Polymer-Energy Treatment of Tensile cracks in Smart Cement

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Abstract: Crack healing effect in smart cement subjected to polymer-energy treatment was investigated. Smart cement was made with 0.1% of conductive filler to make it sensing to various changes. Polymer-energy treatment was used to repair the damaged sample by splitting tensile test. Splitting tensile test was done to quantify the phenomenon. Piezo-resistivity and splitting tensile strength of smart cement recovered 56 % and 71 % of its original specimen respectively after the polymer-energy treatment due to its crack healing effect. Also the Resistivity measurements were sensitive to capture the crack healing.

1. Introduction: Cracks in concrete structures influence the durability and serviceability of the infrastructure in terms of resistance, permeability and transfer properties (Granger et.al, 2007). It is important to repair the cracks and monitor the structure throughout its lifetime. Monitoring electrical resistivity change in a material due to mechanical stress/strain (Piezo-resistivity) is a technique which can be used in any structure to monitor throughout its lifetime (Vipulanandan, 2014).

2. Objective: The main objective was to investigate the recovery of piezo-resistive behavior and tensile strength of smart cement after the polymer-energy treatment under splitting tensile loading.

3. Materials and Method: Smart cement was made with class H cement and 0.1% of conductive filler by total weight of the specimen. Water to cement ratio was 0.38. Cylindrical molds were used with the height of 4 inches and the diameter of 2 inches. Splitting tensile test was done after the curing of 28 days at room temperature. High pressure High temperature device (Pressure-150 psi) was used to pressurize the acrylamide polymer solution (setting time-5 minutes) into the cracks of the damaged specimens and then specimens were immersed in the acrylamide polymer solution while direct current of 0.01 A (Power- 0.13 W) was supplied through the specimen for a week. Figure 1 shows the experimental setup. To quantify the recovery of its piezo-resistivity and strength, splitting tensile test was done again to the repaired specimens. P-q model (Proposed by Dr. C. Vipulanandan) was used to represent the tensile piezo-resistive behavior of treated smart cement. The equation (1) is given below.

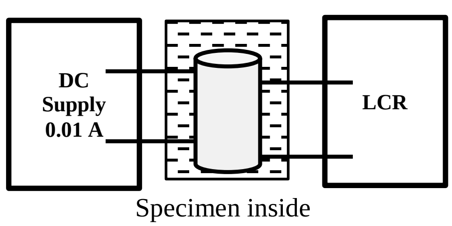

Figure 1: Schematic diagram of Experimental setup

$$\sigma = \frac{\sigma_{max} \times \left(\frac{\left(\frac{\Delta\rho}{\rho}\right)}{\left(\frac{\Delta\rho}{\rho}\right)_0} \right)}{q + (1-p-q) \times \left(\frac{\left(\frac{\Delta\rho}{\rho}\right)}{\left(\frac{\Delta\rho}{\rho}\right)_0} \right) + p \times \left(\frac{\left(\frac{\Delta\rho}{\rho}\right)}{\left(\frac{\Delta\rho}{\rho}\right)_0} \right)^{\left(\frac{p+q}{p}\right)}} \quad \ldots\ldots(1)$$

p, q : Material parameters
σ_{max} : Maximum stress
$\Delta\rho/\rho$: Piezo-resistivity

4. Results and Discussion:

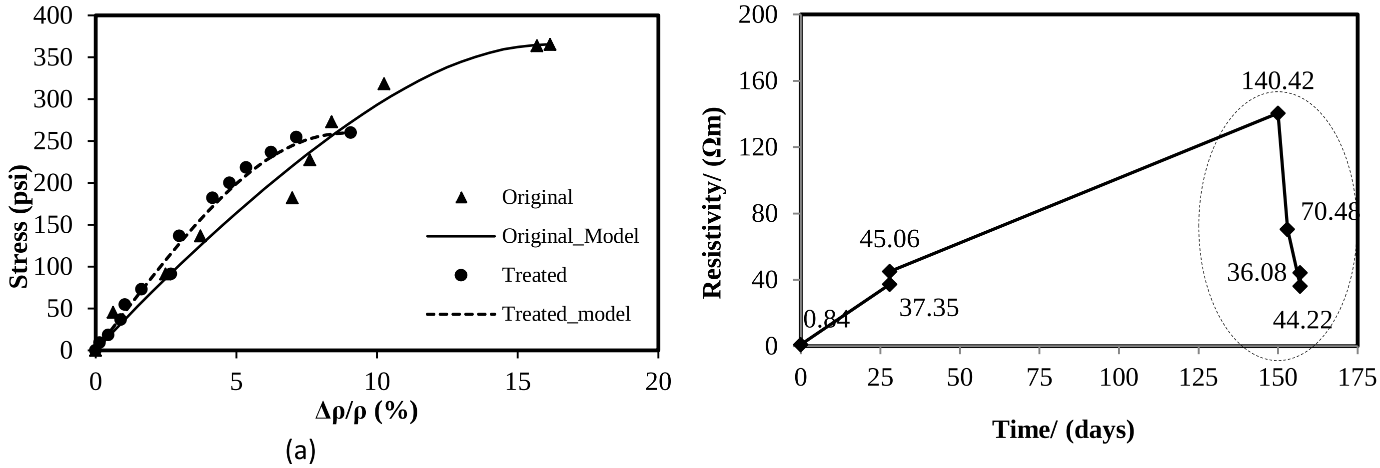

Figure 2: (a) Splitting tensile stress Vs Piezo-resistivity (b) Resistivity Vs Time

The experimental results obtained for original specimen and repaired specimen treated using the polymer-energy are compared in Figure 2 (a). Piezo-resistivity and splitting tensile strength of the original specimen were 16 % and 365 psi and that of repaired specimen are 9 % and 259 psi. Piezo-resistivity and splitting tensile strength have been recovered 56 % and 71 % of its original specimen respectively after the polymer-energy treatment due to its crack healing effect. The variation of resistivity over the time is given in Figure 2 (b). After 7 days of polymer-energy treatment, the resistivity of specimen (36.08 Ω.m) was almost equal to its 28 days resistivity (37.35 Ω.m). That's an indication of crack healing and resistivity measurements were able to capture it.

5. Conclusion: Piezo-resistivity and splitting tensile strength of smart cement recovered 56 % and 71 % of its original specimen respectively after the polymer-energy treatment due to its crack healing effect. Resistivity measurements were sensitive to capture the crack healing.

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7. References:

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