Enhancing the Performance of Smart Cement Modified with Laponite

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Abstract:
In this study, compressive behavior of smart cement modified with Laponite was investigated. An LCR (inductance, capacitance, resistance) meter was used to measure the changes in the electrical properties with applied stress for the samples cured under room temperature and higher temperature at oven. The results indicated that the addition of 1% Laponite increased the 5-day compressive strength by 24%, and reduced the piezoresistivity by 25%. Sample with 1% addition of Laponite and heat treatment attained almost double the compressive strength of control sample and also it reached almost the 1.5 times piezoresistivity of control sample.

1. Introduction
Damages to oil wells, structures and other facilities could happen due to natural and man-made disasters. Capability to detect damages in civil infrastructures as early as possible is critical for the safety of public. Currently, self-monitoring materials have become more popular, based on the piezoresistive behavior of the material (Vipulanandan et. al 2004). Self-monitoring of material would contribute to a longer service life of structures and would make the material not only more durable but also more sustainable. In this study, Laponite which is a synthetic clay composed of a mixture of sodium, magnesium and lithium silicates, was studied as an additive to cement by testing the strength and sensitivity behavior in order to investigate the self-monitoring ability of the smart cement.

2. Objectives
Objective of this study was to investigate the short term performance of smart cement modified with Laponite and also to investigate various treatment methods to enhance the properties.

3. Materials and Testing
Class H cement with Water to Cement (w/c) ratio of 0.38 was modified with conductive fillers to prepare the smart cement. To modify the smart cement, 1% of Laponite was mixed with cement. In order to characterize the electrical properties, 2x4" cylindrical specimens were prepared. Monitoring wires were embedded while preparing the specimen. In order to characterize the 5 day compressive behavior, cylinders were covered with plastic caps and specimens were subjected to different curing conditions (normal room condition, oven at 150°F) till the age of 2 days. Then the samples were kept in normal room condition up to the age of 5 days, and they were de-molded and tested for compressive strength using a destructive testing method. In order to compare self-sensing properties with curing condition, impedance measurements were taken between the wires using LCR meter with AC signal at the frequency of 300 kHz for all the specimens during compression test.

4. Results and Discussions
Figure 1 shows the resistivity behavior of smart cement and Laponite modified smart cement from mixing through hardening to curing in the air for 5 hours, and Figure 2 shows the variation of maximum stresses

and maximum change in specific resistivity during compressive loading. Results indicates that the addition of 1% Laponite increased the initial resistivity, minimum resistivity and time to reach minimum resistivity. The experimental results show that the Laponite modified smart cement treated with high temperature (150°F) attained high compressive strength and high piezoresistivity compared to other specimens. However, the test data shows that the strength gain is enhanced with Laponite even without any treatment.

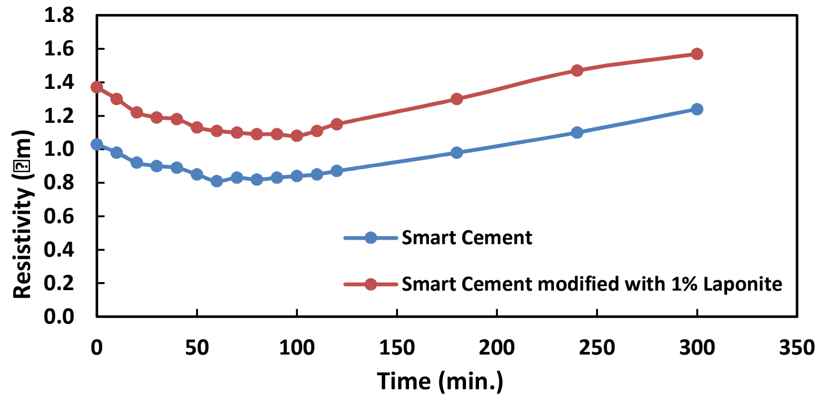

Figure 1: Resistivity change

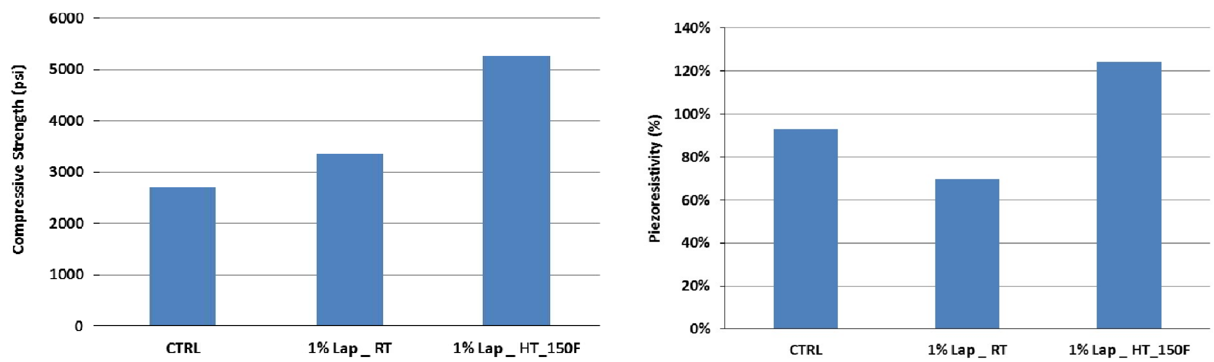

Figure 2: Compressive behavior at the age of 5days (a) Maximum compressive stress attained (b) Piezoesistivity at maximum compressive stress)

5. Conclusions

Addition of 1% of Laponite has enhanced the compressive behavior of the smart cement. In this early age study, Laponite modified smart cement treated with high temperature has attained the maximum compressive strength of 5.3 ksi and piezoresistivity of 124%. Because of its higher strength and sensitiveness, smart cement modified with Laponite could be used to sense the loads and stresses applied to the civil structures by the wind forces and waves during a hurricane.

6. Acknowledgement

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Reference

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