# Comparative Study of Sensitivity of Fabry-Perot Based Fiber Optic Sensor and Piezoresistivity of Oil Well Cement for Real time Monitoring of Small Stress

**D. Islam, Z. Zhu and C. Vipulanandan, PhD., P. E.**
Texas Hurricane Center for Innovative Technology (THC-IT)
Department of Civil and Environmental Engineering
University of Houston, Houston, TX 77204-4003
Tel: 832-670-0185: email: drislam2@uh.edu

**Abstract:** Real-time monitoring of cement in oil wells is of importance to assure proper zonal isolation and safety. Here, an effort to correlate between stress and FP based fiber optic sensor was established and compared with piezoresistive property of oil well cement. It was seen that beside change in piezoresistive behavior, cavity length was sensitive approach to the low stress condition of the oil well cement.

## 1. Introduction

Proper zonal isolation is the key to safe production of hydrocarbons. Hence well cementing is one of the most important operations performed on an oil and gas well. In addition, continuous monitoring of oil well cement during the cementing procedure in oil well is important in order to avoid failure and other adverse consequences. The addition of conductive filler would turn the cementing slurry into piezomaterials, which means the electrical properties will change when they encounter mechanical stress, temperature changes and chemical reactions [1]. As a result addition of carbon fiber make electrical resistivity a good parameter to monitor oil well cement. Meanwhile Fabry-perot fiber optic sensor technology has wide-ranging potential in sensing and measurement. It has different advantages over traditional sensing methods, because it offers immune to radio frequency interference and electromagnetic interference, offer sensitivity to multiple environmental parameters, can be interfaced with data communication system, small sensor and cable size [2]. Hence comparison between the two methods for monitoring behavior of cement is necessary to optimize the reliability and accessibility to continuously monitor the behavior of oil well cement.

## 2. Objectives

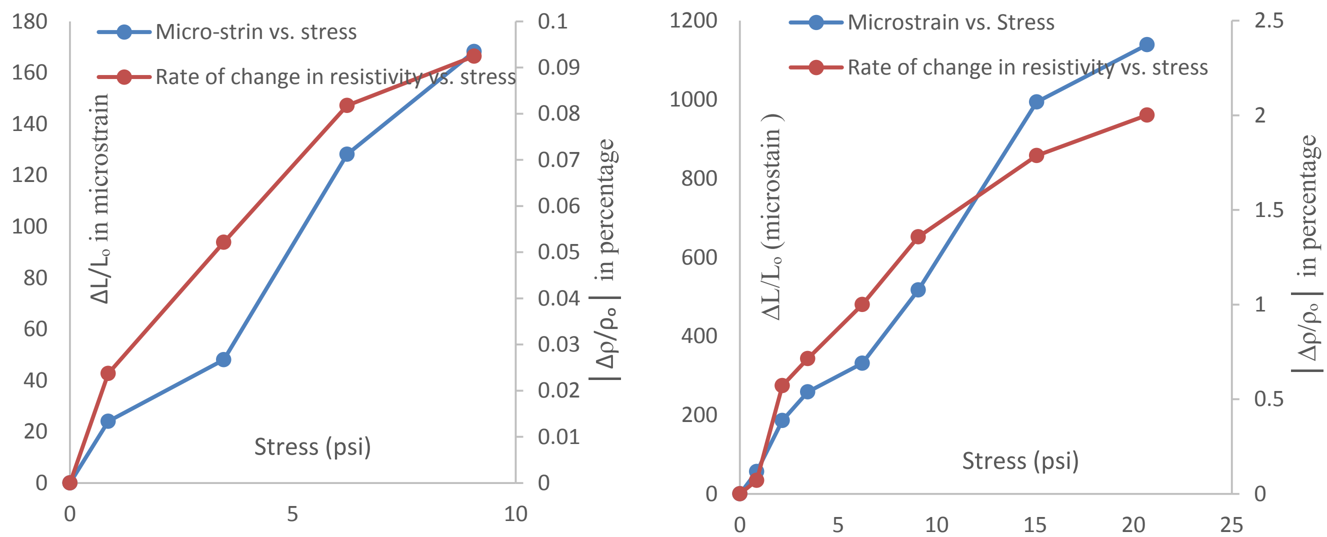
The main objective of this study was to compare the sensing ability of FP sensor and piezoresistivity during monitor their change in low stress application (up to 10 psi) of class H oil well cement during its curing time.

## 3. Materials and Methods

Class H oil well cement and water to cement ratio of 0.4 was used in the experiments. Carbon fiber at a percentage of 0.075% was incorporated. Commercially available precision LCR instrument (AC) was used to measure electrical resistance at 300 kHz frequency. The cement mix was placed in a plastic cylinder mold of 2 inches in diameter and 5 inches in height. Each mold had 2 wires installed to measure the electrical resistance. Beside this, FP fiber optic sensor head was embedded along with a portion of optical fiber within the sample while casting. The system consist of a sensor head, an infrared light source, an infrared array detector and a fiber coupler. The sensor head was placed vertically in the mid height of the sample.

## 4. Result and Discussion

Change in cavity length in the stated fiber optic sensing system, a decrease of 1049 nm from seven days to 30 days after sample preparation when no additional load is applied, which represents 8404 $\mu\epsilon$ in cavity length. Whereas for relative change of resistivity, $\Delta\rho/\rho$ was about 84. In both cases, the change is due to the change in temperature, variation in hydration condition and volume shrinkage within the sample during curing. In addition, in case of Fiber optic sensor reading, with increase in age, rate of change of cavity length also increased irrespective of age of the sample, which indicates a correlation due to stress introduction and rate of change in cavity length.




(a) (b)

**Figure 1: Comparison of rate of change in cavity length and resistance with stress introduction after (a) 7 days and (b) 30 days**

## 5. Conclusions

Beside electrical resistivity, it is seen that Fabry perot fiber optics sensor may give good correlation between stress and its parameter, which in this case is the cavity length.

## 6. Acknowledge

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## 7. References

[1] http://www.uh.edu/news-events/Fulbright/2012/june/0604RPSEA-Vipu.php

[2] Castrellon, J.; "Optical fiber sensors: An overview". (http://cdn.intechopen.com/pdfs-wm/29100.pdf)