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A Review of Accelerated Corrosion Studies on Reinforced Concrete Samples Using Voltage Impressed Test

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***ABSTRACT**:*
There are manycauses of deterioration in reinforced concrete structures, but corrosion is the main culprit. Hereat our review article blog,We address corrosion concepts with respect to reinforced concrete structures as well as significant advancements in corrosion monitoring using electrical methods. When examining corrosion mechanisms, RC structures have inherent heterogeneity and areinfluencedby environmental factors,making datainterpretations difficult.At the steel-concrete connection interface, the surface quality of the steel and local inhomogeneitiesarekeyfactorsin corrosion initiation. The corrosion process of RC structures exposed to atmosphereisinfluencedby the water content and porosity at the connectinginterface between steel and concrete.However,regardless of the process of corrosion- carbonation or chloride-induced corrosion -non-uniformity is expected to be the most common kind of corrosion for RCstructures due to exposure to varying regional environmentandinteractions with depassivatedrebars.study finds, Continuous current is preferred method for simulating corrosion damage in reinforced concrete structures. Results show that constant current accelerated corrosion causes more damage than constant voltage accelerated corrosion. Findings suggest that the continuous current method is preferable for evaluating the effectiveness of various materials and repair techniques.Corrosionwas developed by repeated soaking and drying cycles over two years, and then artificially corroded using an impressed voltage approach. Lepidocrocite,goethite, andmagnetite were identified under bothtypes of corrosion. akaganeite was only detected under naturalconditions.There are a number of commercially available corrosion-inhibiting admixtures for concrete that have not been well evaluated and do not have long-term performance data. The durability of concretes withanodic inhibitors (calciumnitrite-based) and bipolarcorrosion inhibitors was investigated.There are several approaches for conducting accelerated corrosion tests in a laboratory setting. The study's goal is to show the pros and cons of each approach. Two full-scale reinforced concrete two-way slabs were fabricated. Both slabs attained the same amount of corrosion, with a 25 percent mass loss.A study has compared the corrosionproducts created on carbon steelplates exposed to atmospheric corrosion inurban and industrial environments to those obtained during accelerated corrosion trials.The results revealed that the ASTM B117-based accelerated test had low connection with air corrosion testing, however an alternating wet/dry cycle accompanied with exposure to UV radiation had a higher correlation. Reinforcing bar bonding in concrete is critical for reinforcing bar anchorage and reinforced concrete crack prevention. Various test procedures, on the other hand, produce different test findings. A new test procedure has been discovered to produce lower and less unpredictable bond strength and stiffness findings. Impressed current can cause non-uniform, growth of localised corrosion on steel reinforcement. This leads to an overestimation of the damaged structure's load capacity. SEM-EDS was used to study the mill-scale of the steel reinforcement and the concrete-steel interfacial connecting area.
Keywords: *Reinforced Concrete Structures, Corrosion, Voltage Impressed Test, Chloride.*

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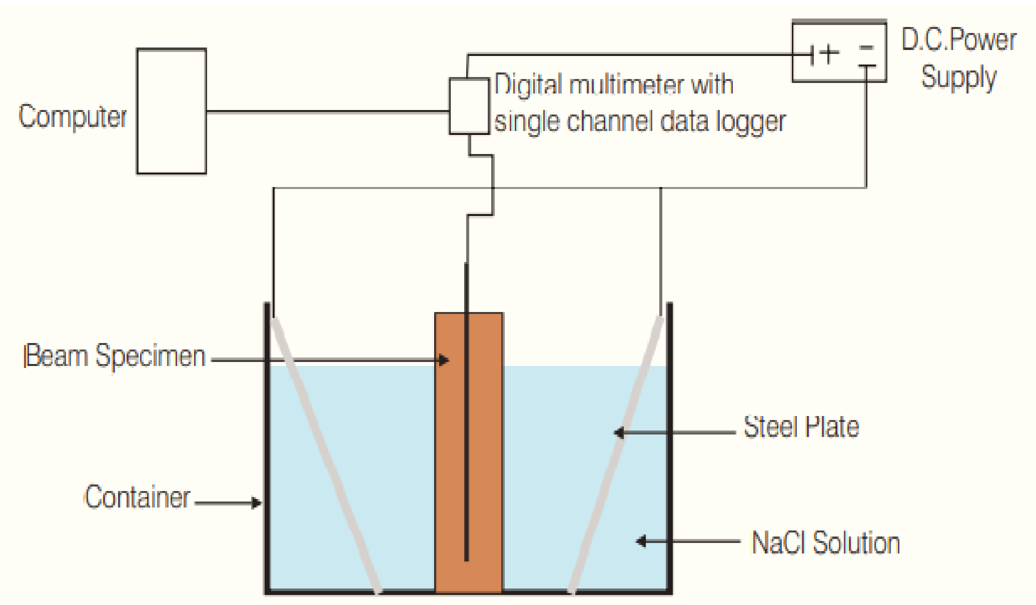
I. INTRODUCTION

