# Effect of Water to Cement Ratio and Temperature on Sensing Properties of Smart Oil Well Cement

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**Abstract:** In this study sensing properties of oil well cement with water to cement ratio (w/c) of 0.38, 0.44 and 0.54 was investigated by measuring the electrical resistivity in low and high temperature conditions. Electrical resistivity was monitored during the curing time and under the compression loading. Experiments showed that initial electrical resistivity was sensitive to varying water to cement ratios and temperatures, the higher the (w/c) value and the greater the temperature, the lower the initial electrical resistivity. Smart cement showed piezoresistive behavior, and the piezoresistive sensitivity was reduced by increasing the water to cement ratio and the curing temperature.

## 1. Introduction

With some of the reported failures and growing interest of environmental and economic concerns in the oil and gas industry, integrity of the cement sheath is of major importance. The sensing ability of cement composites is related to the change of resistivity with different chemical admixture, contamination, water to cement ratio, temperature or external force. Many studies have been done to study the change in electrical resistivity with applied stress referred to as piezoresistivity (Han et al, 2012). Hence electrical resistivity has the potential to be used to monitor and characterize the behavior of cement.

## 2. Objective

The main objective of this study was to investigate the effect of water to cement ratio and temperature on electrical resistivity, and piezoresistive sensitivity of smart cement.

## 3. Materials and Methods

Class H cement with water to cement ratio of 0.38, 0.44 and 0.54 was used in the experiments. Specimens were cured in room and high temperatures for 3 days. The high temperature cured specimens were placed inside the oven with temperature of 85'C and kept in saturated sand to avoid the moisture loss. Standard compressive test was performed for all specimens after 3 days of curing and resistance was measured in the stress axis.

## 4. Result and Analysis

Fig. 1 shows initial electrical resistivity of cement with different water to cement ratio in high and low temperatures. It is evident from fig. 1 that initial electrical resistivity of slurries was reduced by increasing the w/c and the temperature. Increasing the water to cement ratio from 0.38 to 0.54 reduced the resistivity more than 45%. The electrical resistivity of cement with water to cement ratio of 0.54 was 0.88 ohm-m in room temperature. At the same water to cement ratio electrical resistivity electrical resistivity was reduced 35% for 85'C slurry.

Piezoresitive response of specimens is presented in fig. 2. It was found that change in electrical resistivity during compressive loading was more in cement with higher water to cement ratio. Specimens that were cured in high temperature showed less piezoresistivity at the same water to cement ratio. It is also evident that compressive strength was increased by reducing the w/c value and the curing temperature. The fractional change in resistivity at failure for 3-day cured sample with water to cement ratio of 0.38 was more than 250% which proves the piezoresistive sensitivity of the smart cement.

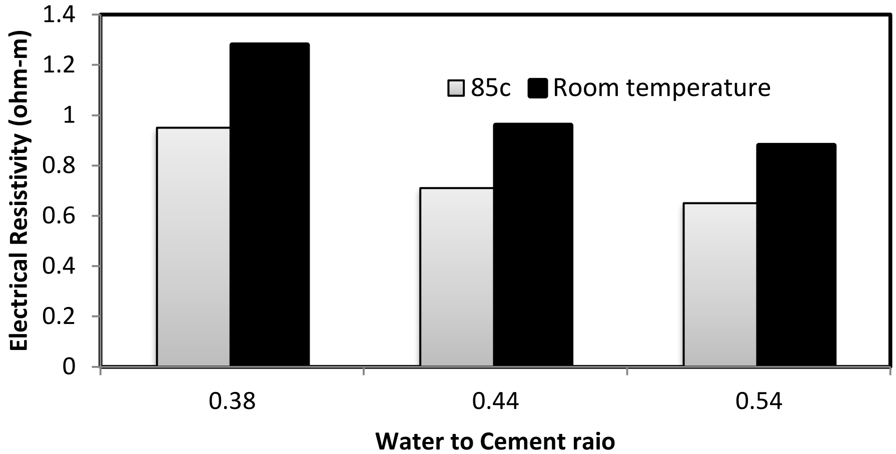


**Figure 1. Effect of water to cement ratio and temperature on initial electrical resistivity**

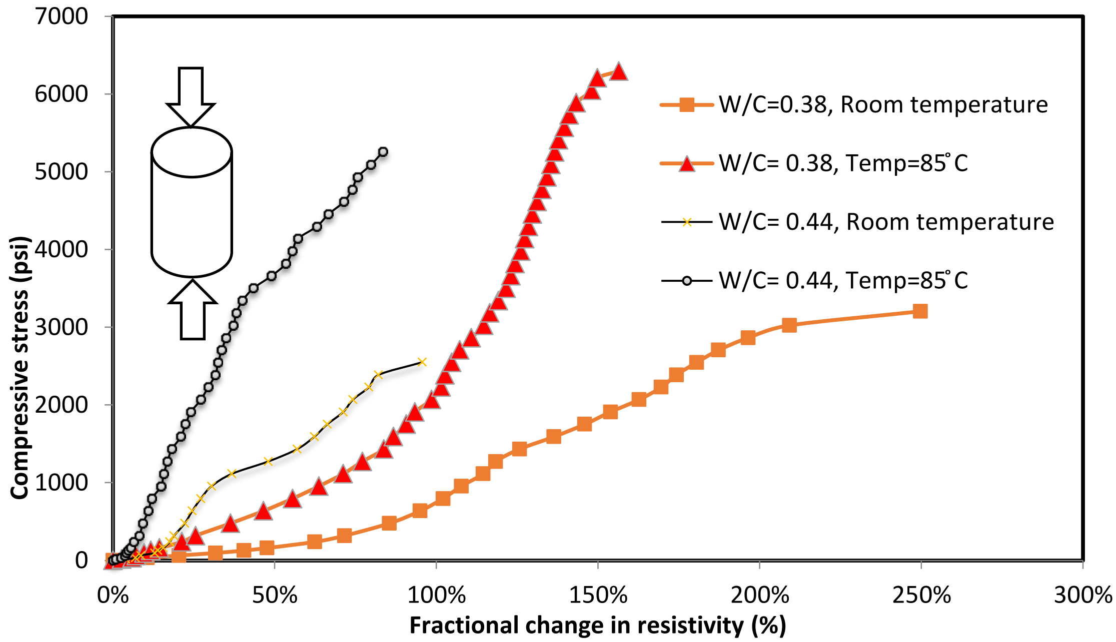


**Figure 2. Piezoresistive behavior of cement with different w/c cured at room and 85'C temperatures.**

## 5. Conclusions

(1) Increasing the water to cement ratio and the curing temperature increased the initial electrical resistivity of cement

(2) Smart cement showed piezoresistvie behavior and change in electrical resistivity at failure was more in specimens with higher w/c and was less in high temperature cured specimens.

## 6. Acknowledgement

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## 7. References

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