Research Notes

RSN 15-02 June 2015

A Corrosion Monitoring System for Existing Reinforced Concrete Structures

Summary

This study evaluated a multi-parameter corrosion monitoring system for existing reinforced concrete (RC) structures in chloride-laden service environment. Although the initial laboratory benchmark testing showed promising results, a pilot-scale system demonstration in the field revealed many challenges. Therefore, the new system in its current state will not be implemented by ODOT in the near future.

Background

Reinforcement corrosion induced by chloride contamination is a leading cause of structural damage and premature degradation in reinforce concrete structure. Currently, Oregon Department of Transportation (ODOT) conducts labor-intensive corrosion surveys to determine the timing and type of remedial action that requires. A corrosion monitoring system of obtaining frequent corrosion information would provide better condition assessment at much lower cost than the periodic hands-on surveys.

Sensor Development

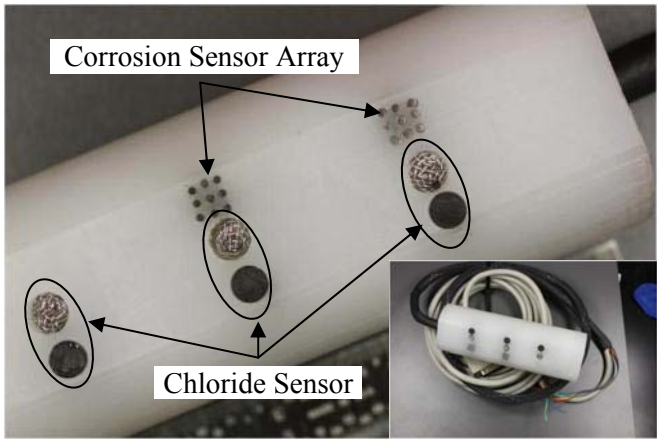
The new corrosion monitoring system was fabricated based on a prototype concrete corrosion measurement system (as shown in the figure to the right) that had been build and patented by Southwest Research Institute (SwRI).

The patented sensor unit prototype includes a multi-electrode array sensor (MAS) to be used as a corrosion current probe. Instead of directly measuring the corrosion rate of the actual rebar embedded in concrete, the MAS measures the instantaneous corrosion rate of multiple miniature electrodes made of the rebar material.

Chloride concentration is measured by an improved Ag/AgCl chloride probes. Conventional chloride probe consist of a single Ag/AgCl probe. Based on field experience, this type of sensor usually suffers a high rate of determination between the interface of Ag/AgCl. The newly develop chloride sensor uses an #20 (Φ0.04") Ag mesh wrapped around AgCl coated surface. This new process method was expected to improve sensor durability for long-term field applications.

Laboratory Evaluation

In a laboratory benchmark test, a chloride concentration vs. potential calibration curve was established and indicated good linearity between 0.01 mol/L and 1 mol/L. The general and maximum localized corrosion rates, as measured by MAS, were sensitive to the incremental chloride concentration in a simulated pore solution. However, once active corrosion is initiated and a great amount of chloride is present, the MAS probe may no longer serve as a good tool to predict the corrosion rate of rebar.



Sensor Prototype

It was also revealed that in a sensor longevity test, only a fraction of sensors can be considered reliable after eight accelerated weathering cycles.

A laboratory pilot-scale test was done by incorporating an array of three sensing units at different depth of a mortar cylinder to monitor the ingress of chloride and the corrosion rate of rebar at different depths. The results identified many challenges to improve the sensor probe. Subsequently, several modifications were made to the system in order to improve field implementation.

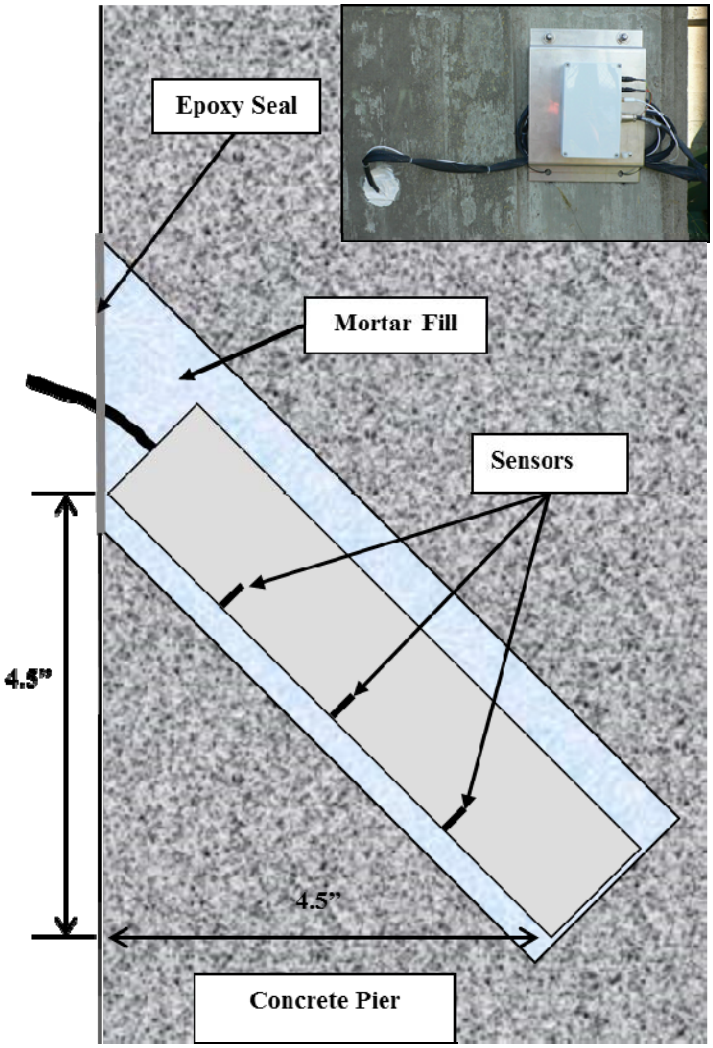
Field Trial

The sensor units were embedded in an epoxy hold in order to performance measurement at different depth of interested RC structures, as shown in the figure to the right.

A detailed guideline along with video documentation was developed as a reference to guide field implementation. A field deployment of the system in an ODOT bridge pier was attempted. However, the data collected from the sensor was inconclusive. All sensors lost communication about 6 months after installation.

To furture develop this sensor technology, the follwing research needs are identified:

- Integration of miniature moisture and temperature probes
- Improvement of sensor durability
- Realiable weather-proof power supply and eletronics



Schematic Illustration of Sensor Embedment

For More Information

The ODOT research report, including the user's guides, is available online. A link to the report is provided below.

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To read the research report go to:
http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/2015/SPR736_CorrosionMonitoring.pdf

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