Reinforced concrete makesup the majorityof construction materials. Steel, which isembedded in concrete is typically exposed to an alkaline atmosphere, that causes the steel to passivate. Any situation that upsets the environment around the steel can cause the passive film to be disrupted and the corrosion process to begin. The occurrence of reinforcing bar corrosion in concrete is a time-dependent process. Corrosion of steel reinforcement and degeneration of reinforced concrete (RC)

structures takes years even under harsh environmental conditions. Chloride-induced steelcorrosion is one of the most serious challenges that steel reinforced concrete constructions encounter everywhere in the world. Key structural components, such as supporting columns, are prone to corrosion attack, especially in cold temperature locations where de-icing salts are used. Saline water could also be a source of chloride contamination in structures.Saltwater contamination of aggregate components in concrete or water used in concrete batching are two further origins for chloride contamination in structures, as well as exposure to the marine environment directly or indirectly. The accelerated corrosion test, on the other hand, can be used to compare the overall relative efficiency performance of different types of binder and steel in a short amount of time.

AcceleratedCorrosion Test

Figure depicts the setup for an acceleratedcorrosion test (also referred to as voltage impressed test). A DCpower source, two stainless steelplates, a data logger, a test specimen, and a jar that holds the required amount of NaCl solution make up the system. For the accelerated corrosion test, Concrete beam specimens with a steel bar implanted in the centre are employed. After preparation, specimens are tested at the requisite age. The positive terminal of the DC power supply is linked to the specimen's steel bar, while the negative terminal is connected to the stainless steel plates. A continuous voltage is applied to the system to start the corrosion process. The data logger continuously monitors and records the current reaction. The specimens are also visually inspected every day for the emergence of cracks.The data logger is programmed to record the circuit's corrosion current at a sampling frequency of 1 minute. When the specimen cracks and the rate of growth of corrosion current with time is insignificant, the accelerated corrosion test is terminated.



Setup diagram for an accelerated corrosion test

II. LITERATURE REVIEW:

S. Altoubat, M. Maalej, and F. U. A. Shaikhworked on "Laboratory Simulation of Corrosion Damage in Reinforced Concrete"

The findings of an experiment involving multiple small-scale columns that were built to imitate corrosiondamage in the field using two acceleratedcorrosion approaches, constantvoltage and constant current, are presented in this study. For this experiment, a total of sixcolumns were cast. The corrosion of one pair of typical RCcolumns was accelerated using constantvoltage, whereas the corrosion of another pairwas accelerated using constantcurrent. As a control, the remaining pair of standard RC columns were used. Sodium chloride (NaCl) solution was used to cyclically wet and dry all of the columns in the experiment. Throughout the test programme, the currents were monitoredhourly and cracks werevisually verified. All of the columns, including the control,were tested to failure in compression after the specimens had incurred a substantial percentage of steel loss. The test findings reveal that impressed constant current accelerated corrosion causes more corrosiondamage than constant voltage acceleratedcorrosion. The findings imply that the continuous current method is preferable for simulating corrosion damage in reinforced concrete structures and evaluating the effectiveness of various materials,repair techniques, andadmixtures in preventing corrosiondamage.

