Monitoring the Electrical Resistivity of Smart Cement Modified with Recycled Eggshell Powder

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Abstract: In this study, class H oilwell cement enhanced with recycled eggshell powder (ESP) was monitored using electrical resistivity. Results suggested that cement properties changed with the addition of ESP, including electrical properties and minimum resistivity. Compared to the control sample (0% ESP), ESP modified smart cement retarded the cement by slowing down the time to reach the minimum resistivity.

1. Introduction:

Eggshell waste poses significant health and environmental issues; annually, in the US, roughly 150,000 tons of eggshell waste is being disposed of. These wastes attract vermin and other rodents, and in reports, companies in the US spend large sums of money on disposal of eggshells approximately 100k $ annually. Therefore, recycling eggshells (about 97% $CaCO_3$) and using the waste material as a cement additive can be a cost-effective and eco-friendly measure to counter this challenge. This investigation provides an additive that improves the sensing and mechanical properties of oil well cement to produce an environmentally friendly and sustainable seal behind the casing. It will also be a method of cement replacement as cement manufacturing is a major contributor to carbon dioxide emissions.

2. Objective:

The specific objectives of this study are the following:

a) Characterize smart cement hydration with addition of eggshell powder.
b) Understand the behavior of smart cement and eggshell powder modified smart cement cured under different temperatures.

3. Materials and Methods:

High sulfate resistant (0% C_3A) Class H oil well cement was used in this study with 0.38 water to cement ration (w/c) using (350 g) cement and (132 mL) of tap water. 10% BWOC Eggshell powder (ESP) added to smart cement (0.07% Conductive Filler) and 0.1% BWOC powder dispersant. The eggshell powder was prepared by first collecting eggshell waste from local sources around Houston. The eggshells were washed and heated up before grinding them to a fine powder on the micro-scale. Figure 1. Mixing of cement was performed in accordance with API RP10B-2 testing standards and procedures by dry mixing the cement with ESP and conductive fillers dispersed inside. Then the dry mix was poured into the blender while spinning at 4000 RPMs within 15 s, then slurry was mixed for 35 s at 12000 RPMs. Curing of samples was in 2X4 inch capped molds in oven (dry curing) as shown in figure 2.

3.1 Test Results:

Table 1. Properties of Eggshell powder loading in water

ESP %	ORP mV	PH	C0 µS	ρ Ω.m
0	200	6.57	427	23.4
1	183	7.77	450	22.2
2	174	8.4	490	20.4
3	161	8.67	525	19.0

