모의 콘크리트 환경에서 강철 철근의 부식을 모니터링하기 위한 현장 고체 기준 전극 평가

Assessment of In-Situ Solid-State Reference Electrode for Monitoring Corrosion of Steel Rebar in Simulated Concrete Environments

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Abstract : The solid-state reference electrodes made of polyaniline-coated MnO_2 (SSRE-PAM) and their electrochemical characteristics were studied in simulated concrete pore solutions (SCPS) containing 0 and 3.5% NaCl. Saturated calomel electrodes (SCE) have been used to conduct electrochemical studies on the stability behavior of SSRE-PAM. Open circuit potential (OCP) and potentiodynamic polarization techniques were used to assess the corrosion performance of steel rebar exposed in SCPS with 0 and 3.5% NaCl using SSRE-PAM. The results demonstrate that the SSRE-PAM was capable of identifying steel rebar in a concrete environment that was either passive or active. Potentiodynamic polarization parameters such as E_{corr} and I_{corr} for steel rebar in SCPS containing 0 and 3.5%)NaCl are greater than that of the passive condition (0% NaCl). All the studies validate the importance of using SSRE-PAM for corrosion monitoring applications in concrete structures.

키워드 : 현장 기준 전극, 모의 콘크리트 환경, 철근 부식
Keywords : in-situ reference electrode, simulated concrete environment, steel rebar corrosion

1. Introduction

In the marine environment, corrosion of reinforced steel rebar (STR) is the most frequent cause of the deterioration of the concrete structure. As a result construction time, money, and resources are wasted, which is occasionally disastrous. Hence, in order to increase the lifespan of concrete structures, corrosion monitoring is required [1]. Because the embedded STR corrosion monitoring is advantageous for extending the lifespan of the concrete structures, it enables prompt repair and rehabilitation of concrete structures without resulting in additional damage. Surface mounting methods are used to measure the majority of corrosion monitoring. However, due to the distance between the STR surface and electrode, SM methods provide inconsistent signals during measurements (Inner ionic resistance) [1]. These problems have been resolved by in-situ corrosion monitoring of the STR in concrete structures, which eliminates the IR drop of the concrete. We developed reference electrodes based on polyaniline-MnO_2 nanocomposites to evaluate the corrosion condition of concrete reinforcement.

2. Materials and methods

2.1 Fabrication of SSRE-MnO_2

PANI-MnO_2 was synthesized as per the literature [2]. The SSRE was fabricated by previous literature [1]. PANI-MnO_2 is used as active material (sensing material). The fabricated electrodes were subjected to electrochemical studies.

2.2 Stability and reversibility test

The stability of the fabricated SSRE-PAM was examined in the SCPS containing 0 and 3.5% NaCl using a high-impedance voltmeter with respect to the SCE.

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2.3 Monitoring the steel rebar corrosion

STR with 12 mm dia and 120 mm length was used for this study. The STR were immersed in the SCPS with 0 and 3.5% NaCl, and their corrosion potential was monitored by SCE and SSRE-PAM using a high-impedance voltmeter for one month. The corrosion potential (E_{corr}) and corrosion current density (I_{corr}) values were examined by potentiodynamic polarization techniques using a VersaSTAT (Princeton Applied Research, Oak Ridge, TN, USA) potentiostat.

3. Results and discussion

3.1 Stability test for SSRE-PAM

The stability of the fabricated SSRE-PAM in the SCPS with 0 and 3.5% NaCl were examined by SCE, shown in Figure 1(a). It can be seen from Figure 1(a) that the potential values of the SSRE-PAM in the SCPS with 0% NaCl 3.5% NaCl were -126 mV and -128 mV, respectively, which is almost equal potential in the SCPS with 0 and 3.5% NaCl. These results confirm that the fabricated SSRE-PAM is not affected by chloride ions, giving stable potential throughout the exposure periods.

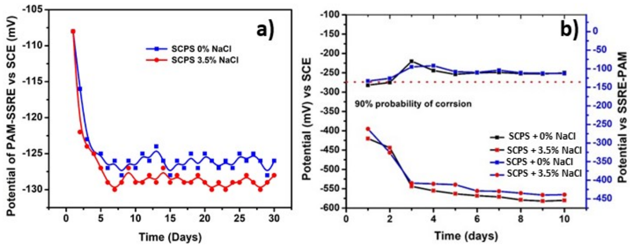

Figure 1. Stability test for SSRE-PAM (a) and OCP results for the STR (b) in the SCPS with 0 and 3% NaCl

3.2 Monitoring the steel rebar corrosion

The OCP and potentiodynamic polarization test for the STR immersed in the SCPS with 0 and 3.5% NaCl were monitored by SCE and SSRE-PAM. The obtained results are shown in Figure 1(b). It can be seen from Figure 1(b) that the fabricated SSRE-PAM can easily differentiate the passive and active status of the steel rebar in the SCPS with 0 and 3.5% NaCl. Further, the corrosion kinetic parameters obtained from polarization studies are given in Table 1. It can be seen from Table 1 that the corrosion potential (E_{corr}) values of the STR in the SCPS with 0 and 3.5% NaCl were -246 mV, -557 mV for SCE and -100 mV and -395 mV for SSRE-PAM, respectively. These results confirm that the fabricated SSRE-PAM can predict the passive and active status of the steel rebar in the SCPS with 0 and 3.5% NaCl.

Table 1. Potentiodynamic polarization parameters for STR immersed in SCPS with 0 and 3.5% NaCl vs SCE and SSRE-MnO_2

System	vs. SCE		vs SSRE-PAM	
	E_{corr} (mV)	I_{corr}($\mu A/m^2$)	E_{corr} (mV)	I_{corr} ($\mu A/m^2$)
SCPS + 0% NaCl	−246	8.761	−100	8.589
SCPS + 3.5% NaCl	−557	22.999	−395	22.154

4. Conclusions

The stability behavior of fabricated SSRE-PAM was tested in the SCPS with 0 and 3.5% NaCl. The stability of SSRE-PAM is not affected by chloride ions in SCPS.

The OCP measurement and polarization studies confirm that the fabricated SSRE-PAM can identify the passive and active status of the STR in concrete environments. Hence, the PANI-MnO_2 can be used as a candidate material for monitoring the corrosion status of STR in concrete environments

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