Transportation Consortium of South Central States

A Comprehensive Reliability-based Framework for Corrosion Damage Monitoring and Repair Design of Reinforced Concrete Structures

Key Points

Project Number:
17STLSU03

Start Date:
05/08/2017

End Date:
11/08/2018

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Funds Requested to UTC:
$100,000

Funding Source(s):
Tran-SET
Texas A&M University
Louisiana State University
Louisiana Transportation Research Center (LTRC)
University of New Mexico

Total Project Cost:
$200,000

Brief Project Description

This study proposes a framework to develop an effective reliability-based model and management system for the corrosion dynamics in the corrosion-damaged reinforced concrete that relates the corrosion process with the corrosion precursors from the environment and inherent to the material with time. The proposed framework will be tied to a reliability-based service life prediction model of reinforced concrete structures where corrosion is detected and the uncertainties inherent within its influencing parameters are quantified. The quantified uncertainties in the parameters that influence the corrosion process will be used to calibrate design factors used in structural design for repair and load rating of corroding reinforced concrete structures using reliability-based service life prediction models. The developed model will conform with inspection practices and reliability concepts by Department of Transportation (DOT) to facilitate implementing the research results into the DOT Integrity/Reliability Management System for use by DOT as well as local counties/parishes, cities, and townships in the Southern region.

Problem Statement

Civil infrastructure specifically transportation networks, waterways, energy grids, and networks are critical functional components of day-to-day life activity in a modern society. The durability and reliability of civil infrastructure are largely affected by the corrosion-induced deterioration of reinforced concrete (RC). A recent cost-of-corrosion study by the Federal Highway Administration has estimated the annual cost of corrosion to USA bridges to be approximately 30 billion, not including indirect costs incurred by the traveling public due to infrastructural closures.

In addition to increasing traffic demands, natural environmental conditions set degradation due to corrosion damage as a critical barrier to durable and reliable infrastructures. By considering material, for example, reinforced concrete as the critical element of the entire macro structure we propose to develop a comprehensive framework to manage structural integrity and to address the corrosion deterioration problem.

Based on the above, we propose a framework that can benefit greatly if a research project is undertaken to develop an effective reliability-based model and management system for the corrosion dynamics in the corrosion-damaged reinforced concrete that relates the corrosion process with the corrosion precursors from the environment and inherent to the material with time. The desirable features of this model and management system would include reinforced concrete samples that are exposed to corrosive environments simulating different locations of the Southern Region for validation of corrosion condition evaluation and in-depth corrosion condition assessment. Another desirable feature involves a methodology for sensing, detecting and estimating the uncertainties inherent in the important parameters influencing corrosion for use reliability-based model and design factor calibrations.

Objective

The purpose of this study is to develop a comprehensive framework for corrosion damage management in reinforced concrete that will provide an effective approach to monitoring and quantification of damage evolution, assessment of structural integrity, and will also provide efficient and cost effective maintenance/repair strategies by incorporating the corrosion monitoring observation to the structural design process.

Intended Implementation of Research

Technology Transfer

The results of this research will be demonstrated in an implementation study for a selected existing structure in a location that is known to be corrosion inductive. Data from the demonstration project will be extracted and used as input in the developed framework to predict its service life and its reliability during this period; i.e. the reliability index will be the main measure to assist in decision-making protocols. The time to intervention through repair will be estimated for different exposure conditions based on the minimum reliability index trigger, and the remaining service life will also be determined based on the reliability of the structure after the intervention. The reliability based results will be translated into load rating factors, which is the standard way for reporting structural conditions of existing structures after inspection. Finally, the findings of the research will be presented in a report that documents the methodology, the collected data, and the obtained results. It will also recommend procedures for implementation of the findings by DOT personnel.

Education, Workforce Development, and Outreach

This project will offer summer internships; one for an international graduate student from Mexico and another for a student from SEC or other Institutions to introduce them to research in Transportation. The developed educational materials prepared in this project will be shared with our partner community colleges to be used to recruit students to Transportation. The project will also offer internships for undergraduate students to work with the research team and learn about monitoring technologies in Transportation. In addition, seminars and webinars explaining the preservation of different assets and structures subject to environmental degradation will be offered to operators and companies interested in corrosion and reliability of reinforced concrete structures in Region 6.

Students working on this project will benefit from exposure to advanced modeling, mechanistic analysis, and linking laboratory samples within corrosive (atmospheric) environments and real-time monitoring technologies that are not typical for traditional civil or materials engineers but will likely be part of everyday life of future engineers. This proposal

provides an ideal environment for the education and training of students at the graduate level in a highly interdisciplinary area that encompasses civil engineering, materials engineering, corrosion, and application to real-world durability and reliability of reinforced concrete structures.

Anticipated Impacts/Benefits of Implementation

The proposed research will develop an efficient management system for corrosion-damaged reinforced concrete elements so that the current bridge inspection and management system can be improved to work better. In addition, an important class of physical assets; reinforced concrete bridges, can be preserved by mitigating corrosion induced damages. The proposed research will provide a necessary asset management system for managing corrosion-induced damages of reinforced concrete structure elements. The proposed research will provide methods for scientific assessment of remaining service life and design for repair and strengthening of critical reinforced concrete structures exposed to corrosion environments. This research aims to address two important Center and DOT missions: (a) Preserve what we have – by providing best practice tools for preserving physical infrastructures and extending their service life, and (b) Implement a decision support system that helps streamline infrastructure operations.

Weblinks:

- Tran-SET's website (http://transet.lsu.edu/completed-research/)
- TRB's Research in Progress (RIP) database (https://rip.trb.org/view/1467088)