

Corrosion Management System of Regional Reinforced Concrete (RC) Bridges

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Tran-SET
Louisiana State University
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AZZ
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\$224,000

Developing a procedure to manage corrosion in RC bridges

The deterioration of concrete infrastructure due to reinforcing steel corrosion has been recognized for several decades as a major technical and economic challenge in the United States. One particular aspect is the natural degradation of the materials forming the reinforced concrete element while in service and under environmental and climatic conditions. This rebar/concrete system has been extensively studied in laboratory but has rarely been directly inspected in field conditions. In laboratory studies, the rebar/concrete interface has been characterized and modeled. In field applications, the corrosion rate, as a kinetic concept, is not measured nor considered as a magnitude in infrastructure asset management plans. Instead, half-cell potential measurements, as a thermodynamic approach, have dominated inspection practices. The use of quantitative, meaningful parameters in the characterization and inspection of concrete bridges should inform the development of procedures for corrosion management of the concrete/rebar system.

The main objective of this study is to investigate theoretical modeling that provides magnitudes of different rebar materials degradation, informed by experimental characterization and in situ measurements for corrosion rates of a bridge element (column) during service conditions. Experimental samples will be characterized and monitored to quantify the corrosion rates at the rebar/concrete interface. Different concrete characteristics will be measured/quantified in laboratory and field conditions before and while in service. With these characteristics quantified, the reliability of each element of the structure will be estimated based on the corrosion and degradation characteristics under load conditions and harsh corrosive environments.

infrastructures affected by corrosion in the most efficient manner, we propose to develop a decision support procedure/methodology to manage integrity of corroding RC bridges which is resulted by evidence-based models of corrosion assessment, monitoring and structural performance. The tool is aiming at increasing the durability and reducing total life-cycle cost of the regional RC bridge infrastructures by improving the predictability of bridge conditions and increasing efficiency of the distribution of resources.

DOTs maintain a considerable bridge and infrastructure inventory among that is exposed to corrosive environments. To address the corrosion induced structure deterioration problem, DOT uses local experience and expertise to make decisions on when and how to fix these corrosion damages. The optimum strategy for management of corrosion-damaged structure elements should be based on systematic methodology of all assets in terms of the current condition, the extent of deterioration, the expected remaining service life, and the impact of alternative maintenance, the use of new materials and repair options on the service life and life cycle cost of such elements.

TranSET Project No. 17STLSU03 has been developing the framework of the environmental degradation of reinforced concrete durability by characterizing physical and electrochemical properties from concrete samples located in different marine environment/countries location. The project included samples that were exposed in the Gulf of Mexico for several months and a database that included results due to exposure of several years. The results include the corrosion likelihood and transport properties in different environments, for specific microclimates. TranSET Project No. 17CLSU08 has been developing corrosion control strategy for concrete samples exposed to aggressive conditions. The results of both efforts will provide enormous leverage for a more efficient corrosion management system based on corrosion mechanisms, monitoring and control conditions. In both efforts, the focus was on uniform corrosion and the more aggressive pitting (localized) corrosion was not considered.

Problem Statement

Civil infrastructure assets are critical functional components of day to day life activity in a modern society. The durability and reliability of these civil infrastructures are largely affected by corrosion-induced structural deterioration. Therefore, in order to improve the durability of the bridge



Objectives

The main goal of this research is to develop a comprehensive and effective management system of corrosion-damaged RC structural elements. The management system will encompass several components: (i) model, characterization and methodologies for conducting preliminary corrosion assessment as well as in-depth corrosion mechanism for both uniform and pitting corrosion, (ii) methodologies for selecting the most suitable repair, inspection and corrosion control methods based on modeling to meet a qualitative/quantitative index, (iii) methodologies for monitoring the component performance following the repair or control action, (iv) experiment-based and data driven probabilistic models of corroding RC structures.

Intended Implementation of Research

Workforce Development: This research project will provide funding to PhD students at two team institutions. The workforce development are: to train the next generation of scientists and engineers who 1) will serve as advanced work force for industry, academia, and/or government agencies with basic understanding of their environmental degradation assets to the need to optimize asset life; and 2) are familiar with the technological and theoretical tools and methods for corrosion and material degradation evaluation, inspection, detection, and prevention.

Outreach Activities: This project will offer assistantship for undergraduate students from Texas or Southern region will be involved to introduce them to research in Transportation. The project will also offer internships for undergraduate students to work with the research team and learn about monitoring and corrosion control 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 of the company that will be included in the co share budget for this project. The AZZ Company will help to organize webinars and workshops in corrosion and reliability of reinforced concrete structures.

Education: Students working on this project will benefit from exposure to mathematical modeling, and linking laboratory samples results and real-time monitoring technologies that are not typical for traditional civil engineers but will likely be part of everyday life of future engineers. The implementation of the fundamentals or results in graduate and undergraduate classes in Materials

Science and Engineering will include a key educational component in this work. This proposal provides an ideal environment for the education and training of students at the undergraduate and graduate level in a highly interdisciplinary area that encompasses civil engineering, corrosion, and application to real-world durability and reliability of reinforced concrete structures

Anticipated Impacts/Benefits of Implementation

1. Establishment of corrosion evaluation procedure for regional RC bridges;
2. Establishment/updates of corrosion indices and classification methodologies/model based on the test of regional bridge structures;
3. Decision support tool for selecting the most suitable corrosion control/mitigation methods;
4. Fragility curves for regional RC bridges in response to the regional demands and the control actions;
5. Integrated tool/method that merges materials, structures, and the management system for corrosion management; and
6. Dissemination of the results in the technical report, 2 journal papers, and several conference presentation.

Web links

- [TranSET's website](https://transet.lsu.edu/research-in-progress/)
(<https://transet.lsu.edu/research-in-progress/>)
- [TRB's Research in Progress \(RIP\) database](https://rip.trb.org/View/1644428)
(<https://rip.trb.org/View/1644428>)

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit [our website](#), LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Mr. Christopher Melson (Tran-SET Program Manager) directly at transet@lsu.edu.

