Designing and Characterizing new coating materials to increase the corrosion resistance of steel reinforcement embedded in concrete

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$ 130,000

Developing new coating materials to protect RC against corrosion

The mechanistic analysis of the performance of different coatings, applied to the steel rebar in concrete simulated pore solution (SPS) and RC samples will be tested by using exposure relevant to corrosive marine environments. Three tasks are proposed in this work. Task 1 includes the evaluation in aqueous solution environment, specifically in SPS. The idea is to identify the best process parameters to obtain the best chemical components and temperature by hot dipping layer to control corrosion of the galvanized steel to then use the information to prepare the metallic powders and RC elements for Task 2. Task 2 will includes laboratory testing, i.e. electrochemical, analytical chemical, and surface testing for the RC elements and reinforcing rebars. Task 3 will be focused on the analysis of results.

Problem Statement

Metallic infrastructures, such as RC elements are frequently exposed to aggressive/corrosive environments that can promote deterioration of their structural properties and shortening of their service life. Chloride-induced corrosion of reinforcing steel in concrete represents one of the most severe and common forms of RC degradation. The high alkaline pH of concrete leads to the formation of a passive film on the reinforcing steel. Diffusion and accumulation of chloride ions within the concrete matrix promotes breakdown of the ferrous passive film and initiation of a potential localized attack at the steel surface. This passive film breakdown process requires a critical chloride concentration, commonly known as “threshold” chloride concentration (TCC). Atmospheric and weather cycling conditions influence the dissolution rate of the rebar steel. In the case where a sacrificial inorganic layer such as Zinc is applied on the rebar the steel corrosion initiation could be defined as the failure of the Zn layer at a certain location. The localized attack can be influenced, as mentioned previously, by the chloride content, but also by other parameters such as temperature, chemical species, oxygen content, etc. Previous research and efforts have been mostly focused on the TCC at the steel/concrete interface but there is no information on the effect of varying the chemical composition of the bath that forms the galvanized layer. The literature on the galvanized composition is limited; however, it is known that the TCC for this material is greater than for bare steel.This research proposes to characterize and quantify a unique materials approach for corrosion control method, which will help owner agencies in making decisions to improve the durability of U.S. bridge infrastructures in the most effective manner through a systematic action plan to control and mitigate corrosion of existing structures.

Objectives

The objectives for this research project are: 1) Characterize chemically, microstructurally, and electrochemically in simulated pore solution, rebar specimens with no corrosion control method and with different composition galvanizing layers (varying bath composition and process temperature) and metallic powder embedded in Epoxy matrix (with different metallic compositions); 2) Prepare different RC element specimens, including specimens prepared with no corrosion control method (Control sample A), specimens with different galvanized Zn layer on rebar (Samples B), and rebars coated with Epoxy Zn Rich powder (sample C). 3) Determine the corrosion mechanism and kinetics of the steel reinforcement protected with different control methods for RC applications (Samples A-C), using advanced electrochemical testing and real time accelerating environmental chamber. 4) Provide guidance to optimize the ball milling processes for Zn based powders used as a Rich Epoxy coating for the rebar. Hot dipping process also will be optimized in terms of chemical composition in the bath and process temperature. Characterize its effect on the corrosion of reinforcing steel by using deterministic-semi-empirical modeling; 5) Train and educate two graduate, and two undergraduate students on processing and corrosion assessment of steel rebar and RC elements, including experimental electrochemical methods. Develop class experimental

demonstrations in electrochemical methods related to corrosion research.

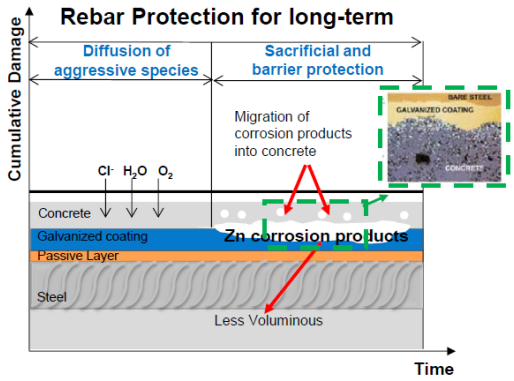

Figure 1. Performance evolution for galvanized rebar

Intended Implementation of Research

The outcome of this research will lead to a comprehensive report that will provide design methods and guidance for utilization of inorganic and organic coatings on rebar corrosion control actions in RC, capable of long-term performance in marine or harsh corrosive environment. Workforce development will also take place through the series of the outreach activities targeting broader audience of corrosion, civil and materials engineers, and potential industrial partners with the goal of increasing their awareness on importance of developing new technologies for ecofriendly and durable transportation infrastructure. The information will also be disseminated in various venues including technical publications, and conference presentations. Two graduate students, and two undergraduate students will be trained in developing reinforced multifunctional corrosion control-based concretes, characterization of their performance and carrying our independently complex electrochemical and corrosion testing.

Anticipated Impacts/Benefits of Implementation

One of the missions of the Department of Transportation (DOT) is to preserve critical concrete structures and systems such as components for bridges and achieve or exceed the minimum design life using cost-effective preservation protocols during the operation (load) stages. The proposed research will develop an efficient and robust framework for corrosion damage management in RC elements to greatly improve the durability. This will help preserve an important class of physical assets, RC bridges against corrosion-induced damages. This research will serve the important mission: to take care of current infrastructure by providing comprehensive tools for preserving concrete structures. This will also help extend the reliability of these concrete structures.

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

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 Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.