Effect of Chemical Attack on the Smart Cement Grouts Physical and Piezoresistive Behavior

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Abstract: In this study, the effects of acidic and basic environments on two types of cement grouts were investigated. Piezoresistivity was identified as the sensing parameter. There was 1.2% weight gain in NaOH solution and 5% weight loss in sulphuric acid solution. The grout samples immersed in sulphuric acid and NaOH showed 50% and 20% reduction in piezoresistivity respectively at an applied stress of 200psi compared to control samples which was cured in air.

1. Introduction: Most concrete structures in service are subjected to aggressive environmental influences that affect the durability of concrete. Among all of the chemicals, sulfates and sulfuric acid are the most important from the point of view of action on structures. Many naturally occurring soils and ground waters contain sulfates which lead to the deterioration of concrete structures. (Mehta, 1986) Other situations where sulfates can attack concrete are; seawater, industrial effluents, fertilizer application, and acid rain. Piezoresistivity has been proven to be a good sensing property in the literature (Carmona et al.(1987), Vipulanandan and sett (2003), Todoroki et al. (2009) and Masoud et al.(2012). It can be used to self-sense stress/strain, sense damage and thermoelectric properties and monitor health of the structure and more.

2. Objective: The overall objective was to quantify deterioration of ultrafine and Portland cement under acidic and basic environment. The properties of interest were weight change and piezoresistive behavior.

3. Materials and Methods: In this study ultrafine cement and Portland cement samples were prepared with 0.6% and 0.38% w/c ratio respectively. 0.075% Conductive filler wad added to investigate the piezoresistive behavior. The prepared samples were allowed to cure seven days in the air. Then samples were immersed in sulfuric acid (H_2SO_4)(pH=1), Sodium Hydroxide (NaOH)(pH=12) and water(pH=7) to study their short term effect in acidic environment. Then the change in weight and electrical resistivity were measured with time. In order to quantify the compressive behavior compression test was performed for limited load. During compression test, electrical resistance was measured in the stress axis. Alternating current (AC) resistance measurements were made using a LCR meter at a frequency of 300 kHz. Furthermore, changes in resistivity were related to the applied stress. Impedance spectroscopy method was used to investigate the sensing behavior of th acrylamide polymer. (Vipulanandan and Prashanth, 2013).

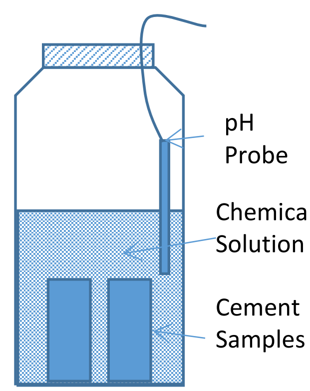

Figure 1: Schematic diagram of the chemical resistance test

4. Results and Discussion: The weight changes with time for the ultrafine cement grout is shown in figure 2. In this test, weight increased in NaOH solution and water after seven days the increases were 1.23% and 2.57% respectively. The weight for both air and sulfuric acid cured samples decreased to 1.5% and 5% respectively. The weight change of ultrafine cement with immersion time represents the degradation rate of the ultrafine cement when it is immersed in a corrosive solution.

Figure 3 and Figure 4 shows the piezoresistive behavior of ultrafine cement and Portland cement respectively. For ultrafine cement specimens immersed in sulphuric acid showed around 50% reduction in piezoresistivity compared to control sample which cured in air. For control sample the piezoresisitivity of the ultrafine cement and Portland cement were 21.5% and 20.5% respectively at 190 psi compressive stress. NaOH solution also reduced the piezoresistivity from 21.5% to 17.3% for ultrafine cement and from 20.5% to 12.7% for Portland cement after 7 days. The effect in reduction on cements by NaOH is lesser than sulphuric acid solution.

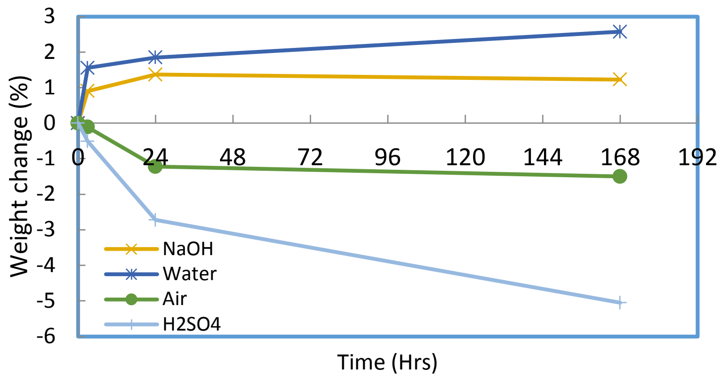

Figure 2: Weight change with time for fine cement

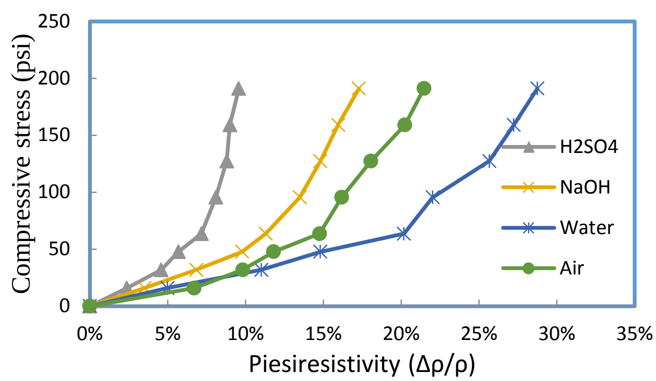

Figure 3: Compressive behavior of ultra fine cement

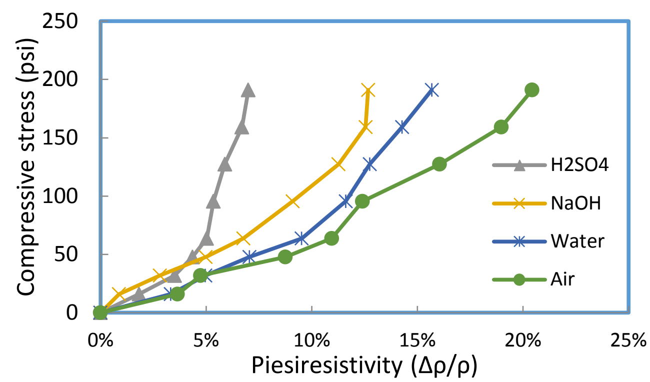

Figure 4: Compressive behavior of Portland cement

5. Conclusion:

- For ultrafine cement the weight increased by 2.6% and 1.2% in water and NaOH solutions. The maximum weight loss was observed 5% for samples immersed in sulpuric acid.
- For an applied compressive stress of 200 psi the piezoresistivity of ultrafine grout decreased from 21.5% to 9.5% for sulphuric acid solution and for portland cement it decreased from 20.5% to 7%.

6. Acknowledgements: This study was supported by the Center for Innovative Grouting Materials and Technology (CIGMAT) and Texas Hurricane Center for Innovative Technology (THC-IT), University of Houston, Houston.

7. References:

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