INVESTIGATION OF THE FEASIBILITY OF ELECTROCHEMICAL EXTRACTION OF CHLORIDE (Cl) IN RETROFITTING REINFORCED CONCRETE STRUCTURES IN THE COASTAL AREAS

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Corrosion of steel reinforcement is one of the primary modes of deterioration in reinforced concrete structures worldwide, largely driven by chloride attacks from marine environments, de-icing salts, and other sources of chloride ingress. This type of deterioration significantly compromises the structural integrity of concrete, leading to costly repairs and frequent maintenance. Every year, a staggering amount of money is spent on retrofitting and reconstructing these damaged structures, which has prompted extensive research into effective repair and rehabilitation methods. Among the various techniques studied, Electrochemical Chloride Extraction (ECE) has emerged as a promising method for retrofitting deteriorating reinforced concrete structures subjected to chloride attacks. ECE works by applying an electrical current to the concrete, which drives chloride ions away from the embedded steel reinforcement, thereby reducing the risk of corrosion. However, due to the lack of proper standards and guidelines on this method, it has not been widely adopted in the industry. This study aims to quantify the efficiency of chloride extraction and to determine the positive and negative side effects of using ECE as a treatment method for chloride-contaminated reinforced concrete structures through comprehensive laboratory tests. A major challenge in applying ECE in real-world scenarios is the difficulty of immersing large-scale structures in an electrolyte solution. To overcome this, a novel test setup was designed that simulates in-situ conditions and can be scaled up for industry applications. The research focused on monitoring the variation of chloride concentration in both the concrete and the electrolyte solution, assessing these variations over time, depth, and chloride-to-cement ratios of the test specimens. The study also explored the effects of ECE on the physical, mechanical, and chemical properties of the concrete to provide a holistic evaluation of its impact on structural performance. The results of this investigation indicate that ECE can effectively extract chloride ions from concrete, highlighting its potential as a viable corrosion mitigation technique. The study emphasizes the importance of optimizing experimental parameters, including the current density, duration of treatment, and composition of the electrolyte, to enhance the efficiency of chloride removal. Additionally, the development of practical testing methodologies bridges the gap between laboratory research and real-world applications, offering engineers and practitioners valuable guidance for implementing ECE in the field. This research underscores the need for standardized procedures and guidelines to facilitate broader industry adoption of ECE, ultimately enhancing the preservation of aging concrete structures. The findings contribute significantly to improving corrosion mitigation techniques and provide crucial insights for professionals involved in infrastructure maintenance and rehabilitation, paving the way for future advancements in the field.

Keywords: Chloride-induced corrosion, Corrosion mitigation, ECE, Rehabilitation, Reinforced concrete structures

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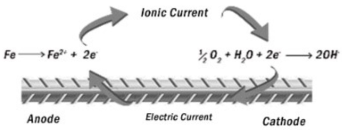
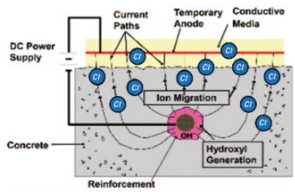
1. THEORY



Basic Equations

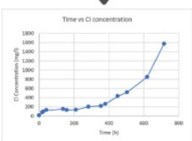
Test Setup



Theory

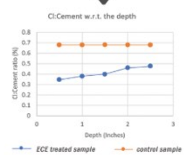
2. EXPERIMENTAL PROCESS

Chloride concentration variation of electrolyte with time



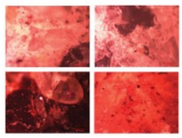
Chloride concemtration variation of electrolyte with time

Cl:Cement ratio variation of concrete w.r.t. depth



Cl:Cement ratio variation of concrete w.r.t. depth

Impact of ECE on the physical properties of concrete



Microscopic images of the face of ECE treated test specimen

Impact of ECE on mechanical properties of concrete

Specimen	Failure load (kN)	Compressive strength (N/mm²)
ECE treated sample	465.9	20.7
Control sample	546.2	24.2

Compressive strength test results of ECE treated test specimen and a control sample

Impact of ECE on chemical properties of concrete

Variation of alkalinity of concrete after ECE treatment

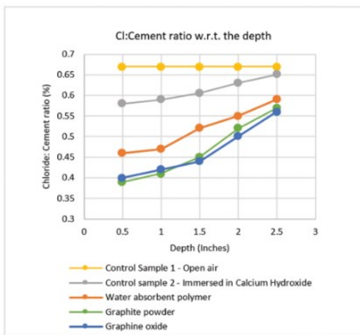
2. EXPERIMENTAL PROCESS FOR INDUSTRY APPLICABILITY

Paper medium soaked with graphene oxide

Cotton and graphite powder medium

water absorbent polymer medium

ECE treatment process



Cl:Cement ratio variation in concrete for tested 3 mediums w.r.t. depth