Effect of Bentonite on the Shrinkage and Piezoresistive Behavior of Smart Cement

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Abstract
The effect of bentonite addition to smart cement was investigated at closed room condition. Based on literature review 2% to 8% bentonite was added to the smart cement and the change in electrical resistivity, length and weight were measured during the curing of the cement. Addition of bentonite increased the electrical resistivity during the curing of the cement and also reduced the Moisture loss and shrinkage. Piezoresistivity at failure for Smart Cement control specimen and with addition of 2%, 4% and 8% bentonite were 59%, 60%, 70% and 43% respectively. Compressive strength of smart cement was significantly reduced with addition of bentonite.

1. Introduction
Hurricanes can cause a significant amount of sediment transport due to heavy water flow and flooding.
When hurricanes affect a certain area, the surge of water increases the contamination of cement in that construction areas, by pushing massive amounts of contaminants and toxins from the earth. One of the major contaminant can be the ground soil because most of the soil have expansive properties in Houston area. Hence there is a requirement for studying moisture losses, shrinkage, strength and piezoresistivity of expansive soil contaminated cement. Bentonites are clays rich in Smectite regardless of their mode of origin (Patterson and Murray, 1983). Smectite is a type of clay mineral (e.g., montmorillonite) that undergoes reversible expansion on absorbing water. So the laboratory testing program was designed by contaminating the cement with bentonite to achieve the real field conditions.

2. Objective
The objective of this study was to investigate the effect of bentonite addition on the oil well cement's shrinkage and piezoresistive behavior.

3. Materials and Methods
In order to quantify the amount of Shrinkage and moisture loss in Smart cement, Cement with water-to-cementitious material (w/cm) ratio of 0.40 and Bentonite replacement levels of 2%, 4% and 8% were designed and one control mix which was prepared without addition of bentonite. To develop the Bentonite modified smart cement mixtures, the Class H oil well cement was partially replaced with Bentonite by weight of the total binder content. Conductive filler of 0.03% by total weight was used and dispersed into the dry binder. Then the dry binder was mixed with water in a jar by using a drill pit mixer. Initial conductivity measurements were taken by using conductivity probe and the readings were converted to resistivity. Cylindrical (2" x 4") specimens were prepared and tested under uniaxial compression after 10 days. Oven heated just before the test to eliminate the effect of moisture. Resistance measurements were taken by using LCR meter. Since the sample has four probes, six combinations of readings were taken and averaged to get more accurate results.

4. Results and Discussion
From continues monitoring it can be visible that the resistivity was highest for 8% Bentonite addition (Figure 1). Figure 2 shows the change in compressive strength after 10 days with different percentage of

Bentonite addition. 2% addition shows lowest compressive strength compare to other three specimens. Replacement of bentonite reduced a significant amount of strength of smart cement. It can be seen the initial resistivity values are indirectly proportional to the ultimate compressive strength of all 4 specimens.
Figure 3 compares the percentage shrinkage change of bentonite modified smart cement with curing time. As seen in figure, it is obvious that the shrinkage was reduced from 6.5 to 1 % by increasing bentonite from 2 to 8 %. Control specimen and the specimen with 2% addition of bentonite were showed the similar shrinkage values. 4, 8 % bentonite addition shows a reducing shrinkage trend due to the expansive property of bentonite.

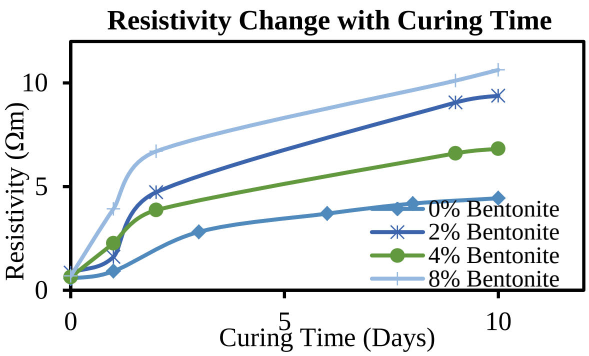

Figure 1: Resistivity change of Bentonite replaced Smart Cement specimens with curing time

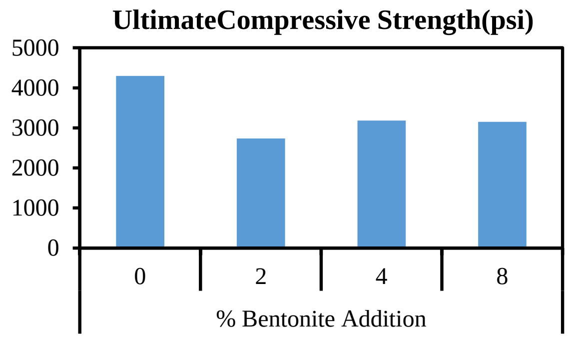

Figure 2: Compressive strength of the smart with varying % of Bentonite

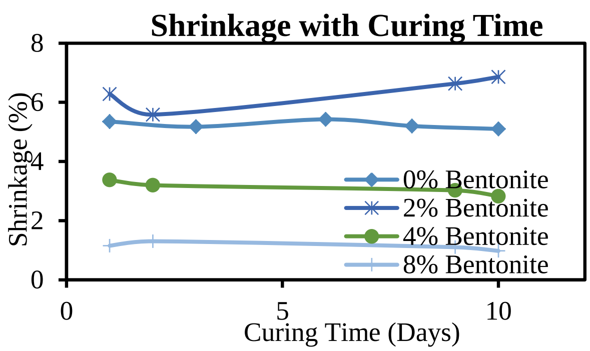

Figure 3:Percentage shrinkage change of bentonite modified smart cement with curing time

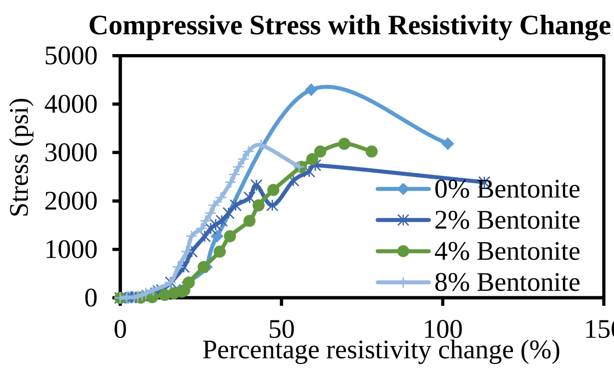

Figure 4: Piezoresistivity of the smart cement varying with % of Bentonite

4. Conclusions

1. Shrinkage and moisture loss of the bentonite contaminated smart cement was decreased with the addition of bentonite into the oil well cement slurry.
2. Piezoresistivity at ultimate compressive strength was 59%, 60%, 70% and 43% for 0%, 2%, 4% and 8% of bentonite addition. Highest piezoresistivity was observed with 4% of addition.
3. Compressive strength was decreased with replacement of bentonite.

5. Acknowledgment

This study was supported by the Texas Hurricane Center for Innovative Technology (THC -IT).

6. References

Memon, Shazim Ali, Rao Arsalan, Sardar Khan, and Tommy Yiu Lo. "Utilization of Pakistani bentonite as partial replacement of cement in concrete." *Construction and Building Materials* 30 (2012): 237-242.