International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-10, Issue-1, February 2023
https://doi.org/10.55524/ijirem.2023.10.1.20
Article ID IJIRD-1235, Pages 114-116
www.ijirem.org

Sacrificial Cathodic Protection Method of Reinforcement from Corrosion

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ABSTRACT- Cathodic protection prevents corrosion of steel incorporated in concrete structures and bridges. Because of the action of chloride ions, reinforced structures readily corroded in a maritime environment. For the majority of concrete structures, Cathodic Protection offers long-term rehabilitation techniques. Due to the corrosion of the reinforcing steel, concrete structures exposed to marine conditions are deteriorating. Effective corrosion protection must be taken into consideration for both new construction and damage repair because this deterioration progresses quickly and seriously. For all concrete structures in marine conditions, cathodic protection is anticipated to be a realistic corrosion protection method. The following factors were taken into account in this study to establish high reliability for cathodic protection of concrete structures: (1) establishing standards for cathodic protection on concrete structures (2) analysing the issue of overprotection in prestressed concrete constructions.

KEYWORDS- Concrete, Reinforcement, Corrosion Protection, Safety Critical Element

I. INTRODUCTION

Corrosion of embedded steel causes concrete structures to deteriorate and lose resilience. Studies on the corrosion of embedded steel demonstrate that the corrosion products produced on the steel surface cause tensile stresses on the surrounding concrete of up to 490 MPa [1-3].According to reports, chloride ions are mostly to blame for the corrosion of steel buried in concrete, which causes concrete to deteriorate [4–7].Due to this, concrete structures fail unexpectedly and prematurely, which has a significant economic and social impact.Therefore, it is crucial to prevent the corrosion of the steel embedded in concrete.

Cathodic protection is a key technique used to control the corrosion of steel embedded in concrete among the different corrosion control technologies available. The goal of a cathodic protection system is to move the steel's potential to a range where corrosion is least likely to occur. The Federal Highway Administration has found that cathodic protection is the sole restoration method capable of preventing further corrosion in such buildings, regardless of the salt content in concrete. Cathodic protection successfully halts the corrosion process. Therefore, cathodic protection has been deemed the most effective method for stopping the corrosion of steel embedded in concrete by the Federal Highway Administration of the USA. AASHTOAGC-ARTBA Task Force 29, the American Concrete Institute (ACI), and the National Association of Corrosion Engineers (NACE International) have also. Provides cathodic protection for structures made of reinforced concrete. As a result, impressed current cathodic protection for concrete is frequently used [8–12]. For cathodic protection to be effective, it needs to be carefully monitored and maintained. It is known that potential measurement is the most often utilised field approach for identifying corrosion activity in embedded steel among the many electrochemical methods. The benefit of using sacrificial anodes is that they don't need an additional power source. They can be applied to post-tensioned or prestressed concrete without increasing the possibility of movements that could cause hydrogen embrittlement of the steel. Also, electrical shorting is not a problem because the anode is directly attached to the steel. Zinc that has been arc sprayed and has a thickness of 300 to 400. Several studies examined arc-sprayed zinc with thicknesses ranging from 300 to 400 lm [13]. The anode's reaction products at the anode/concrete interface have disrupted the electrical continuity. The current output also fell significantly over time when the concrete was relatively dry due to the passivating effects of the ZnO/Zn(OH)2 produced. Due of these, the current wouldn't be enough to keep the cathodic protection in place. For usage as submerged anodes, aluminium alloys with Zn and in were also researched.

Here, the oxidation products created at the sacrificial anode/concrete interface caused the anode current output to rapidly decrease over time. Due to the high resistance of the concrete environment, greater driving voltage anodes are needed. Magnesium anodes are thus advantageous for application. However, there are very few research on the application of magnesium alloy sacrificial anodes for cathodic protection in concrete. These research suggested that for the cathodic protection to solidify, longer times are needed. Additionally, the durability of the magnesium anode's performance in protecting steel in concrete needs to be confirmed. Consequently, the focus of this paper is on assessing the long-term effectiveness of Mg anodes for cathodically safeguarding the steel embedded in concrete

II. CORROSION PREVENTION PROCESS

Cathodic protection, electrochemical approaches, coatings on the surface of the concrete, substitute reinforcements, and the use of corrosion inhibitors are a few techniques used to prevent corrosion of steel embedded in concrete. The utilisation of the sacrificial cathodic protection technology and the research into it are the main topics of this paper.

