

Detection Sensitivity of Iron-Foil Corrosion Sensor in Simulated Concrete Solution

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1 Introduction

This study uses a simulated concrete solution with variable chloride ion concentrations to evaluate the ability of the corrosion sensor to predict the time of its rupture. Additionally, for the practical use of the corrosion sensor, a non-destructive monitoring system was developed. The measurement system was equipped with a short-range wireless, passive radio frequency identification (RFID) unit and was used to monitor actual buildings.

2 Structure and Mechanism of the Corrosion Environment Sensor

Our sensor consists of an iron-foil circuit on a resin film. The circuit is equivalent to a single conducting wire. A resistance of 15Ω is used if the sensor is corroded; however, the measurements of the electrical resistance indicate an intact condition. In contrast, a resistance greater than 100Ω is used if the sensor is corroded and the circuit is severed.

3 Performance Testing of the Sensor

The sensor was tested for its performance in a saturated calcium hydroxide ($\text{Ca}(\text{OH})_2$) solution that simulated an internal concrete environment.

Figure 1 illustrates the environment created to test the performance of our sensor. Air from a pump was passed through the saturated $\text{Ca}(\text{OH})_2$ solution to remove CO_2 from it. The CO_2 -free air was made to enter the test chamber to create the test environment. The pH of the test solution was constantly maintained at 12.

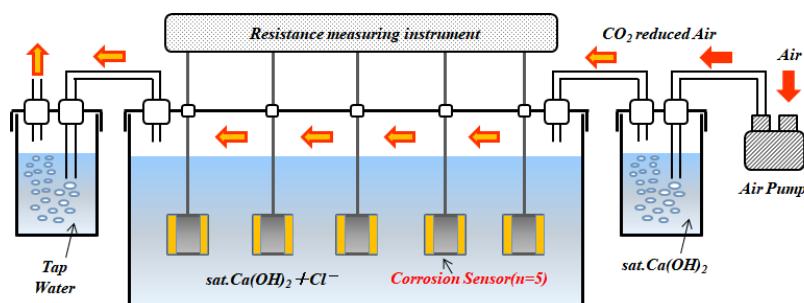


Figure 1. Configuration of the corrosion sensor evaluation experiment.

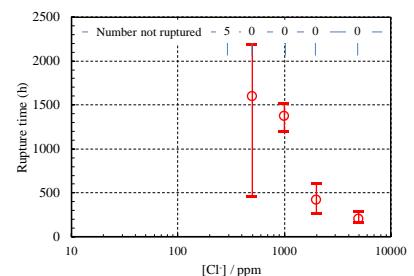


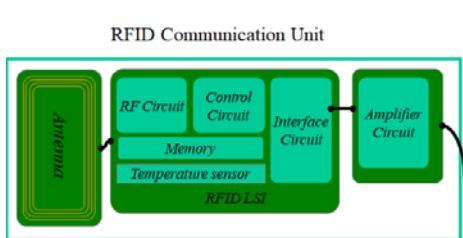
Figure 2. Rupture time of corrosion environment sensor at each chloride ion concentration.

4 Performance of Detection by the Corrosion Sensor

Figure 2 shows the rupture time of our sensors. Even after a lapse of 2,500 hours, no rupture occurred at the chloride ion concentration of 200 ppm. The earliest rupture time was observed at a concentration of 5,000 ppm. Furthermore, the time for rupture variability increased with decrease in the chloride ion concentration. The rupture time at a chloride ion concentration of 500 ppm was longer, by approximately 1,000 hours, than that observed at 5,000 ppm.

5 Measurement System of the Sensor

Figure 3 shows how the sensor is connected to the passive RFID. The sensors and passive RFID units were connected by cable and embedded inside the structure. To measure the electrical resistance of the sensor, an electromagnetic wave was transmitted from the antenna of the RFID reader/writer to the RFID unit embedded in the concrete, and the measured output value was then returned to the RFID reader/writer. This system is powered by the electromotive force generated inside the RFID large-scale integration (LSI) chip.



Corrosion Sensor



Figure 3 . Configuration of the RFID corrosion sensor. Figure 4. Application of the system to bridge pier repairs.

6 Examples of Application of the Sensor and Measurement System

The measurement system adopted by this sensor is often used in concrete structures with high risk of steel corrosion. Major applications include port structures, such as lighthouses and piers, and road structures, including bridges where penetration of chloride ions from antifreeze agents is a concern. It is also applied to verify the effectiveness of repairs to concrete structures. Figure 4 shows examples of the application to bridge pier repairs.

7 Conclusions

- The corrosion environment sensor ruptured due to corrosion in environments with a chloride ion concentration of 500 ppm. The higher the chloride ion concentration, the shorter was the time to rupture.
- By adopting passive RFID as the communication interface to the corrosion environment sensor, we were able to build a practical preventive maintenance system against steel corrosion.
- We were able to demonstrate the long-term durability of the sensor system by applying it to repair work on real structures and maintaining it for seven years with no failures.

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