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RESEARCH PROJECT TITLE

Autonomous Measurements of Bridge Pier and Abutment Scour using Motion-Sensing Radio Transmitters

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Autonomous Measurements of Bridge Pier and Abutment Scour using Motion-Sensing Radio Transmitters

Radio Frequency IDentification (RFID) technology can help in collecting field data and remotely monitoring bridge scour

Tech transfer summary

Introduction

Scour around the foundations (piers and abutments) of a bridge due to river flow is often referred to as "bridge scour." Bridge scour is a problem of national scope that has dramatic impacts on economics and safety of the traveling public. Bridge scour has resulted in more bridge failures than all other causes in recent history.

Despite the recognized need for the collection of more field data to improve our predictive approaches for bridge scour, very few scour data were collected until the late 1980's. This deficiency is primarily due to the difficulty of performing accurate and complete field measurements of scour during floods, the inability to get skilled personnel to perform the measurements, and the limitations associated with existing methods and instruments.

The FHWA, among other agencies, recognized the need to develop new methods and implement advanced instruments to collect field data and remotely monitor bridge scour during floods. Advancements in sensor technology over the last half-decade warrant success towards the development of autonomous scour detection systems, which could minimize the exposure of DOT crews to dangerous conditions especially during floods. These sensors can help towards the development of a warning system for bridge scour preventing loss of life and property due to catastrophic failures. Thus, monitoring bridge scour can be a cost-effective approach for protecting the traveling public from potential bridges failure by alerting traffic engineers to close the bridges during floods if the scour depth reaches a critical level.

Objectives

The main objective of this study is to evaluate the capabilities of Radio Frequency IDentification (RFID) technology in collecting field data and remotely monitoring bridge scour. RFID is a wireless automated identification technology that utilizes waves at radio frequency (RF) to transfer information between a reader and a transponder via an antenna (Figure 1). RFID technology has several advantages over other scour monitoring methods because: 1) It requires only that the transponder falls within the detection field of the antenna, even if it is buried in the scour-hole; 2) It can identify the locations of different transponders; 3) It is flexible and cost effective because a reader/antenna system can be used with any number of transponders, which have low acquisition cost; and 4) It can be fully controlled by a host computer and therefore be fully automated.

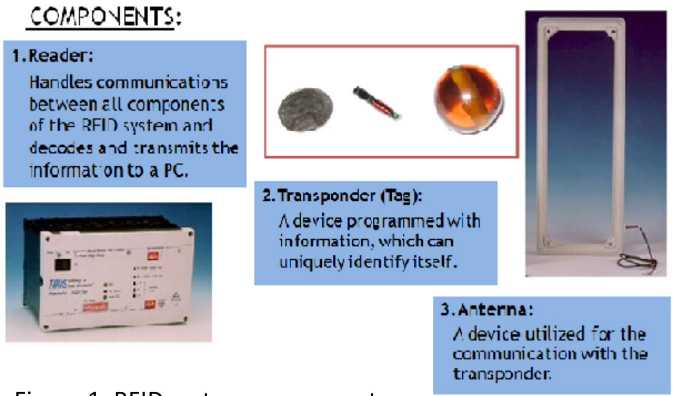

Figure 1. RFID system components.

Figure 4. Detection of the particles in the Raccoon River via an antenna towed by a boat. On the left corner, a scour ball found floating in the river.

Research Description

The following methodological steps were undertaken to achieve the overarching objective of the study:

1. Configure an RFID system to monitor bridge scour (Figure 2).
2. Perform laboratory experiments (142 runs) to determine the maximum detection range of the RFID system and predict pier scour (Figure 3).
3. Evaluate of the performance of the configured RFID system at the field (Figure 4).

A B

Figure 2. General view of the configured RFID systems: (A) the Texas Instruments system with RF of 134.2 kHz; (B) the HiTAG system with anti-collision and RF of 125 kHz.

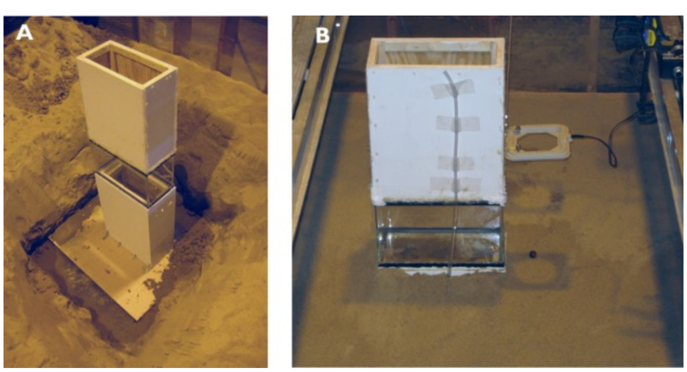

Figure 3. Flume experiment setup showing a rectangular pier model, the detection antenna, and the transponder.

Key Findings and Recommendations

- The Texas Instruments RFID system read one smart particle per time, and its effective reading range was about 3ft (~1m). The HiTAG RFID system had similar detection ranges but the anti-collision feature facilitated the simultaneous identification of up to 1,000 smart particles (transponders placed into marbles).
- The maximum detection distance of the antenna did not change significantly for the buried particles compared to the particles tested in the air. Thus, the low frequency RFID systems (~134.2 kHz) are appropriate for monitoring bridge scour because their waves can penetrate water and sand bodies without significant loss of their signal strength.
- The pier model experiments showed that the two systems were able to predict successfully the maximum scour depth, however the HiTAG anti-collision feature allowed for the prediction of the scour-hole bathymetry in addition to the scour depth.
- The preliminary field experiments with the HiTAG system at the Raccoon River, IA near the Railroad Bridge located upstream of 360th street Bridge, Booneville showed that the RFID technology is transferable to the field.
- Since the inception of this project, further research showed that there is significant progress in RFID technology. This includes the availability of waterproof RFID systems with passive or active transponders of detection ranges up to 60 ft (~20 m) within water – sediment column. These systems do have anti-collision and can facilitate up to 8 powerful antennas which can significantly increase the detection range. Such systems need to be further considered and modified for performing automatic bridge scour monitoring.