Multifunctional corrosion control system as a sustainable approach for reinforced concrete elements

Developing an innovative, sustainable, and environmentally multifunctional corrosion control technology, based on geo-polymer binders with BPT additions

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Corrosion inhibitors can decrease the corrosion kinetics and thus increase the durability of reinforced concrete elements. Inhibitors are widely used in corrosion technology, but their use for controlling steel corrosion in concrete is narrow. Although studies have suggested this effect of different inhibitors applied to reinforced concrete system, disadvantages of applying such technology have appeared. Some flow into the environment resulting in contamination, or negatively affect the physico-chemical properties of the reinforced concrete, and others can lead to cancer, like calcium nitrite. Of the different inhibiting substances evaluated that are appropriate for the alkaline medium in concrete, calcium nitrite has provided successful results, even for cracked concrete. Therefore, it has been used commercially with moderate success. However, some disadvantages and issues for this chemical due to carcinogenic and toxic properties have been raised, as well as the cost and scarcity in some countries. It has been found that $Ca(NO_2)_2$ improves the corrosion resistance of steel to chloride-ion attacks for w/c ratios lower than 0.5.. It was found that when using 2%wt $Ca(NO_2)_2$ solely, the metal lost its passivity even before the 400 days of exposure to the aggressive medium. But, when ZnO was added, at equal proportions, the steel remained in its passive state, reducing Cl- diffusion to the reinforcement, which allows Ca(NO2)2 to act eciently on the reinforcement, maintaining its passivity. The optimized results were found when equal proportions of the two inhibitors were used (ZnO/Ca(NO2)2 mixture at 2%wt). Another study, to find a nitrite replacement, the other tested inhibitors (gluconate, phosphate, urotropine, chromates, resorcinol, fluoroglucinol, and zinc oxide) did not show much improvement compared to nitrites.

Problem Statement

A research team comprised of Texas A&M University (TAMU) and the University of Texas at San Antonio (UTSA) propose to develop a multifunctional corrosion control system including an organic compound, 1-benzyl-4-phenyl-1H-1,2,3-triazole (BPT) micro-capsulated as a potential corrosion inhibitor with the addition of GPs for reinforced concrete elements. The physico-chemical properties prepared with both control actions will be numerically defined to construct a deterministic analog to compare the effect of the strategy. Specimens prepared with single or both forms of corrosion control methods will be tested. These lab specimens will be prepared with no corrosion barrier/inhibitor (Control type A), specimen with BPT microcapsules (Sample B), and samples with both GPs and microencapsulated BPT inhibitor (Samples C). Three electrochemical techniques will be performed to address the corrosion resistance of the rebar inside the specimens prepared by comparing them with control specimens. The corrosion potential will be measured to determine the corrosion tendency; the corrosion rate will be determined through the polarization resistance technique, which will be verified with Electrochemical Impedance Spectroscopy. This technique will possibly validate theoretical modeling.

Objectives

This study aims to develop an innovative, sustainable, and environmental multifunctional corrosion control technology, based on geo-polymer binders with BPT additions that will have a dual action. That is to block against corrosion species, while inhibiting the corrosion of the reinforcing steel. It is expected that this project will enhance infrastructure integrity, durability and sustainability by enforcing a new sustainable

multifunctional corrosion control system to the concrete field to achieve suitable corrosion resistance and enhanced durability with mitigated environmental contamination.

Intended Implementation of Research

Workforce Development: This research will produce a comprehensive report that will provide design methods and guidance for utilization of GP and green inhibitors in RC, capable of long-term performance in marine or harsh environments. Outreach activities targeting a broader audience of corrosion, civil and materials engineers, and potential industrial partners to increase awareness of new technologies for eco-friendly and durable transportation infrastructure will also be done. The information will be disseminated in various venues including technical publications, and conference presentations. Research team will also disseminate research findings at American Ceramics Society (ACerS) and the National Association of Corrosion Engineers (NACE). Result of this project will be also presented in at least two papers published in journals.

Outreach and Education: Train and prepare two Ph.D. students, and two undergraduates in developing reinforced multifunctional corrosion control-based concretes, characterization of their structural properties and carrying our independently complex electrochemical and corrosion testing. The outcomes of this project will be incorporated into courses at Texas A&M University and the University of Texas at San Antonio, including MSEN 410 Materials processing, MSEN 643 Materials Electrochemistry, Corrosion, and MSEN 644 Corrosion Laboratory and ME 4683 Corrosion Engineering. In each course, a module will be developed to demonstrate effects of the processing, structure, and properties of new concrete on the corrosion resistance of reinforcing steel.

Anticipated Impacts/Benefits of Implementation

The main deliverables from this study are:

1) Better basic understanding of corrosion of reinforcing steel in geopolymer based concrete.

2) Recommendation for optimized multifunctional cement composition with optimal corrosion inhibition properties.

3) Assessment and quantification of the benefits and limitations of the proposed approach for possible applications in transportation infrastructure.

4) Dissemination of the results in the technical report, journal papers, and several annual conference presentations.

Figure 1: Corroded pipe

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.