3.5% NaCl을 함유한 혼합 시멘트 추출물에서 철근의 부식에 관한 연구

Studies on the corrosion of steel rebar in blended cement extracts containing 3.5% NaCl

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Abstract

An attempt has been made on a constructive approach to evaluate the performance of snail shell ash (SSA) for its corrosion performance under marine environments. Corrosion performance of steel rebar in chloride contaminated SSA with (0% to 50%) replacement levels of cement extract medium was examined through electrochemical and weight loss techniques. Initially, snail shell powder (SSP) is made by pulverizing and subsequently SSA is by thermal decomposition methods. A critical level of 20 % SSA improved both corrosion resistance properties of cement extracts. SSA is a suitable replacement material for natural limestone in cement productions.

키 워 드 : 강화부식, 달팽이 껍질, 내식성
Keywords : reinforcement corrosion, snail shell, corrosion resistance property

1. Introduction

Ordinary Portland cement (OPC) is one of the essential ingredients for concrete production, which is one of the second most used materials in the world next to water [1]. Because, every country is increasing the infrastructure for global urbanization, thus increasing the demand of the cement for the construction industry every day. The worldwide cement production is approximately 4.4 million metric tons in 2020 [2], which is set to increase by 12-23% by 2050 from the present level [3]. Commonly, 1.5 to 1.8 tonnes of natural limestone and 0.4 tonnes of clay were used for each tone of cement productions [4], which is reducing the natural resource and also around 5-8% of CO^2 was emitted from the cement industry [3]. Therefore, considering the environmental sustainability and life of future generations, the cement industry is reducing the consumption of natural limestone by using various industrial and agricultural waste materials (supplementary cementitious materials) as partially reducing the cement content in construction. Hence, in this study, the corrosion performance of steel rebar in chloride contaminated cement containing various replacement levels of SSA extracts (0, 10, 20, 30, 40, and 50% of SSA) were examined by electrochemical methods and gravimetric weight loss methods.

2. Materials and Method

In the present investigation, ordinary Portland cement (OPC) and thermomechanical treated (TMT) steel rebars were used. and the composition of the TMT steel rebar used were (wt%): 98.425% Fe, 0.240 % C, 0.040% Cr, 0.030% Ni, 0.950% Mn, 0.010% Mo, 0.020% Cu, 0.001% Sn, 0.016% P, and 0.008% S. The cement extracts were prepared at different replacement levels of OPC by SSA namely 0%, 10%, 20, 30, 40, and 50%. For example, the 10% SSA with cement extract solution was prepared by 90g of OPC+10% of SSA (i.e., cement replaced with 10% of SSA), then 100ml of distilled water was added to the above mixture and shaken vigorously using a mechanical shaker for 2 hrs. The potentiostat (VersaSTAT Princeton Applied Research, Oak Ridge, TN, USA) was used for electrochemical impedance spectroscopy (EIS) and The gravimetric weight loss measurements were performed as per ASTM G1−03 standard.

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3. Result and Discussions

3.1 Electrochemical Impedance Studies

Figure 1(a) relates the impedance curves for steel rebars in various cement extracts for an exposure period of 1 and 30 days. It was observed from Figure 1(a) that, the impedance values for the systems namely 0, 10, 20, 30, 40, and 50% of SSA with cement extracts were 2097, 2201, 2281, 1924, 1875, and 1410 Ω.cm2, respectively for the initial (1day) exposure. All the systems reduced the impedance values towards a low direction at the end of 30 days of exposure indicating the active condition of steel rebars suggest the initiation of corrosion phenomena on the steel rebar/solution interface. However, the steel rebars immersed in the cement replaced with 20% of SSA system showed more impedance values when compared to other systems. It was concluded from the electrochemical impedance studies that the optimum cement replacement level of up to 20% of SSA is sufficiently suitable for better durability of the reinforced concrete structures under marine environments.

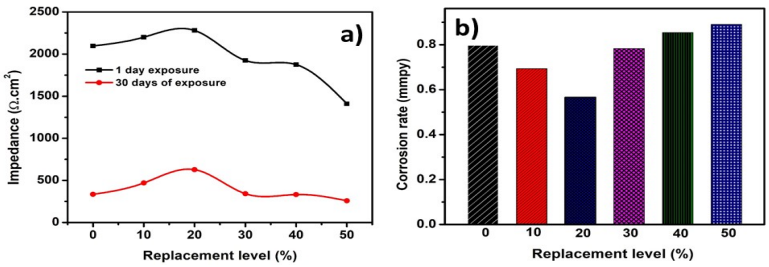

Figure 1. Corrosion studies: (a). Electrochemical impedance and (b). Gravimetric weight loss methods

3.2 Gravimetric weight loss method

It was observed from Figure 1(b) that, the corrosion rates of steel rebars immersed in chloride contaminated cement extract with 0, 10, 20, 30, 40 and 50% of SSA were 0.7973 mmpy, 0.6937 mmpy, 0.5655 mmpy, 0.7833 mmpy, 0.8536 mmpy, and 0.8907 mmpy, respectively. The steel rebar immersed in cement replaced with 20% of SSA showed a lesser corrosion rate when compared to all other systems.

4. Conclusions

The electrochemical test and weight loss measurements confirmed that up to a critical replacement level of 20% SSA improved the corrosion resistance of concrete. It was concluded that the animal origin from the marine was found to be a sustainable engineering material for construction industries and also for the marine environment. SSA is a suitable replacement material for natural limestone in cement productions.

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