S.M.A Shibli et al. [14] research was done on the metallurgical properties of anodes, which were greatly enhanced when ZnO was used as reinforcement. The Al+5% Zn alloy anode was strengthened with 0.5% ZnO, which raised the efficiency from 58% to as high as 83%. A higher amount of inert metal oxides in the sacrificial anodes would reduce the energy density of the anode mass, hence the maximum concentration of the composite was restricted to 0.5%. Further research revealed that ZnO strengthened the alloy melt during casting, lowering the potential to a more cathodic state and enhancing the galvanic properties. This enhanced anode performance.

G.T. Parthiban et al. [15] This study was conducted to evaluate the cathodic protection of steel embedded in concrete using a magnesium alloy anode. For cathodic protection, a magnesium alloy anode with a three-year design life was put in the middle of a reinforced concrete slab containing 3.5% sodium chloride by weight of cement. Monitoring, plotting, and analysis were done on the potential of the embedded steel as well as the current flowing between the anode and the steel. Additionally, the chloride concentration of concrete was measured and studied at various times and locations. It was discovered that the magnesium anode caused the steel's potential to move first, at all distances, to more negative potentials and later, towards less negative potentials. There was no discernible decrease in the chloride levels the areas as time goes on. The elimination of corrosive ions like chloride from the vicinity of steel could be linked to the mechanism of cathodic protection with the sacrificial anode.

A.M. Hassanein et al. [16] At low rates of steel corrosion, a more uniform distribution results from the study of the boundary conditions of the steel that significantly affect current distribution. A steel bar facing the anode will typically get 50% more current than the surface facing away from it. The current distribution is noticeably worse when there are more reinforcing layers. To increase current distribution in this situation, a surface anode might not be sufficient and distinct anodes might be required. At a constant anode current density, an increase in the concrete's resistivity, cover, and anode to cathode area ratio will increase the voltage drop through the concrete, improving the conditions at the steel that encourage steel passivity. In order to translate the permissible voltage drop through the reinforcing steel and anode system into connection spacings and acceptable resistivities of installed components, this may be utilised to define the voltage drop that is acceptable through the system used to specify the permitted voltage drop through the reinforcing steel and anode system, which is then converted into the permitted connection spacings and resistivities of installed components.

D. Dong et al. [17] titanium coatings that were thermally sprayed were examined as anodes for the cathodic defence of reinforced concrete. The titanium anode coatings were activated using three unique catalyst systems. In some studies, the catalyst was applied to the metallizing wires as a precoat; in other trials, the catalyst solution was applied to concrete blocks either before or after the titanium arc spraying. The coated reinforced concrete blocks were operated for more than 95 days at a steady current density and 95% relative humidity. As shown by the driving voltage measurements across the samples, the catalyst precoating on the titanium wires had no impact on the driving voltage over the lifetime that was observed. In other studies, the surface of the reinforced plastic was treated directly with the catalyst, which resulted in only the cobalt oxide catalyst greatly decreased the driving voltage needs for concrete blocks. Whether cobalt oxide was used on the concrete blocks before or after titanium arc spraying, both methods reduced the driving voltages.

L. Bertolini et al. [18] According to research, cathodic protection must lower its potential to below a protection value that varies (depending on temperature, chloride content, and pH) roughly in the range of -0.5 to -0.75 V in order to restore passivity conditions on corroding reinforcements in chloride-contaminated structures (SCE). Cathodic protection must lower the steel potential below an initiation potential, which varies depending on temperature, pH, and chloride content but typically falls within the range of -0.2 to -0.4 V (SCE), or at least 0.3 V more noble than the repassivation potential, in order to prevent corrosion on passive rebars of new structures. Furthermore, because to the passive steel's high polarizability, protective conditions can be achieved on rebar that is relatively far from the anode without running the risk of hydrogen embrittlement on those that are closest to it.

Kishanrao M Godbole et al. [19] Researchers found that the saline environment in underwater concrete piers, particularly those that are exposed to splash zones, accelerate corrosion more than is typical. As a result, the typical concrete cover thickness is insufficient and ineffective at preventing corrosion. For reinforcement above 12mm diameter bars, the concrete cover depth must be increased by +5 to 10mm in addition to the nominal depth indicated in the rules. By delaying carbonation and chloride corrosion, the higher cover depth is able to postpone the electrochemical reaction and reduce carbonation depth.

III. CONCLUSION

Finally, the outcomes of these tests have demonstrated that cathodic protection can be successfully used in specific situations. The conductive covering with wet spray or trowel-applied repair mortar was found to be the system with the least amount of practical problems and the quickest response times. Cathodic protection is currently being compared economically to total column breakout and repair. There are several steps that can be taken to stop carbonation and chloride penetration on new reinforced concrete structures. Cathodic protection offers an efficient solution for the long-term protection of buildings once chloride contamination has occurred.

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