UNIVERSITI TEKNOLOGI MARA

PERFORMANCE OF ORGANIC ZINC-RICH PAINT (ZRP) COATING ANODE IN SELF-POWERED CEMENT-BASED BATTERY FOR CATHODIC PROTECTION (CP) OF CHLORIDE-INDUCED CORROSION IN REINFORCED CONCRETE (RC)

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PhD

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Reinforced concrete (RC) is an extremely popular construction material that is used worldwide. Continuous exposure of RC structures to corrosive environment such as chlorides lead to deterioration and destruction of structures. It is one of the major durability challenges in civil and construction industry, where it can affect the structural soundness and performance as well as its service life. Cathodic protection (CP) of chloride-induced corrosion in existing RC structures is a well-known electrochemical technique to mitigate corrosion by supplying external electrical current from continuous energy source through concrete and on protected steel reinforcement surface, regardless of the chloride content in concrete. CP is divided into two types which are sacrificial anode cathodic protection (SACP) and impressed current cathodic protection (ICCP) systems. ICCP consists of an inert anode that corrodes at a very low rate, a monitoring system and a continuous external direct current (DC) power supply to force an amount of electrical current from anode to steel reinforcement. ICCP system is preferred since the current output is adjustable to deliver a sufficient amount of current required especially in high resistivity concrete. However, continuous DC power supply can cause high energy consumption which is non-environmentally friendly for a long-term protection. There is an alarming need in replacing it with an alternative green energy source in powering ICCP system. Recently, cement-based battery was introduced for low power operation system, but the effectiveness of anode used is reduced over time. The used of cement-based battery as an alternative energy source could promote a green technology to the environment since it utilises cement which is extensively used as part of the construction materials of RC structures. This study aims to evaluate the effectiveness of reusable steel can incorporated with organic zinc-rich paint (ZRP) anode in cement-based battery for self-powered CP of chloride-induced corrosion in RC. The electrical, thermal and electrochemical performance of different coating layers of ZRP (one – layer ZRP (I), two – layers ZRP (II) and three – layers ZRP (III)) and other anode materials in cement-based battery design were evaluated and the corrosion resistance were analysed using linear polarization method. Accelerated corrosion technique (ACT) was used to obtain pre-corroded RC specimens initiated by chloride-induced corrosion at different corrosion rate. The unprotected (without CP), protected (with conventional CP) and protected (with ZRP (I) anode in cement-based battery in CP) of different rates of pre-corroded RC specimens partially immersed in 3.5% NaCl solution, were monitored and measured using half-cell potential (HCP) measurement and mass loss method, accordingly. Findings of this research showed that one layer – ZRP (I) anode in cement-based battery design indicated the highest performance and greater longevity compared to previous cement-based battery designs. Upon the application of self-powered ZRP (I) anode in cement-based battery in CP system, the potential and mass loss of pre-corroded RC specimens partially immersed in 3.5% NaCl solution were decreased. Therefore, the new CP method could effectively reduce the chloride-induced corrosion in RC structures and the power consumption from non-environmentally friendly DC power supply in conventional CP will also be reduced, since it utilises cement matrix as a source of green energy. This could help in reducing the carbon dioxide (CO_2) emission to the environment that leads to climate changes.

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I realized that this thesis still in needs of constructive critics and suggestions for further improvement from readers. And, hopefully, it may be useful as well as meaningful contributions to other related studies in the near future.

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