Electrical Characterization of Alkali Silica Degradation in Concrete

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Abstract: The concrete behavior under alkali environment was characterized using the electrical method. Measurements after 15 months of curing in water showed 0.33% reduction in length compared to 0.09% and 0.13% increase in length in 1 N and 3 N NaOH solutions. Electrical resistivity of concrete after 15 months of curing in water showed an increase of 189%. After placing the concrete in 1 N and 3 N NaOH solution, a sudden drop showed in the electrical resistivity due to infiltration of the basic solution into the concrete. Just after 1 day of curing in 1 N and 3 N NaOH solution, electrical resistance of the specimens reduced by 57% and 76% respectively. Curing the specimen for 15 months under 1 N and 3N NaOH solution showed 148% and 219% increase in electrical resistivity.

1. Introduction

The alkali–silica reaction (ASR), more commonly known as "concrete cancer“ is a swelling reaction which occurs over time in concrete between the highly alkaline cement paste and the reactive non-crystalline (amorphous) silica found in many common aggregates, given sufficient moisture. This reaction causes the expansion of the altered aggregate by the formation of a soluble and viscous gel of sodium silicate or sodium silicate hydrate, depending on the adopted convention (S. Moturi and C. Vipulanandan, 2010). This hygroscopic gel swells and increases in volume when absorbing water: it exerts an expansive pressure inside the siliceous aggregate, causing spalling and loss of strength of the concrete, finally leading to its failure. Several structures has been affected by this phenomena such as Dee Why Ocean Pool and King St Bridge in Australia, Sixth Street Viaduct in Los Angeles, Seminoe Dam in Wyoming , many hydraulic dams in Canada and so many other roads, dams and bridges all around the world. Smart structures play significant role in maintaining civil infrastructure systems from these kinds of degradations. Vipulanandan et al. (2015) suggested electrical resistivity measurements as a simple, economical and nondestructive method for monitoring the long-term characterization of smart concrete. The electrical sensing provides a quick response to any elastic or inelastic deformation or any environmental changes such as acid attacks in real time.

2. Objective

The overall objective of this study was to investigate the changes in electrical resistivity of the concrete due to alkali environment of 1 N and 3N NaOH solutions.

3. Materials and Methods

Specimens were prepared based on ASTM C1260 using class H cement with water-cement ratio of 0.47 and gravel to cement ratio of 2.25 by weight. After mixing, the mortar was cast into prismatic molds and cured for 1 day under room temperature. After 1 day, specimens were demolded and initial size and electrical resistance measurements were done using the Vernier caliper and LCR meter. Specimens then cured under water for 24 hours. After that, specimens were taken out and had been kept under water, 1N NaOH ad 3 N NaOH for 15 months and continuous size and electrical resistivity measurements had been done on them for 15 months. To minimize the contact resistances, the resistance was measured at 300 kHz using two-wire method.

4. Result and Discussion

As shown in Fig.1, the average of initial length of the specimens were 306.3 mm and electrical resistance were 2.3 kΩ. After curing all the specimens under water for 1 day, the average length of the specimens reduced to 304.9 mm and the average electrical resistance of the specimens increased by 22% to 2.8 k Ω. Length measurements after 15 months of curing for water cured specimen showed 0.33% drop to 303.9 mm, for 1 N NaOH solution cured specimen showed 0.09% increment to 305.2 mm and for 3 N NaOH solution cure specimen showed 0.13% increment to 305.3 mm. Electrical resistance measurements after 15 months of curing for water cured specimen showed 189% increment to 8.1 k Ω. After putting the specimens under 1 and 3 N NaOH, a sudden drop in their electrical resistance had been observed which is due to high ion concentration of the solution. Just after 1 day of curing under 1 N NaOH, electrical resistance of the specimens dropped by 57% to 1.2 k Ω. Curing the specimen for 15 months under 1 N NaOH leads to have 148% increment in electrical resistance to 2.9 k Ω. Just after 1 day of curing under 3 N NaOH, electrical resistance of the specimens dropped by 76% to 0.7 k Ω. Curing the specimen for 15 months under 1 N NaOH leads to have 219% increment in electrical resistance to 2.1 k Ω.

