Electrical Resistivity and Piezoresistive Properties of Repaired Cement Sheath with Smart Cement Grouts

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Abstracts: The effect of piezoresistive smart cement grouts with and without sodium meta-silicate in repairing damaged solid smart cement was investigated. The piezoresistivity of the smart cement grout at failure was decreased with the addition of 1% SMS. The strength regain of the repaired smart cement with smart cement grout was about 70-75% of the original strength.

1. Introduction:
Cement-based grouts have been widely used in many construction areas such as grouting of soils and rocks, repairing of cracks in massive concrete structures and masonaries, to coat pre-stressed cables, to stabilize ground near tunnels, rehabilitating old defective masonaries in historical buildings, and repair cracked oil well cement sheath (Anagnostopoulos 2014, Chun et al. 2008). Sodium silicate based cement grout significantly reduces the permeability of the grouted region (Chun et al. 2008).

2. Objectives:
To study the effect of piezoresistive smart cement grouts in repairing the damaged solid smart cement.

3. Materials and Methods:
Smart cement grout was prepared by adding 0.075% conductive filler with class H oil well cement to make it piezoresistive and the water to cement ratio was 0.8. Sodium meta-silicate solution was prepared adding 1% w/w SMS in water. To determine the electrical resistivity, two probe method with fixed 2 electrical wires were used to measure the resistance. Cylindrical specimens were prepared with 2 inches diameter and 4 inches height. Two wires were placed at 2 inches apart. Previously failed specimens were used to repair with the grout. The grout were poured into the crack of the specimen by using spatula.

Mold Calibration:

The resistivity (ρ) is defined as RA/L (where, R = measured resistance, A = area of the electrical flow, L = distance between the probe). The two probe test mold was first calibrated by determining the resistivity of the cement slurry with a direct resistivity measuring device and the corresponding resistance measurement by an AC resistance measuring device. Then from the resistivity relationship, the A/L ratio of the test mold was determined. This ratio was used to determine the resistivity of hardened cement.

4. Results and Discussion:
4.1 Electrical resistivity with curing time: Electrical resistivity of the cement grout cured under room temperature up to 28 days was monitored. The initial resistivity of the grout without SMS was found 1.08 Ω.m and the grout with 1% SMS was 0.69 Ω.m. The minimum resistivity of the grout without SMS was found as 1.04 Ω.m (at 180 min) but for the grout with 1% SMS was found as 0.54 Ω.m (at 300 min). The resistivity after 24 hour was found as 2.16 Ω.m and 1.01 Ω.m for grout without and with SMS respsectively. The resistivity is increased with curing time increases. With curing the grout without SMS has the higher resistivity compared to the grout with 1% SMS (Fig. 1). After 28 days of curing, the resistivity of the grout without SMS was found as 9.4 Ω.m but for the grout with 1% SMS it was 4.9 Ω.m which is 45% less than the grout without SMS.

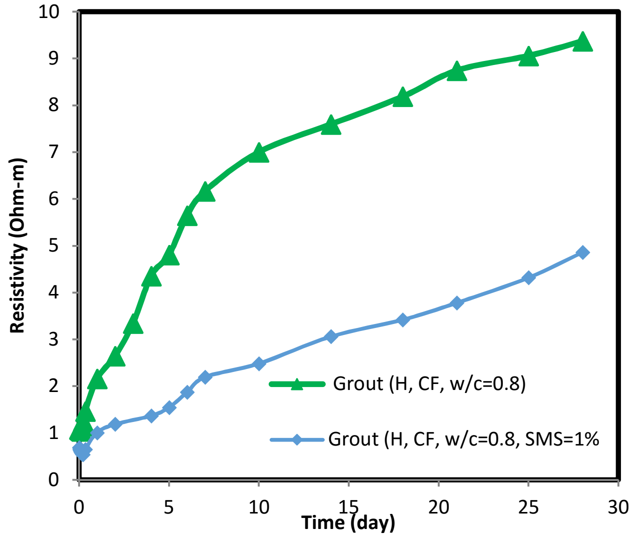

Figure 1: Resistivity with curing time up to 28 days for cement grout with and without SMS

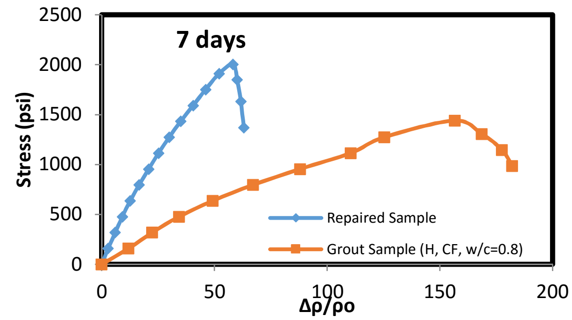

Figure 2: Stress-Piezoresistivity relationships after 7 days for cement grout without SMS

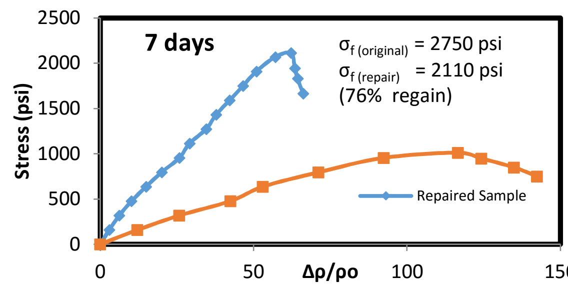

Figure 3: Stress-Piezoresistivity relationships after 7 days for cement grout with 1% SMS

4.2 Piezoresistive Behaviour: The resistivity of the cement grout specimen and the repaired specimen with compressive stress was determined after 7 days of curing. The cement grout made without SMS failed at a compressive stress of 1440 psi and the repaired specimen failed at compressive stress of 2005 psi (Fig. 2). The original specimen failed at a stress of 2880 psi, thus the grout helped the regain of 70% of the strength. The piezoresistivity of the grout specimen and the repaired specimen at failure was 155% and 58% respectively. On the other hand, the cement grout made with 1% SMS failed at a compressive stress of 1010 psi and the repaired specimen failed at compressive stress of 2110 psi (Fig. 3). The original specimen failed at a stress of 2750 psi, thus the grout helped the regain of 76% of the strength. The piezoresistivity of the grout specimen and the repaired specimen at failure was 115% and 62% respectively.

5. Conclusions: 1. After 28 days of curing the grout with 1% SMS showed a resistivity of 4.9 Ω.m which is 45% less than the resistivity of the grout without SMS (9.4 Ω.m)

2. The grout without SMS and with 1% SMS helped the repaired sample to regain about 70% and 76% of its original strength respsectively.

3. The piezoresistivity of grout without SMS and with 1% SMS at failure after 7 days was 155% and 110% respectively and those for the repaired sample was 58% and 62% respectively.

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2. B. S. Chun, H. C. Yang, D. H. Park, H. S. Jung, 2008. "Chemical And Physical Factors Influencing Behavior of Sodium Silicate-Cement Grout". Proceeding-The Eighteenth International Offshore and Polar Engineering Conference, 6-11 July, 2008, Vancouver, Canada.