# Crack Propagation Monitoring in Smart Concrete Using Electrical and Ultrasonic Methods

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**Abstract:** Smart concrete samples with water to cement ratio of 0.38 and sand to cement ratio of 1.67 have been cured for 3 days in high temperature of 100˚C and the compression test has been done while the electrical resistance and ultrasonic wave propagation have been monitor during the test. Results have shown that both methods are sensitive to crack propagation; however ultrasonic method is not sensitive to pressurizing the sample.

## 1. Introduction

Several studies were done on ultrasonic cement analyzer as the only continuous characterization method for concrete; however, this method is hardly applicable in field studies. Vipulanandan et al. (2014) suggested electrical resistivity measurements as a simple, economical and nondestructive method for monitoring the long-term characterization of oil well cement. They also studied the piezoresistive behavior of modified cementitious and polymer composites which is defined as the changes in the electrical resistivity of the materials with applied stress. In this paper the sensitivity of electrical resistivity and ultrasonic measurements on crack propagation has been studied.

## 2. Objectives

Piezoresistive behavior and crack propagation of smart concrete after 3 days of curing under high temperature of 100˚C have been investigated.

## 3. Materials and Methods

Specimens have been prepared using class H cement with water-cement ratio of 0.38 and sand-cement ratio of 1.67. For all the samples 0.045% (By the weight of total, BWOT) of conductive filler (CF) was added to the slurry in order to enhance the piezoresistivity of the cement and to make it more sensing. After mixing, the mortar was casted into the cylindrical molds with height of 4 inches and diameter of 2 inches, in which, two conductive wires were embedded 2 inches far from each other in order to measure the piezoresistivity of the specimens. Specimens were cured for 3 days under high temperature of 100˚C and after that they were tested by Tinious Olsun device by displacement rate of 0.005 inches per minute. The pulse velocity meter (PV) with the frequency of 150 kHz has been used for monitoring the crack propagation during the test. The change in resistance was measured continuously using the LCR meter. To minimize the contact resistances, the resistance was measured at 300 KHz using two-wire method.

## 4. Result and Discussion

As we can see in Fig.1. piezoresistivity of the concrete sample is 192% after 3 days of curing under high temperature of 100˚ C. while pressurizing, pulse velocity is almost constant which means this nondestructive method is not sensitive to pressurizing. After reaching to ultimate load, when the major cracks start developing in the sample, both pulse velocity and resistance showed considerable changes due to crack propagation.

## 5. Conclusion

Adding just 0.045% of conductive filler BWOT to concrete, made the concrete smart which was sensitive to loading. The piezoresistivity of specimens after 3 days of curing under 100˚C temperature was 192%. Test results showed that ultrasonic and electrical methods are both sensitive to crack propagation.

## 6. Acknowledgement

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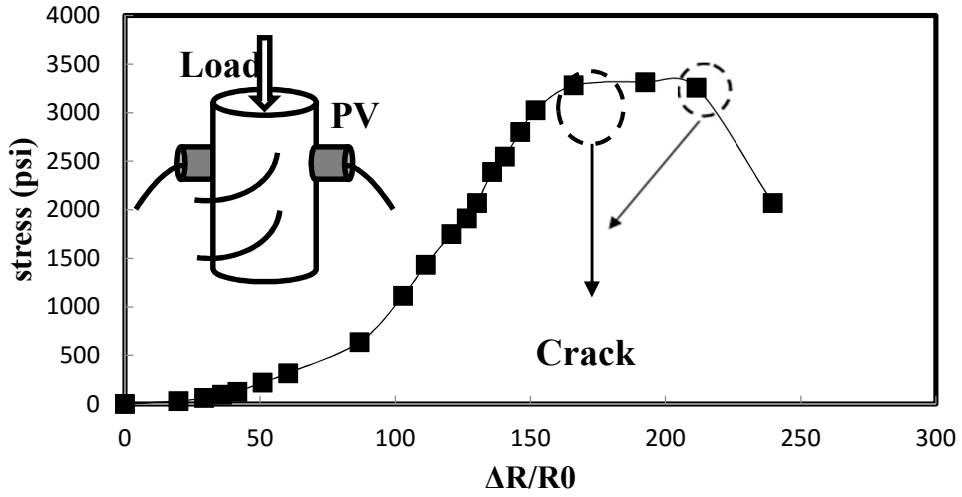


**Figure 1. Piezoresistivity of the smart concrete after 3 days of curing under high temperature of 100°C**

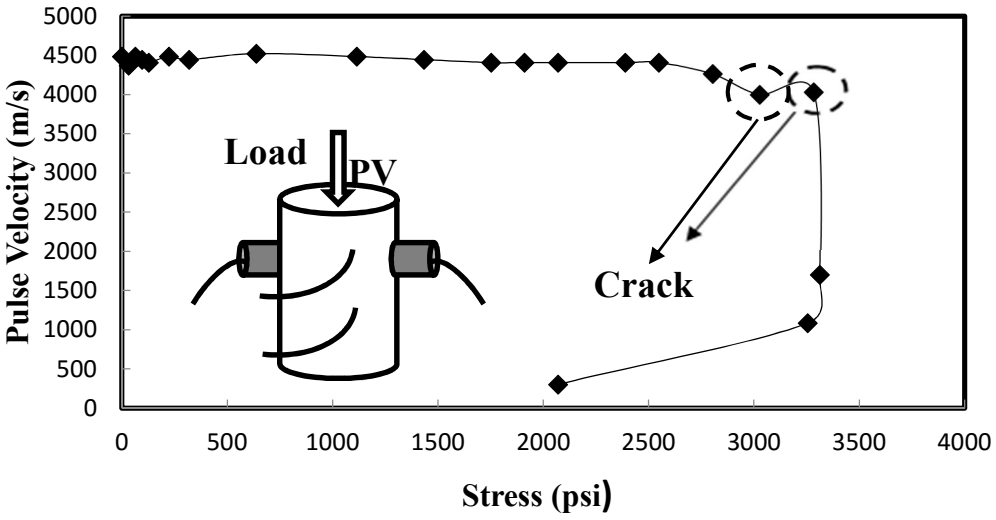


**Figure 2. Monitoring crack propagation using ultrasonic method**

## 7. References

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