Effects of Aggressive Ammonium Nitrate on Durability Properties of Concrete using Sandstone and Granite Aggregates

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***Abstract*—**The storage of chemical fertilizers in concrete building often leads to durability problems due to chemical attack. The damage of concrete is mostly caused by certain ammonium salts. The main purpose of the research is to investigate the durability properties of concrete being exposed to ammonium nitrate solution. In this investigation, experiments are conducted on concrete type G50 and G60. The leaching process is achieved by the use of 20% concentration solution of ammonium nitrate. The durability properties investigated are water absorption, volume of permeable voids, and sorptivity. Compressive strength, pH value, and degradation depth are measured after a certain period of leaching. A decrease in compressive strength and an increase in porosity are found through the conducted experiments. Apart from that, the experimental data shows that pH value decreases with increased leaching time while the degradation depth of concrete increases with leaching time. By comparing concrete type G50 and G60, concrete type G60 is more resistant to ammonium nitrate attack.

***Keywords*—**Normal weight concrete durability, Aggressive Ammonium Nitrate Solution, G50 & G60 concretes; Chemical attack.

I. Introduction

CONCRETE is an economical construction material which is employed in a wide variety of applications on the ground, underground, and under sea level. It is used in foundations, pavements, storage tanks, piles, buildings, dams, and other structures. Durability, compressive strength, impermeability, abrasion resistance, and resistance to environment attacks are important properties of concrete. Durability is the capacity of concrete to resist deterioration from heating and cooling, freezing and thawing, and action by chemicals such as fertilizers. Concrete that is durable requires the integration of design, materials, and construction. It depends on the materials used, full compaction, and adequate curing [1]. Concrete exposed to aggressive environment lead to deterioration of concrete. Chemical fertilizer plant is considered as aggressive environment. Different types of fertilizers will attack concrete and heavily damage it. Factors that affect the susceptibility of concrete to damage include chemical composition of its ingredients and physical factors such as porosity, density and permeability at the time of its exposure to corrosive agents. However, the maximum damage of concrete is reported to be caused by ammonium salt.

Ammonium nitrate causes dissolution of cement-based materials through the reaction between ammonium nitrate and calcium hydroxide in the cement paste. The reaction is expressed in (1):

$$2NH_4NO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)_2 + 2NH_3 + 2H_2O \quad (1)$$

The reaction between ammonium nitrate and concrete was reported as potentially aggressive. Due to the removal of calcium hydroxide, the hardened cement paste will be decalcified causing the pH value to decrease [2]. The reaction yields calcium nitrate and ammonia, both of which are easily water-soluble. Subsequently, an expansive calcium nitro-aluminate is formed by reaction between calcium nitrate and hydrated aluminates from the cement paste [3]. Lea [4] reported that this compound forms "climbing salts" by the transportation of water from humid to dry surface. The concrete is weakened through the leaching of lime in cement paste. This eventually leads to cracking on the concrete surface. The deterioration of concrete reduces the effectiveness of concrete as protective cover for steel reinforcement. The steel reinforcement will be corroded, leading to spallation of concrete [2].

The durability of concrete subjected to aggressive environments is affected by transport properties, which are influenced by the pore system [5]. Major factor influencing the durability is the permeability of the concrete. Permeability allows the ingress of oxygen, carbon dioxide, water, and other deleterious substances into the concrete. Permeability should be kept to the minimum level by using sufficient cement contents, low water/cement (w/c) ratio, adequate compaction and sufficient hydration of the cement through appropriate curing methods [6].

II. Experimental Details

A. Materials for Concrete Mixtures

Cement

The cement used conforms to the requirements set under ASTM C-150 [7], Type 1 Ordinary Portland Cement.

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