tap water

4.2: Salty water

Initial Resistivity of the specimen was 15.5Ωm (Figure – 3). On first contact with salty water, resistivity of smart cement grout decreased by about 57% in 4 hours and by 81% in 8 hours along with increase in the weight of specimen by 7% and 14% respectively (Figure – 3).

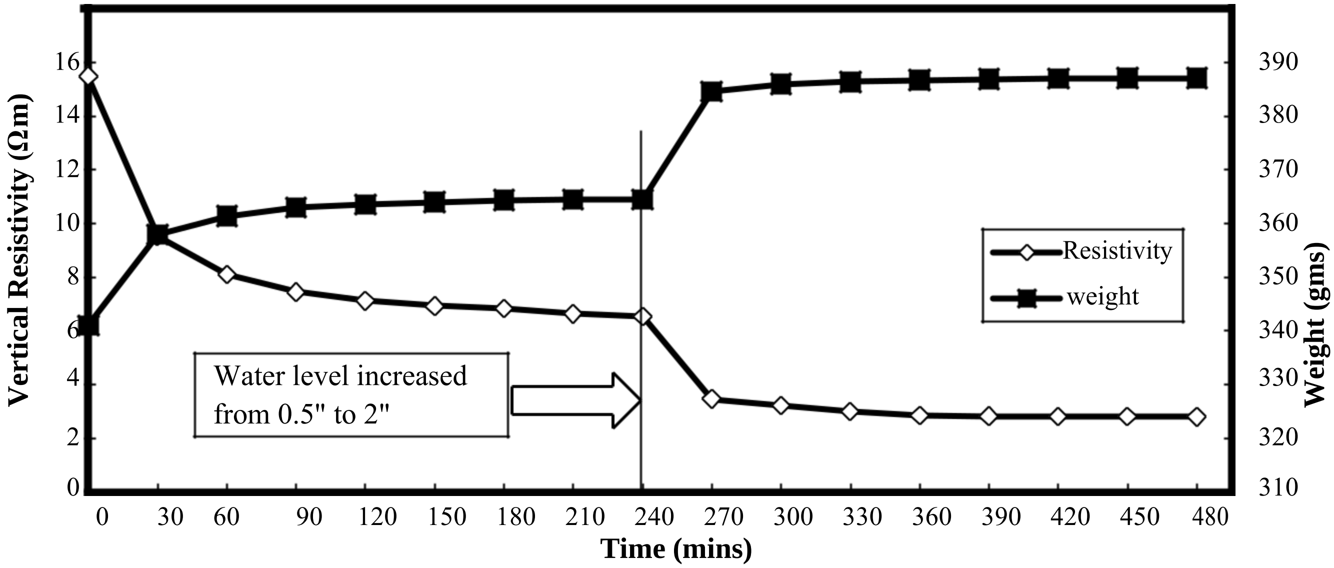

Fig – 3. Variation in Resistivity and weight with time for specimen dipped in salty water

Variation in Resistivity with moisture content for samples immersed in tap water and sea water can be seen in Figure – 4 (a) & (b). Moisture content can be predicted from the change in resistivity values. Also, as there is substantial difference in the resistivity values for samples immersed in tap water and sea water; so nature of water (tap water or seawater) can also be determined.

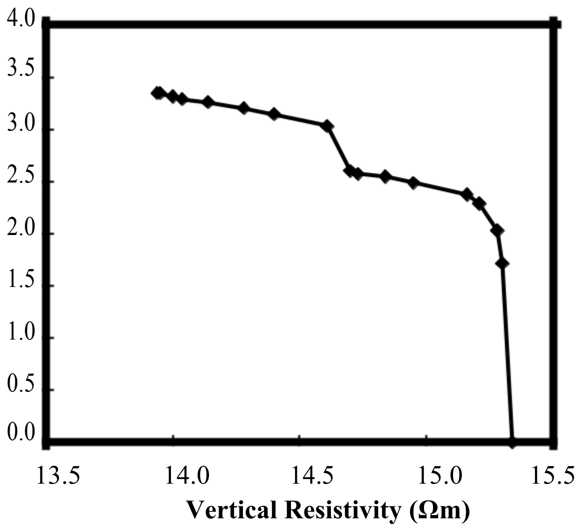

Fig – 4 (a)

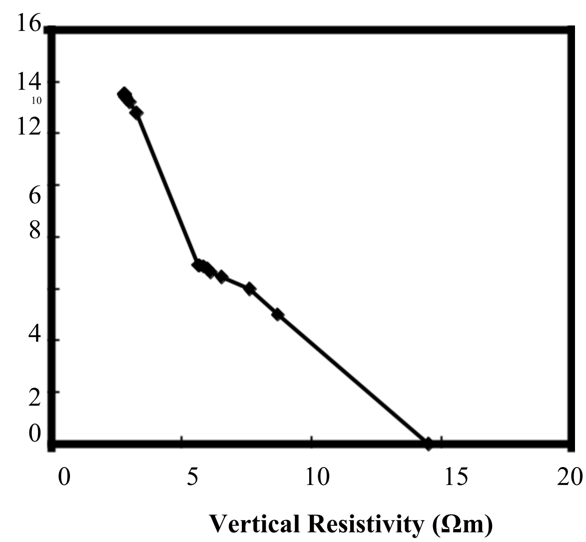

Fig – 4 (b)

Fig – 4. Variation in Moisture Content with Resistivity (a) for specimen immersed in tap water (b) for specimen immersed in sea water.

5. Conclusion:

Based on the experimental study, following conclusions are advanced:

1. Moisture detection is an advantageous and beneficial application of Smart Cement.

2. Resistivity decreased by 5% and 57% in 4 hours, upon the first contact with tap water and sea water respectively.

3. Moisture content can be determined based on the electrical resistivity of smart cement. Also, Moisture penetration can be differentiated between sea water and tap water on the basis resistivity and weight change values.

6. Acknowledgements:

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7. References:

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