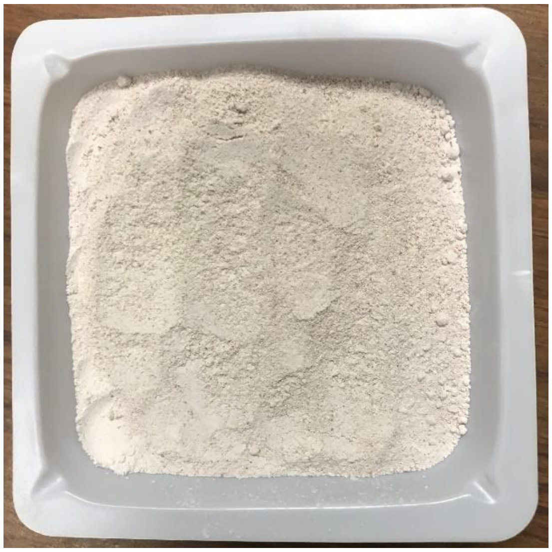

Figure 1. Eggshell powder

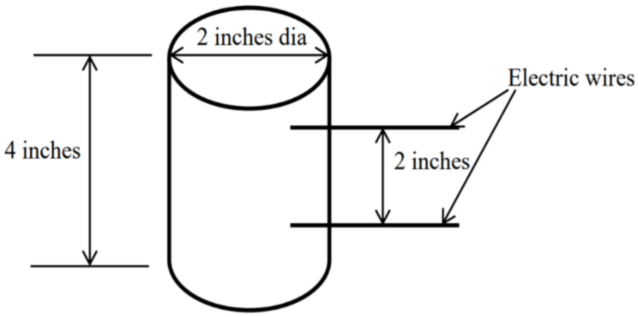

Figure 2. Molds dimensions used to cure smart cement

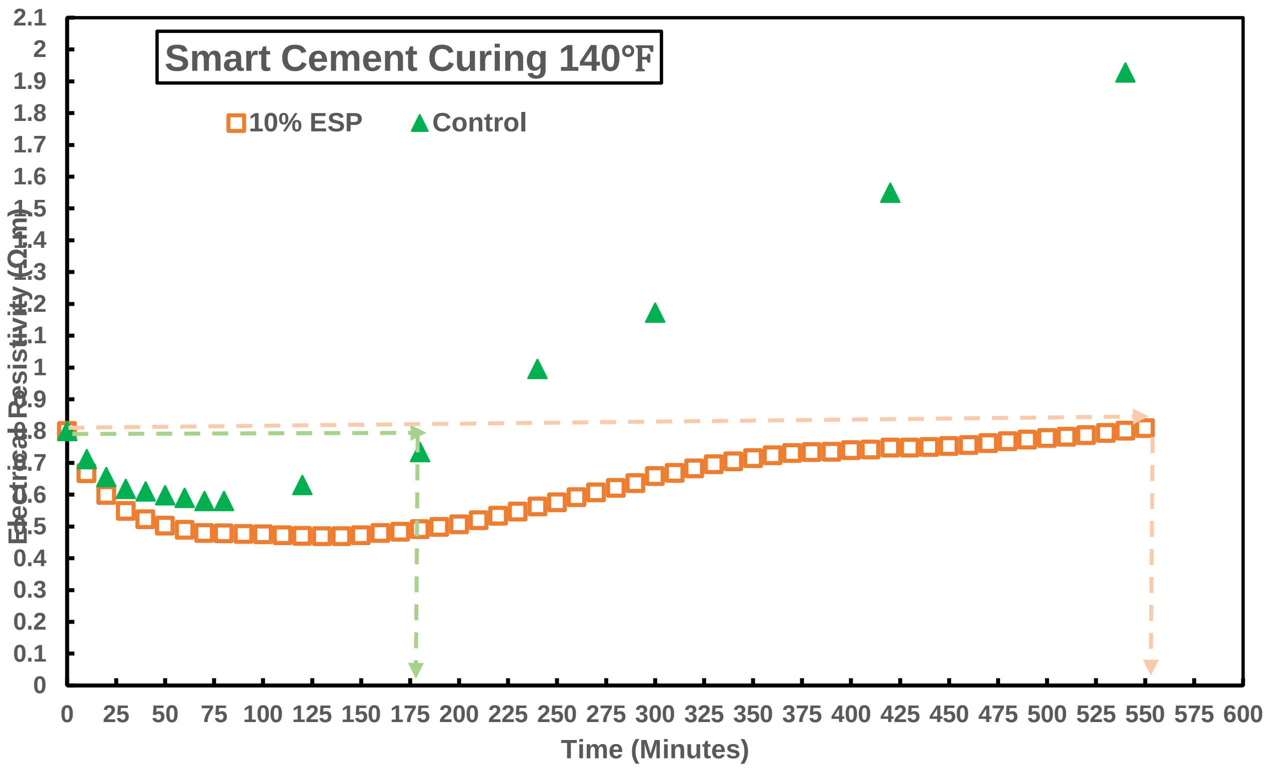

Figure 3. Curing of smart cement and ESP modified smart cement at 140 °F

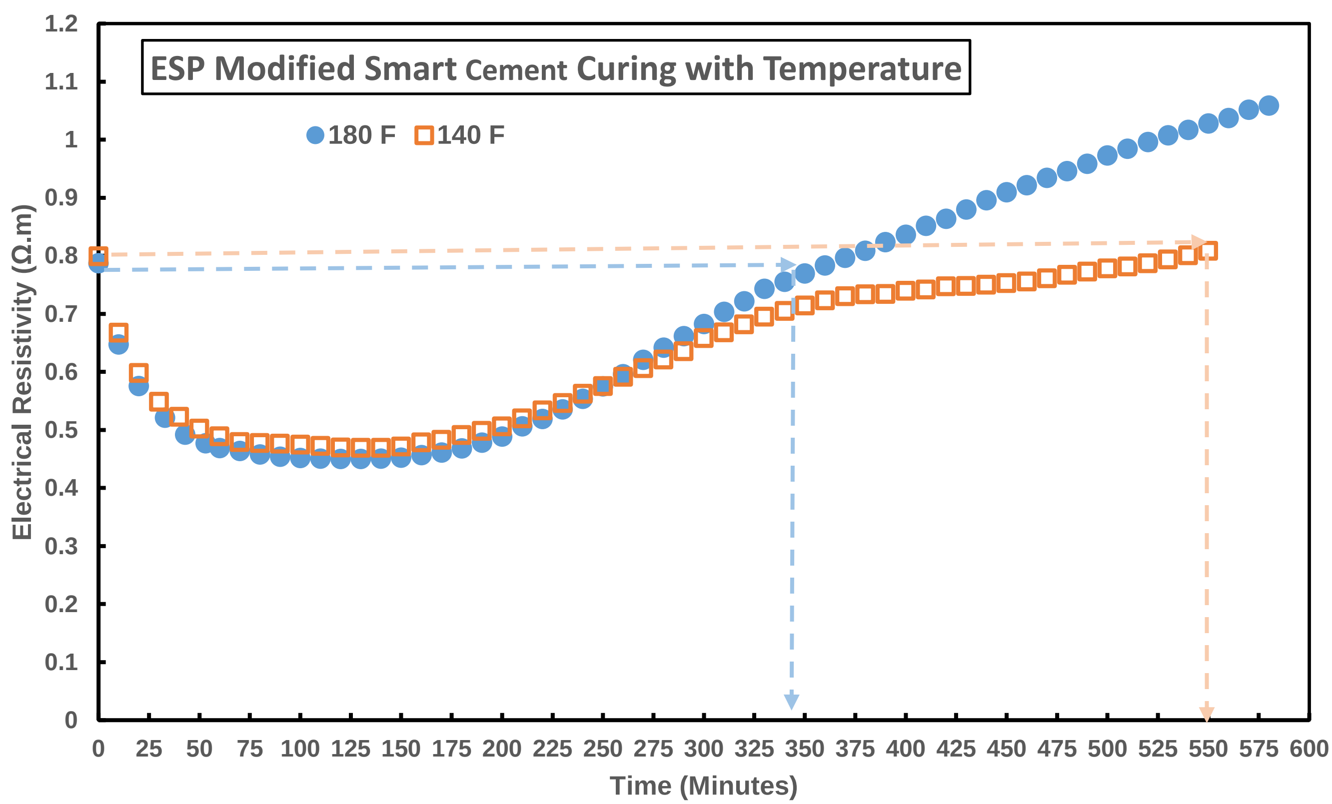

Figure 4. Curing of ESP modified smart cement at different temperatures

4. Conclusion:

1. Eggshell Powder when added to water decreases the oxidation potential (ORP) while increasing both the PH and Conductivity as shown in Table 1.
2. Time to reach minimum resistivity for 0% ESP smart cement was 0.58 Ω.m after 70 minutes of curing under 140 °F. On the other hand, 10% ESP smart cement minimum resistivity was 0.47 Ω.m after 130 minutes. With that, ESP extends the time to reach minimum resistivity and lower down the minimum resistivity indicating that ESP is a retarder for cement.
3. Time to reach minimum resistivity of 0.45 Ω.m for 10% ESP modified smart cement cured at high temperature 180 °F was 120 minutes.
4. From figures 3 and 4, the dashed arrows point to the time for each sample to return to the initial resistivity. For samples cured at 140 °F in figure 3, 0% ESP smart cement's resistivity bounces back to initial value at a faster rate than ESP modified cement as it takes approximately 3 hours for 0% whereas 10% ESP around 9 hours. Higher temperature curing of ESP modified smart cement accelerates the time to reach initial resistivity to 6 hours.

5. Acknowledgements:

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6. References:

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