

December 2013

RESEARCH PROJECT TITLE

RFID Tags for Detecting Concrete Degradation in Bridge Decks

SPONSORS

Federal Highway Administration
Iowa Department of Transportation
(InTrans Project 11-404)

PRINCIPAL INVESTIGATOR

Stephen D. Holland, Associate Professor
Center for Nondestructive Evaluation
Iowa State University
515-294-8659 sdh4@cnde.iastate.edu

CO-PRINCIPAL INVESTIGATOR

Terry J. Wipf, Professor and Chair
Civil, Construction, and Environmental
Engineering, Iowa State University

FOR MORE INFORMATION

www.instrans.iastate.edu

**Institute for Transportation
Iowa State University
2711 S. Loop Drive, Suite 4700
Ames, IA 50010-8664
515-294-8103**

The mission of the Institute for Transportation (InTrans) at Iowa State University is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, reliability, and sustainability while improving the learning environment of students, faculty, and staff in transportation-related fields.

The Center for Nondestructive Evaluation (CNDE) is a National Science Foundation Industry/University Cooperative Research Center and a member of the Institute for Physical Research and Technology (IPRT) at Iowa State University. The Center focuses on the research and development of new theories and techniques for use in quantitative nondestructive evaluation.

The sponsors of this research are not responsible for the accuracy of the information presented herein. The conclusions expressed in this publication are not necessarily those of the sponsors.



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.

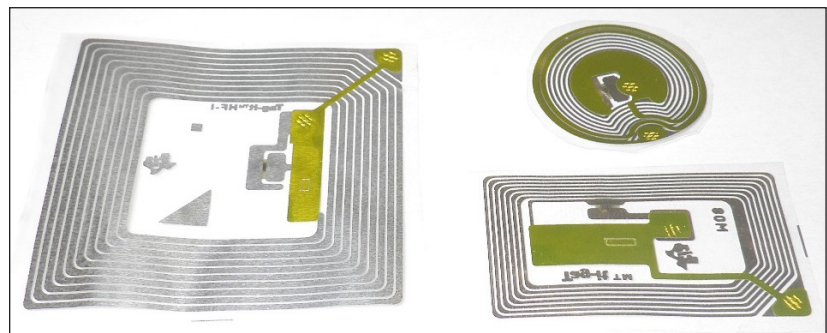
Project Description and Background

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.

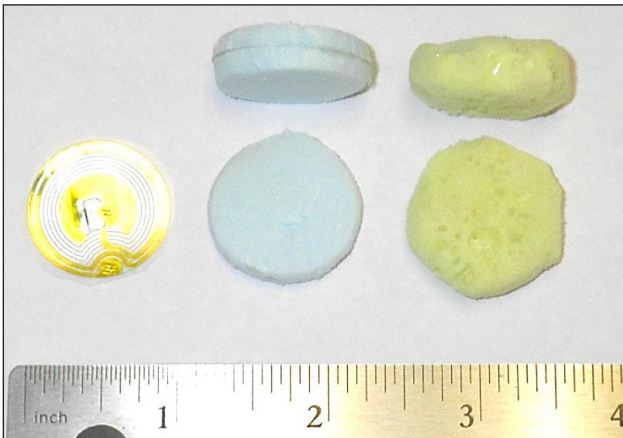


Upper right style of RFID tag was selected due to its small form factor and the desire to minimize the inclusion in the concrete



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.