Emel Ken Benito[I], Marish S[2.]. Madlangbayan[3.], Nimfa Maren S[4.]. Tabucal[5.], Marloe[6.] and Perlie P[7.]. Velasco[8.]carried out the study on "Corrosion Damage Measurement On Reinforced Concrete By Impressed Voltage Technique And Gravimetric Method"

The effect of seawater on the corrosion behaviour of reinforcingsteel in concrete was explored in this study. To replicate sea water, a 3% sodium chloride solution was employed. The solution served as both a mixing medium and an immersion medium. In this investigation, normal-normal water (NN), normal-sea water (NS), seawater-normal water (SN), and seawater-seawater (SS) were used as mixing and immersion media combinations (SS). Impressed Voltage Test (IVT) and gravimetric methods were utilised to measure corrosion. Corrosioncurrent curves,gravimetric mass loss, the average and maximum current passed were all severe in SS but non-existent in NN, according to the findings. However, the distinction between NS and SN is not clearly defined, but it has been proven to differ in terms of corrosioncurrent behaviour before and after cracking. It was discovered that adding chloride to a concrete mix, regardless of its environment, causes quick crack growth. Except in the SS combination, statisticalanalysis revealed that the presence ofchloride had no effect on the outcome of percent mass loss when compared to the controlsample.

Musab Alhawat[1.], Othman Hameed Zinkaah[2.] and Almahdi Araba[3.] carried out a study on "Study of corrosion products induced under different environmental conditions"

Corrosion inreinforced concrete structures is primarily influenced by material attributes and environmental factors. The rust productsproduced in twodifferent environmental situations were studied in this paper. Corrosion was caused in the first group of specimensby running wettingand drying cycles for twoyears, whereas the second group was artificially corroded using an impressed voltageapproach. X-ray diffraction (XRD) was used to analyse the composition of corrosionproducts assembled over steel reinforcement, while Energy-dispersiveX-rayspectroscopy was used to identify the key elements present in corrosion (EDX). Scanning electronmicroscopy(SEM) was used to examine the morphological characteristics of the corrosion that was studied. At the same level of corrosion, XRD and SEM data revealed that lepidocrocite,goethite, and magnetite were identified under both types of circumstances, however akaganeite was only detected under naturalconditions.

V L Satish, V Ravindra studied about "Evaluation of corrosion resistance of corrosion inhibitors in concrete structures by Impressed voltage test"

There are a number of commercially available corrosion-inhibiting admixtures for concrete that have not been well evaluated and do not have long-term performance data. Laboratory tests were carried out on two commerciallyavailable corrosion inhibitors to establish their efficiency and corrosionresistance characteristics in concrete withOPC and PPC in this study.The durability ofconcretes withanodic inhibitors (calciumnitrite-based) and bipolarcorrosion inhibitors was investigated in this work (amino alcohol-based). To investigate the efficiency of inhibitors, acceleratedcorrosion testing (Impressed voltage test) was performed. The Calcium Nitrite Inhibitor has demonstrated to be more effective in lowering the rate of corrosion of embeddedsteelreinforcement in PPC mixtures.Both inhibitorshave shown superior results in lowering the corrosionrate of embeddedsteel in OPC mixtures than in the control mix.

Said Mahmoud., Hussein, Amgad, Hassan, Assem A and Gillis studied on "Comparison Of Different Accelerated Corrosion Techniques"

This paper discusses several approaches for conducting accelerated corrosion tests in a laboratory setting. The approaches are designed to cause corrosion in full-scale structural reinforced concrete members. The study's goal is to show the pros and cons of each approach. For this experiment, two full-scale reinforced concrete two-way slabs were fabricated. The slabs were of the same size, measuring 1900 mm x 1900 mm x 150 mm. Using two separate accelerated approaches: constant voltage and constant current, the slabs attained the same amount of corrosion, with a 25 percent mass loss. Each slab's caused corrosion was assessed. Current measurements, half-cell potentialtests, andmass loss were used to assess the corrosion status. The real mass lossand the theoreticalmass loss estimated using Faraday'sequation were found to be quite close in both ways. In the circumstance of continuous voltage, the concrete loses its resistivity during corrosion, which is effectively indicated by an increase in current. As a result, utilising continuous voltage may cause greater harm than typical ambient circumstances. The constant current approach, on the other hand, keeps the current intensity constant throughout the corrosion process, independent of the concrete's resistance, resulting in a uniform corrosion rate that avoids excessive damage.