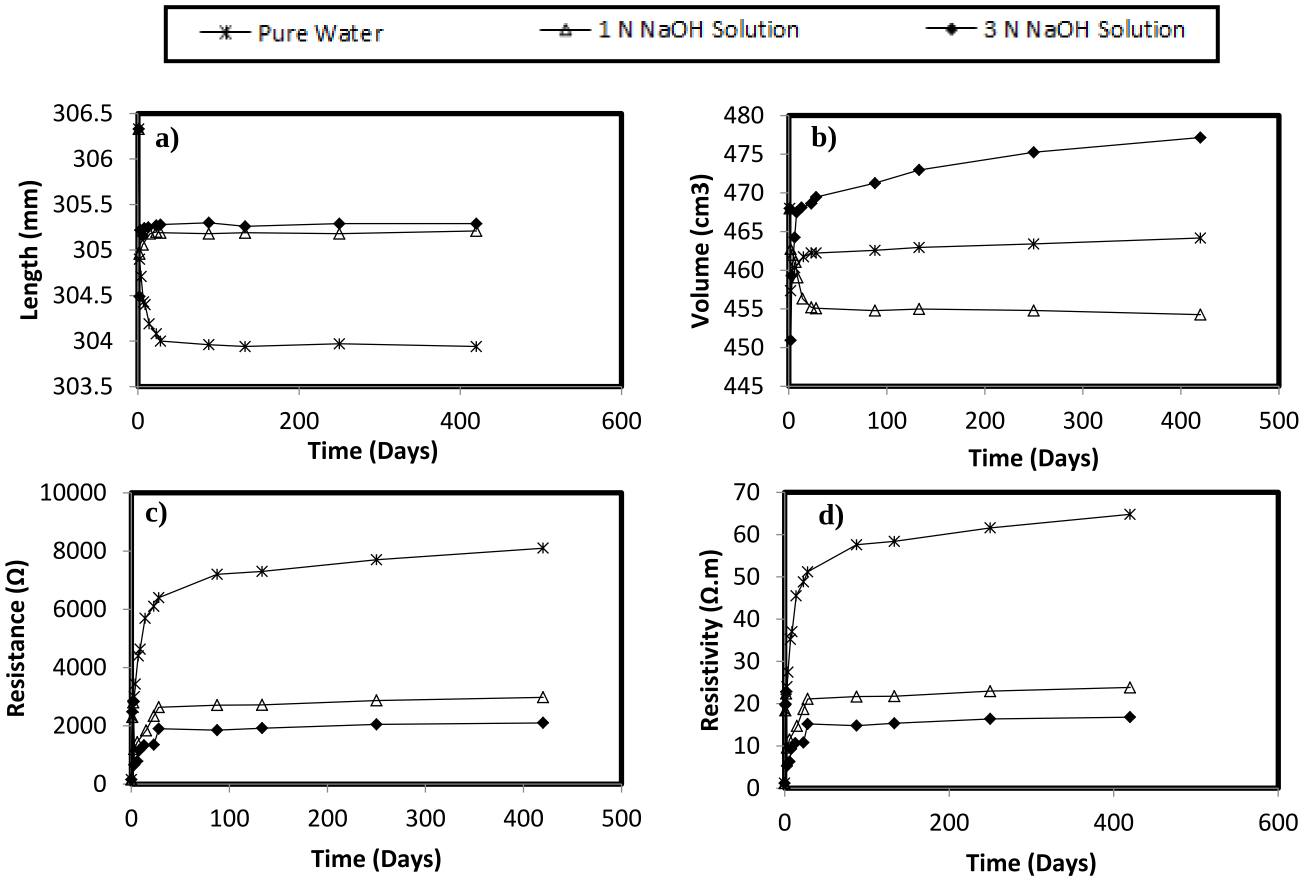

Figure 1: Alkali Silica Degradation of Concrete: a) Length; b) Volume; c) Electrical Resistance; d) Electrical Resistivity

5. Acknowledgements

This study was supported by the Center for Innovative Grouting Materials and Technology (CIGMAT) and Texas Hurricane Center for Innovative Technology (THC-IT).

6. References

1. Moturi, S. and Vipulanandan, C. (2010) " EIS Approach to Determine Potential Reactive Chemicals Causing Alkali-Silica Reaction in Concrete" CIGMAT 2010 Conference and Exhibition.