Interface Damage Sensing and Repair of Nonmetallic Reinforced Cement Composites Using Smart Coating

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Abstract
Non-metallic reinforced cement composite behavior was investigated by monitoring the interface degradation due to de-bonding and cracking under tensile testing. The repair of the local damaged interface by cement injection allows recovering up to 40 % of the strength after 1 day. An alternative repair using smart polyester coating material shows higher recovery of the original interface strength estimated up to 80% strength.

1. Introduction
An alternative reinforcement using nonmetallic reinforcement, such fiber reinforced composites, is increasingly introduced to the construction industry. The bond strength and interface properties are crucial aspects of the reinforced composite behavior. Nondestructive methods are greatly needed to reveal the actual interface behavior of the composite. Furthermore, the interface damage detection and repair are challenging problems especially in the context of hazardous environment hosting multiple risks such as hurricane, flooding, etc. Hence, impedance spectroscopy (Vipulanandan and Prashanth, 2013) is a practical nondestructive method that can be used to investigate the interface behavior of reinforced cement composite.

2. Objective
The objective of this study is the investigation of nonmetallic-coating interface damage by monitoring the changes in the electrical properties and the assessment of repair efficiency using smart materials.

3. Materials and method
In this study, class-H cement was used to produce the paste using 0.3 water-to-cement ratio. The anchors are made of insulator polymer concrete-based material. The polyester resin was used by content of 25 % by weight of sand. Cobalt napthenate (0.2 wt. % of resin) was added as promoter and methyl ethyl ketone peroxide (2 wt. % of resin) was used as initiator. Rectangular specimens (1.5 in x 1.5 in x 4.0 in) equipped with contact wires embedded into the prepared molds. The nonmetallic reinforcement strand was set adequately in the mold before pouring of the coating cement. Two repair materials were investigated. Smart class-H cement slurry was prepared using 0.7 water-to-cement ratio with added conductive filler (0.03 wt. % of cement). Secondly, repairing material using polyester-based coating was applied. The reinforced composite specimen was tested up to partial damage under tensile loading of the embedded strand. Therefore, the repairing materials were used separately to heal the damaged area then additional pullout tests were carried out to assess the repair efficiency and the interface strength recovery of the reinforced cement composite.

4. Results and Discussion
The interface damage started at 1.8 ksi of stressing level. The formation of the related crack continued up to local ultimate damage at 3.7 ksi. Repairing the crack by injection of smart cement showed a recovery of 40% of the original strength. However, the repair using smart polyester-based material increased the recovery up to 80%. The impedance spectroscopy method was sensitive to detect the initiation debonding as observed in figure (4).

Figure 1. Tensile test setup

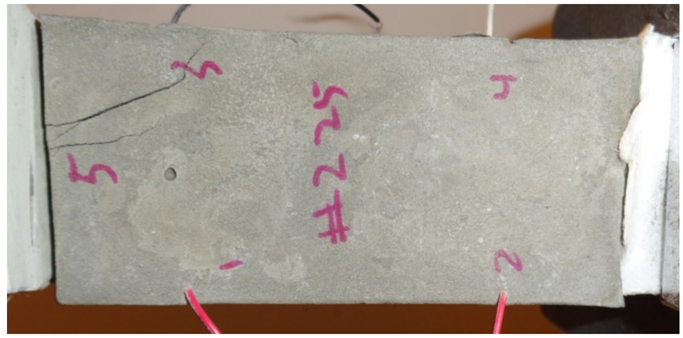

Figure 2. local damage initiated at the interface

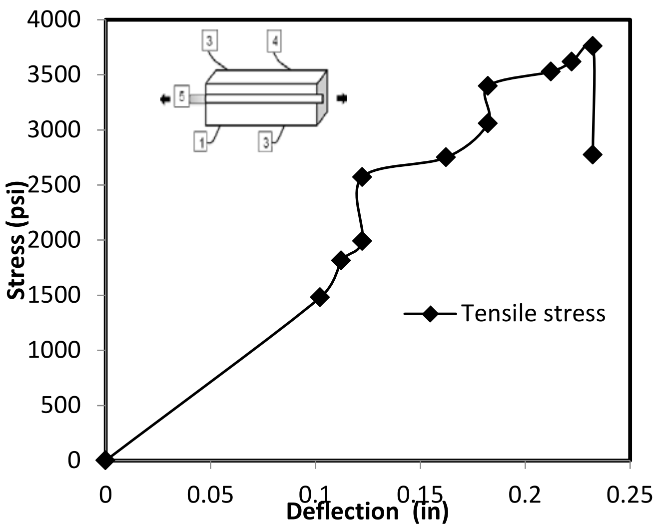

Figure 3. Stress-deflection under tensile loading.

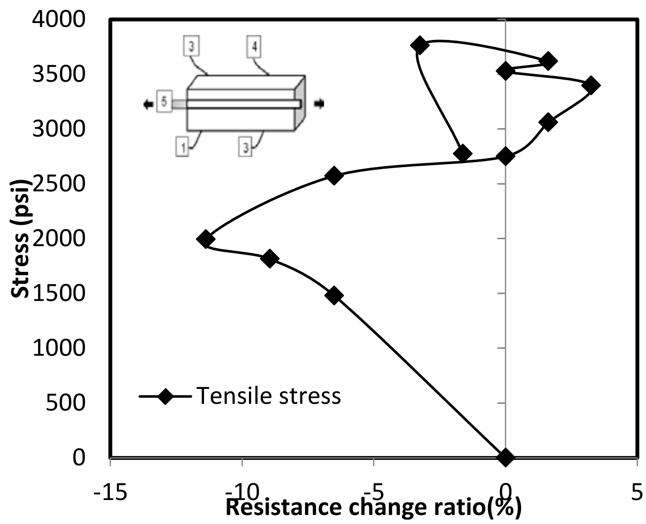

Figure 4. Stress vs electrical resistance change "51"[300 kHz]

5. Conclusion

Impedance spectroscopy method applied to smart cement coating is able to sense the interface damage of reinforced composites. Moreover, smart polyester-based repair material shows more efficiency to recover the interface strength.

6. Acknowledgment

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7. References

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