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Study of pitting resistance of rebar steels in Jakarta coastal using simulated concrete pore solution

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Abstract

Carbon steels are generally used to a reinforcement in the concrete constructions, such as bridges, piling, etc. These constructions are not a bit placed in the coastal areas, especially the coastal area of Jakarta. The industrial activities and urban development were a source of sediment loads and pollutants in coastal sea water Jakarta. The presence of chloride content and pollutants in sea water could affect the process of corrosion of reinforcement steel in concrete especially pitting corrosion. In this paper, the behavior of pitting corrosion of reinforcement steel in sea water of Jakarta coastal using simulated concrete pore solution has been studied. The sea waters were taken from two different locations of Jakarta coastal, Ancol beach and Muara Baru fishing port. Each of the sea water was used as a solvent in the simulated concrete pore solution with or without carbonates. The simulated concrete pore solution with chloride was also utilized for comparison test. The cyclic and potentiostatic electrochemical polarization were conducted to evaluate the behavior of pitting corrosion of reinforcing steel. The experimental results showed that the reinforcing steel was susceptible to pitting corrosion in the simulated concrete pore solutions (SPS) of sea water with or without carbonates and in the simulated concrete pore solutions containing 3.5% NaCl. The addition of sodium carbonate and sodium bicarbonate in SPS of sea water increased the breakdown potential value and the total time for the metastable pitting decreased slightly.

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Keywords: Reinforcing steel; pitting corrosion; jakarta coastal sea water; simulated concrete pore solution; carbonates.

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1. Introduction

Corrosion of reinforcement bar (rebar) steel in concrete is the main factor causing premature damage to the concrete construction, especially the concrete structure of the coast [1]. It could initiate cracks and accelerate the corrosion process in concrete. The delamination and spall also affect decreased durability, rigidity and the service life of concrete structures [2-4]. In addition, the carbonation is another important phenomenon which caused corrosion of reinforcement steel in concrete and reduces the durability of concrete structures [5] caused by the diffusion of CO_2 into the concrete. If it reacts with the hydrated cement compound, the pH of concrete reduces from pH 13 to pH 9 causing to the passive film of steel and accelerated the corrosion process [6]. Additionally, the environmental climate conditions and climate change also contributed directly or indirectly to the corrosion rate of reinforced concrete structures [7-10]. Experimental evidence indicated that the intrusion of chloride and carbonation were strongly influenced by climate conditions and the surrounding environment, the atmospheric CO_2 concentration, temperature and humidity [11].

The penetration of chloride from sea water into concrete and the associated risk for reinforcement corrosion were divided into an initiation phase and a propagation phase. The initiation phase describes the ingress of chloride during the wetting/drying concrete and terminated by depassivation of the reinforcement. Then, the increasing of chloride content is required to prevent repassivation and to enable stable pit growth [12]. The stable pit growth called by pitting corrosion of steel in concrete is also affected by the pH, temperature, microstructure and composition of the concrete-steel interface, and composition and surface of the steel in concrete [13].

According to the World Resources Institute, in 2011, the greenhouse gas emitter of 2,053 billion tons produced by Indonesia was ranked sixth after India and Russia [14]. The higher greenhouse gas emitter in Indonesia's air reduced sustainability of reinforcement concrete (RC) structure. For achieving environmental friendly sustainable RC structure, Rajit et al [15] used photo catalytic materials to the RC structure during its construction phase that could reduce the corrosion problem of RC materials.

The present paper reports the pitting resistance of rebar steels exposed in the simulated concrete pore solution (SPS) containing the Jakarta coastal sea water with or without carbonates. For comparison, the distilled water SPS with chloride also utilized in this study. The results of the study may be used to assess the sustainability of RC structure in the Jakarta's coastal.

2. Experimental

2.1. Specimen Preparation

The specimens with a surface area of 1.13 cm^2 for the polarization measurements were cut from the rebar steel using cutting machine, connected with copper wire as an electrical contact and mounted with resin to cover the unexposed area. The specimens were polished with SiC paper from grit 400 to 1200 grit. The specimens were then washed in distilled water. The chemical composition of rebar steel is shown in Table 1.

Table 1. Chemical composition of reinforcing steel

Chemical composition (wt%)									
C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Fe
0.37	0.23	0.54	0.03	0.04	0.14	0.06	0.15	0.013	Bal.

The polarization measurement used three electrodes, the specimens as working electrode, graphite rod auxiliary electrode and saturated calomel electrode (SCE) as reference electrode.

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