Characterizing of Steel-Smart Polymer Concrete Interface for Corrosion Detection

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Abstract
Study of electrical properties at the interface level could determine the difference in the electrical resistance and capacitance of interfaces between smart polymer concrete and corroded rebar, and that of smart cement and non-corroded rebar. In this research, detecting and quantifying interface corrosion was investigated. The laboratory test also indicated the interface corrosion change with respect to time.

1. Introduction

Corrosion is a naturally occurring phenomenon commonly defined as the deterioration of a substance (usually a metal) or its properties because of a reaction with its environment. It is the primary factor affecting the longevity and reliability of pipelines that transport crucial energy sources throughout the nation. For the past two decades, there has been a tremendous amount of research focused on smart coatings for structural applications; coatings the can sense certain conditions and then respond (Harovel G. Wheat, 2012). These are coatings that typically contain one or more indicators that can sense condition such as corrosion and respond by means of changes in pH, color, fluorescence or a combination thereof (Harovel G. Wheat, 2012). In the industry of gas and oil, corrosion of steel casing is of concern because it requires almost immediate repairs and rehabilitation to extend the service life of the structures. Literature reviews revealed that not much research work have been done so far regarding the electrical properties at the interface level between steel and its surrounding composite materials such as polymer concrete.

2. Objective

The objective of this study was to develop a non-destructive electrical test method to determine and monitor the presence of interface corrosion for steel embedded in smart polymer concrete.

3. Materials and Methods

Polymer concrete specimens embedding two kinds of rebar have been prepared for laboratory tests. The specimens have cylindrical shape with diameter of 2 inches and height of 4 inches. The polymer concrete was composed of polyester coating (20% by total weight) and sand (80% by total weight). Methly ethyl ketone peroxide and Naphthenate were used as hardener and catalyst respectively. To improve the electrical properties, conductive filler was also added into the composite. The rebars used had size of #3 and length of 6 inches. The specimens were instrumented with 2 silver-paint wires connected to the polymer concrete (illustrated in Figure 2). The electrical resistances and capacitance of the polymer concrete, rebar, and transitional contact surface between the polymer concrete and rebar were measured with impedance analyzer precision LCR meter.

4. Discussion

The equivalent circuit adopted based on expected behavior of the material under this study is shown in Figure 1. The total impedance of the equivalent circuit is given as follows:

$$Z = R_b + \frac{R_c}{1 + \omega^2 R_c{}^2 C_c{}^2} + \frac{R_i}{1 + \omega^2 R_i{}^2 C_i{}^2} - j\left(\frac{\omega R_c{}^2 C_c}{1 + \omega^2 R_c{}^2 C_c{}^2} + \frac{\omega R_i{}^2 C_i}{1 + \omega^2 R_i{}^2 C_i{}^2}\right)$$

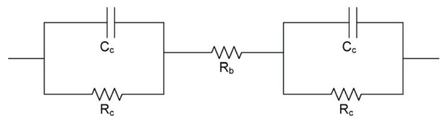

Figure 1 – Equivalent circuit

In the equation, ω is the angular frequency of the applied signal. Applied signal was carried out with frequency range of 20Hz to 300 kHz. Figure 2 shows the product of resistance and capacitance (R*C) at interface level between polymer concrete and rebar (both corroded and non-corroded types). Figure 2 shows the product of resistance and capacitance (R*C) at the interface between the rebar (both corroded and non-corroded types) and oil well cement. From the plot, it can be seen that the R*C for the corroded rebar is greater than that of non-corroded rebar with respect to time.

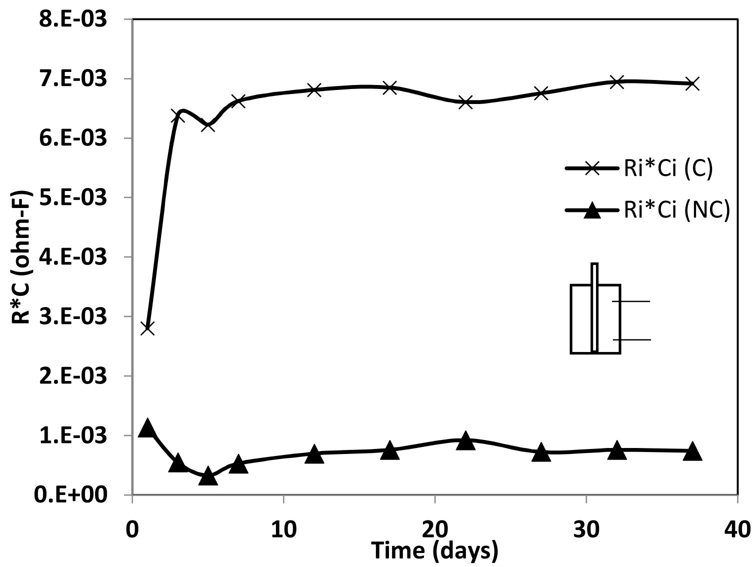

Figure 2 – R*C vs Frequency

5. Conclusion

In conclusion, the analysis of electrical properties at the interface level resulted in determining the difference in the electrical resistance and capacitance of interfaces between polymer concrete and corroded rebar, and polymer concrete and non-corroded rebar. This relatively simpler electrical test method could be highly effective in determining the presence of corrosion at the steel-polymer concrete interface.

6. Acknowledgement

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7. References

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