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RFID Tags for Detecting Concrete Degradation in Bridge Decks

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RFID Tags for Detecting Concrete Degradation in Bridge Decks

Abstract

Steel reinforcing bar (rebar) corrosion due to chlorine ingress is the primary degradation mechanism for bridge decks. In areas where rock salt is used as a de-icing agent, salt water seeps into the concrete through cracks, causing corrosion of the rebar and potentially leading to catastrophic failure if not repaired. This project explores the use of radio frequency identification (RFID) tags as low-cost corrosion sensors. RFID tags, when embedded in concrete, will fail due to corrosion in the same manner as rebar after prolonged exposure to salt water. In addition, the presence of salt water interferes with the ability to detect the tags, providing a secondary mechanism by which this method can work. During this project, a fieldable RFID equipment setup was constructed and tested. In addition to a number of laboratory experiments to validate the underlying principles, RFID tags were embedded and tested in several actual bridge decks. Two major challenges were addressed in this project: issues associated with tags not functioning due to being in close proximity to rebar and issues associated with portland concrete coming in direct contact with the tags causing a detuning effect and preventing the tags from operating properly. Both issues were investigated thoroughly. The first issue was determined to be a problem only if the tags are placed in close proximity to rebar. The second issue was resolved by encapsulating the tag. Two materials, polyurethane spray foam and extruded polystyrene, were identified as providing good performance after testing, both in the lab and in the field.

Keywords

Bridge decks, Corrosion, Nondestructive tests, Radio frequency identification, Reinforcing bars, Remote sensing, Sensors, Salts, Structural health monitoring, RFID tags, Corrosion detection, Nondestructive evaluation, Rebar corrosion, Reinforcing steel corrosion

Disciplines

Civil Engineering

Comments

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Institute for Transportation

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RESEARCH PROJECT TITLE

RFID Tags for Detecting Concrete Degradation in Bridge Decks

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RFID Tags for Detecting Concrete Degradation in Bridge Decks

tech transfer summary

This project explores the use of radio frequency identification (RFID) tags as low-cost corrosion sensors in bridge decks.

Problem Statement

Steel reinforcing bar (rebar) corrosion due to chlorine ingress is a primary degradation mechanism for bridge decks. In areas where rock salt is used as a de-icing agent, salt water seeps into the concrete through cracks, causing corrosion of the reinforcing steel and potentially leading to catastrophic failure if the bridge is not repaired or replaced.

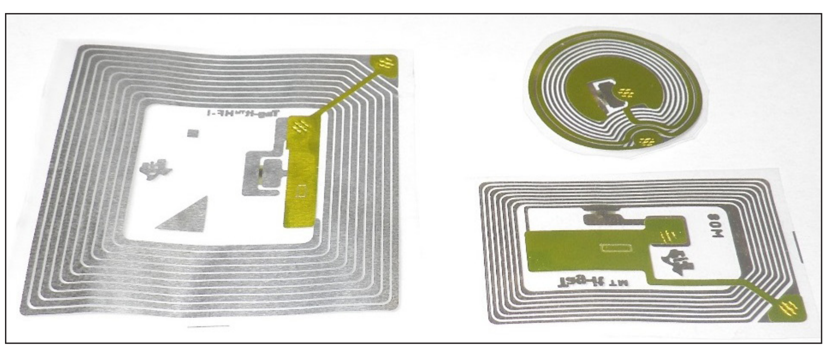
Project Description and Background

This project explores the use of radio frequency identification (RFID) tags as low-cost corrosion sensors. RFID tags, when embedded in concrete, will fail due to corrosion in the same manner as reinforcing steel after prolonged exposure to salt water. In addition, the presence of salt water in the concrete interferes with the ability of an RFID scanner to detect the tags. The degradation of the concrete is monitored by scanning for these tags and, when tags start to disappear, it is an indication that the concrete is beginning to degrade.

Research Methodology

During this project, a fieldable RFID scanner was constructed and tested. In addition to a number of laboratory experiments performed to validate the underlying principles, RFID tags were embedded and tested in several actual bridge decks.

Two major challenges were addressed in this project: tags not functioning due to being in close proximity to reinforcing steel and a detuning effect associated with portland cement coming in direct contact with the tags, preventing them from operating properly. Both issues were investigated thoroughly.



Upper right style of RFID tag was selected due to its small form factor and the desire to minimize the inclusion in the concrete

Fabricated equipment cart used for field testing

Interference from reinforcing steel is unavoidable except by placing the tags at least a few inches away from it. The detuning effect is caused by the dielectric constant of the concrete and can be resolved by encapsulating the tag in a foam that more closely approximates the dielectric constant of air.

Tags encased using extruded polystyrene (center) and polyurethane spray foam (right)

Key Findings

Two materials, polyurethane spray foam and extruded polystyrene, were identified as providing good performance after testing, both in the lab and in the field. The encapsulated RFID tags were tested successfully in an actual bridge deck and, while only a portion survive the pour and are readable, the fraction is sufficiently high to make this a practical approach.

Implementation Readiness and Benefits

One of the biggest challenges in inspection is actually locating the tag. Because our reader is limited to a small area at a time, scanning a bridge can be time consuming (many hours for a typical highway bridge). However, this issue could be resolved by consistent tag placement—by placing tags near easy reference points such as near control joints for example. In addition, a much larger antenna could be utilized.

Overall, we have determined that, while there are a few minor issues that need to be considered, this technique is very promising as a simple, easy-to-implement, and low-cost supplement to current inspection techniques seeking to identify chlorine ingress and resulting reinforcing steel corrosion in bridge decks.

Some issues remain to be addressed. The most significant one is to determine exactly when in the degradation cycle of a modern bridge these tags begin to fail. Unfortunately, a small-scale test is unlikely to provide a meaningful answer.

The most practical answer would probably come from field experience, although an accelerated lifing test would be possible (albeit expensive). In addition, incremental improvements to the RFID reader and antenna to support higher speed, larger area, and higher sensitivity would reduce cost and improve performance. Another option is that the practicality of tags with genuine on-board sensors increases as RFID tag technology matures, and these sensors could give a more direct readout of internal conditions within the concrete.