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Properties of plain and blended cement concrete immersed in acidic peat water canal

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Abstract

Reinforced concrete structures exposed to the acidic environment, such as acidic soil, agricultural building, industrial acid, are unavoidable in practice. Structures and infrastructures in acidic environment are usually have durability problems related to degradation of concrete cover and corrosion of steel reinforcement. Acidic soil such as peat, contains organic humic acids that can retard cement hydration process, and potentially reduce the concrete integrity after continuous exposed to the environment. This research is aimed to investigate concrete degradation when subjected to peat water by direct field exposure in water canal. The specimens were made from Ordinary Portland Cement (OPC), Portland Composite Cement (PCC) and OPC replaced with 10% (by cement weight) Palm Oil Fuel Ash (OPC POFA). Those plain and blended cement specimens were cast and cured in water pond in laboratory, then immersed in peat water canal up to 120 days. Compressive strength, tensile strength and porosity of specimens were measured at 28, 91 and 120 days. After 120 days of immersion, compressive and tensile strength reduction, and porosity increase were seen for the OPC specimens. The PCC and OPC POFA specimens performed a gradual increase in both compressive and tensile strength, and reduction of porosity with the exposure period. The results indicated that cement type had significant effect on concrete properties exposed to the peat water directly. The test results showed that the PCC samples are more chemically resistant to acid attack in peat water, followed by the OPC POFA samples and finally the OPC samples after subjected to acidic peat water canal.

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Keywords: acid; canal; palm oil fuel ash; pozzolanic material; strength.

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1. Introduction

Concrete in aggressive environment, such as acid is usually prone early degradation due to harmful ions attack on cement matrix. This is due to calcium binding by the acid ions in the cement matrix that lead to deterioration of concrete. Previous studies confirmed that the acidic resistance of concrete is determined by type, cement composition, pH, aggregate type, and inclusion of pozzolanic materials in cement mixture [1−2]. There are several methods to improve the concrete properties in aggressive environment such as reducing water to cement ratio, using high performance coatings, using water reducing admixture, improving compaction, producing special mortars, controlling curing and incorporating pozzolan in the cement. Inclusion of pozzolanic materials such as slag, fly ash (FA), rice husk ash, and palm oil ash (POFA) as cement replacement in concrete was reported beneficial to improve the acid resistance of cement at late curing ages by forming CSH through pozzolanic reaction to reduce porosity, refine microstructure and enhance the mechanical properties [3−6].

The effect of acid attack to reinforced concrete structures and infrastructures in peat environment, such as concrete pipes, waterways, foundation piles that are exposed directly to the peat water has recently been of concern due to possible premature reduction of the structures service life. Peat is characterized by its high water and organic matter content from decomposition plants in water logged areas for a very long time. The organic content contains acids that has low pH (3-5). Concrete in that environment usually is vulnerable to acid attack since the pH of medium is extremely acidic and can lead to premature deterioration of concrete, reduction of structural integrity, and high cost for maintenance and repair [7].

Many studies about interaction between cement and humic acid in peat soil were conducted in the last few decades to determine suitable materials for peat soil stabilization. A study about peat stabilization using cement has reported that the organic peat acid could disturb the cement hydration process and delay any strength gain of the stabilized ground [8]. Another study explained that the reaction between cement and water in peat will still produce portlandite or $Ca(OH)_2$ and Calcium Silicate Hydrate (CSH) gels at slower rate than normal cement hydration process. This is because the reaction between the humic acids in peat with portlandite or $Ca(OH)_2$ in cement matrix forming insoluble products which precipitate out the clay particles. The insoluble products will delay the cement early strength gain, and inhibit the subsequent pozzolanic reactions [9]. This condition reflects on how the humic acid will attack the concrete hydration product for cast in situ concrete. There were two studies about the impact of peat water acidity in mortar and concrete exposed directly to peat water in laboratory condition [10−11]. In those research, the plain and blended cements were immersed in water from peat swamp. Those initial studies have concluded that the specimens made using blended cements performed better resistance to the peat water than the OPC (Ordinary Portland Cement) control specimens. However, concrete properties that is exposed directly to the peat water has never been reported yet. This research is aimed to study to study the compressive strength, tensile strength, and porosity of the specimens made from plain (OPC) and blended cements (PCC and OPC POFA) binders that were directly exposed to the acidic peat water canal.

2. Materials and method

In this study, the concrete specimens were manufactured using a plain cement (Ordinary Portland Cement-OPC), and blended cements, namely (Portland Composite Cement-PCC) and OPC-Palm Oil Fuel Ash (OPC POFA), aggregates and water. Fine aggregates were river sand with specific gravity of 2.69, fineness modulus of 1.90, and water absorption of 2.24%. Coarse aggregates had specific gravity of 2.72 and water absorption of 2.64%. The type I OPC was used as a control mix, while the PCC is a new type of cement produced to replace the type I cement commercially. The OPC POFA concrete consisted of 10% POFA by cement weight. The palm oil ash was taken from a local incinerator. The ash was dried and sieved using sieve #200. The chemical composition of OPC, PCC and POFA are summarized in Table 1.

The physical and chemical composition of the peat water from Rimbo Panjang, Riau Province are listed in Table 2. The analyzed parameters were color, turbidity, organic content, alkalinity, sulfate and chloride ions, and organic impurities (manganese and iron). From the table, it could be seen that some basic properties of peat water, except manganese, sulfate and chloride ions, were not within tolerable limits of drinking water. Peat water had pH of 3.85, which was acidic than the required pH for drinking water (6.5-8.5). The organic content of peat water was 328