Effect of Micro-Sand on the Curing of Modified Smart Cement

A. S. Mohammed and C. Vipulanandan Ph.D., P.E.
Center for Innovative Grouting Material and Technology (CIGMAT)
Department of Civil and Environmental Engineering
University of Houston, Houston, Texas 77204-4003
Tel: 713-743-4278: E-mail: Asmohammed2@uh.edu

Abstract: Electrical resistivity at room temperature was monitored during the early age curing of oil well cement (class H) with water-to-cement ratio of 0.38 and modified with micro-sand. In this study, up to 9% of micro-sand by (weight of cement) was used. Effect of different percentage of micro-sand on the density of the oil well cement was also investigated. It was found that addition of 9% of the micro-sand increased the initial electrical resistivity of the cement by 14% and increased the minimum electrical resistivity (ρ_{min}) by 38% and time to reach the minimum electrical resistivity (t_{min}) decreased by 30%. Density of smart cement increased by 2% when the micro-sand percent was 9%. The electrical resistivity at the end of 24 hr increased from 4.12 Ω-m to 4.32 Ω-m by adding 9% of micro-sand.

1. Introduction

With the growing interest for environmental concerns, monitoring the durability of cement-based materials used in oil wells is a major importance to mitigate the risk of cement failures. Electrical resistivity is a good tool to monitor the behavior of the cement. However, some modifications are needed since previous experiments showed that the electrical resistance of unmodified cement had so much fluctuation and was not interpretable. Sand is commonly used in oil well cement since it is tolerable in high temperature and increases the compressive strength of the cement (Muller et al. 1991). Silica is known to provide this behavior in cement as it is a good accelerator for cement hydration. Furthermore, increase in density due to nanosilica addition into cement slurry is based on transformation of water into crystal bound water, which is responsible for a small expansion of cement slurries (Singh et al. 2013).

2. Objective

The main objective of this study was to investigate the effect of micro-sand on the electrical resistivity sensitivity and density of smart cement.

3. Materials and Methods

The smart cement with 0.1% conductive fiber was mixed with different percentage of micro-sand up to 9% (by the weight of the cement). In this study, the water-to-cement ratio of 0.38 was used. The cement with 0.1% conductive fiber was mixed then placed in plastic cylinder mold of 2 inches in diameter and 4 inches in height. Each mold had 2 wires installed to measure the electrical resistance (R) using LCR meter (AC). Electrical resistance then converted to the resistivity (ρ) using calibration factor K as in Eqn. 1.

$$\rho = R * \left(\frac{L}{A}\right) = R * K \quad (1)$$

4. Result and Analysis

The density of modified smart cement with 0% and 9% of the micro-sand were 16.52 ppg and 16.85 ppg respectively, a 2% increase as shown in Fig. 1(a). Electrical resistivity was investigated during the early curing age of modified cement. Adding 9% of micro-sand increased the initial resistivity from 1.06 Ω-m to 1.21 Ω-m a 14% increase as shown in Fig. 1 (b). Minimum electrical resistivity (ρ_{min}) increased by 38% by adding 9% of micro-sand as summarized in Table.1. Time to reach minimum electrical resistivity (t_{min}) decreased by 30% when the amount of micro-sand changed from 0% to 9% as summarized in Table.1.

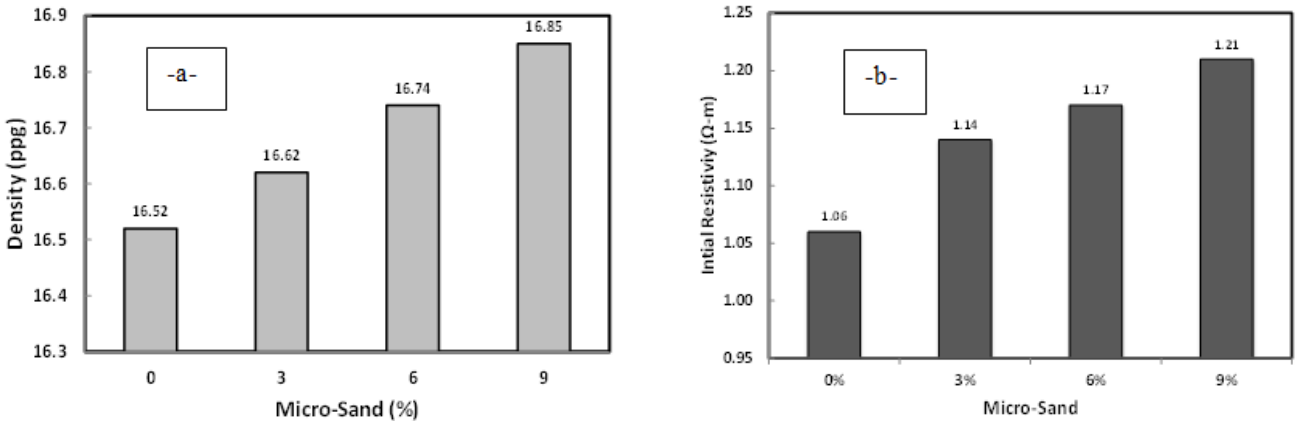

Figure 1. Effect of Micro-Sand on the Smart Cement Behavior (a) Density (b) Initial Electrical Resistivity

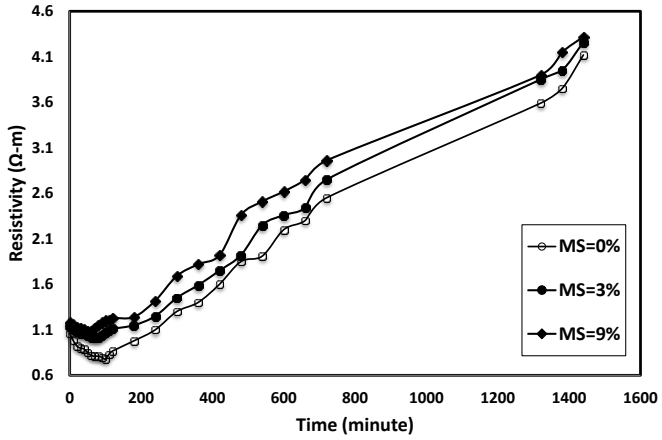

Figure 2. Effect of Micro-Sand on the Electrical Resistivity of the Smart Cement

Table 1. Electrical Resistivity Parameters for Cemented Micro-Sand

Micro-Sand (%)	0	3	9
ρ_{min} (Ω-m	0.78	1.04	1.08
t_{min} (min)	100	90	70

5. Acknowledgement

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6. Conclusions

Based on the experimental study following conclusions are advanced:

1. Increasing the amount of micro-sand increased the initial electrical resistivity and minimum electrical resistivity (ρ_{min}) of smart cement by 14% and 38% respectively.
2. Additional of 9% micro-sand to the smart cement decreased the time to reach minimum resistivity (t_{min}) by 30% and increased the density by only 2%.

7. References

1. Mueller D.T., Dillenbeck III R.L, "The Versatility of Silica Fume as an Oil well Cement Admixture" Paper presented at 1991 SPE 21688 Production Operations Symposium Oklahoma City, Oklahoma, (April 7-9).
2. Singh, L.P., Karade, S.R., Bhattacharyya, S.K., Yousuf, M.M., Ahalawat, S. (2013) "Beneficial Role of nanosilica in cement based materials-A review", Construction and Building Materials, Vol. 47, pp. 1069-1077.