Renato Altobelli Antunes[1.], Rodrigo Uchida Ichikawa[2.], Luis Gallego Martinez[3.] and Isolda Costa[4.] carried out study on "Characterization of Corrosion Products on Carbon Steel Exposed to Natural Weathering and to Accelerated Corrosion Tests"

The goal ofthis study was to compare the corrosionproducts created on carbon steelplates exposed to atmosphericcorrosion in urbanand industrialenvironments to some of those obtained during acceleratedcorrosion trials. X-raydiffraction, Mossbauerspectroscopy, and Ramanspectroscopy were used to characterise the corrosion products. For nine months, the specimens were subjected to natural weathering in bothatmospheres. Scanningelectronmicroscopy was used to examine the morphologies of the corrosion products. Lepidocrocite was the most common mineral discovered. The corroded specimens also included goethite and magnetite, albeit in lesser amounts. The results revealed that the ASTM B117-based accelerated test had low connection with air corrosion testing, however an alternating fog/dry cycle accompanied with UV radiation exposure had a highercorrelation.

S.H. Chu[1.], A.K.H. Kwan[2.] studied on "A new method for pull out test of reinforcing bars in plain and fibre reinforced concrete"

Reinforcing bar bonding in concrete is critical for reinforcing bar anchorage and reinforced concrete crack prevention. A pull out test of a reinforcingbar embedded in a concreteblock is commonly used to determine it. Various test procedures, on the other hand, produce different test findings. Finite element analysis was used in this study to uncover changes in stress distribution inside the concreteblock caused by unequal contactpressure and friction at the test setup's concreteblock-steelplate interface. The test equipment was changed by adding a rubberpad and a PTFEfilm at the interface to decrease test mistakes caused by such unequal contact pressure and friction. Pullout tests of reinforcingbars in plain and fibre reinforcedconcrete were done using the modified setup, and the results werecompared to those obtained without the use of a rubberpad or PTFEfilm. The new test was discovered to produce lowerand less unpredictable bond strength andstiffness findings. For structural analysis and design, this new test procedure would yield more accurate bond characteristics.

Thi Hai Yen Nguyen[1.], Van Hong Linh Bui[2.], Van Mien Tran[3.], Nguyen Thi Cao[4.], Withit Pansuk[5.], and Pitcha Jongvivatsakul[5.] carried out the study on "Verifying the Reliability of Impressed Current Method to Simulate Natural Corrosion in Reinforced Concrete"

The impressed current approach has been widely utilised in laboratory research toaccelerate the corrosion of steel reinforcement in reinforcedconcretestructures, regardless of its suitability for the varied goals of studies linked to the deterioration of reinforcedconcrete buildings. The goal of this research is to determine the impact of the impressedcurrent method on the steel-concreteinterface in reinforcedconcrete in order to evaluate the method's accuracy in replicating natural corrosion. SEM-EDS was used to study themill-scale of the steelreinforcement and the steel-concreteinterfacial area. The findings show that impressedcurrent can cause non-uniform, localisedcorrosion on steel reinforcement. Naturalcorrosion generated by chloride conditions was most likely the source of the corrosion products created. The oxidation of OH- at the anode, on the other hand, can prevent the precipitation of corrosionproducts at the steel-concreteinterfacial area, hence reducing the creation of concrete cracks. This leads to an overestimation of the damaged structure's load capacity and casts question on the use of this approach to model corrosion behaviour.

Sonjoy Deb studied about "Accelerated Short-Term Techniques to Evaluate Corrosion in Reinforced Concrete Structures"

The emergence of reinforcing bar corrosion in concrete is a time-dependent process. Corrosion of steel reinforcement and degeneration of reinforced concrete (RC) structures takes years even under harsh environmental conditions. The accelerated corrosion test, on the other hand, can be used when it is necessary to examine the relativeperformance of several types of binder and steel in a short amount of time. Although the acceleratedcorrosiontest may not always replicate genuine corrosion, it can model steel corrosion in real RC structures to some extent.

III. Conclusion

The conducted literature evaluation helps in understanding the trends and identifying the research need. The research can be done towards the findings of pull out strength and percentage of corrosion ingression in the Reinforced concretestructure subjected to acceleratedcorrosion using voltageimpressed test. This test can be used to determine a variety of concrete durability factors. Thistest can also beused to compare different types of construction materials. This test can be used to simulate a variety of harsh field situations by altering the chloride content, grade of concrete, and voltage applied.

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