Sulphate Resistance of Concrete Containing Silica-Fume

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Abstract- **The principal objective of this paper is to investigate the durability of silica fume concrete to obtain more information which will contribute to a better understanding to the use of silica fume with local aggregate materials (Basrah governorate) in the different concrete mixtures exposing to internal and external sulphate, then study the properties and durability of these mixtures. The experimental study were conducted on (100 mm) concrete cubes containing silica fume with replacement ratio of (5%, and 10%) by weight of cement. The test solutions used to supply the sulphate ions and cations were 5% sodium sulphate solution, 5% magnesium sulphate solution, and 10260 ppm sulphate in ground water. Tap water was used as the reference solution. compressive strength was used to assess the changes in the mechanical properties of concrete specimens exposed to sulphate attack along duration of 360 days. The test results showed that silica fume concrete (10% silica fume replacement) exhibit good durability with respect to sodium sulphate and ground water solutions, on the other hand, it exhibit bad resisting in magnesium sulphate solution exposure. While silica fume concrete (5% silica fume replacement) showed good sulphate resisting in all test solutions. The test results also showed that the w/(c+s) ratio is the most important parameter influencing in resisting of concrete to sulphate attack.**

Keywords- **External Sulphate attack; Silica fume; Ground water, Sodium and Magnesium Sulphate Solution; Internal Sulphate; Compressive Strength Loss.**

I. INTRODUCTION

Sulphate can attack concrete by reacting with hydrated compounds in the hardened cement paste. These reactions can induce sufficient pressure to disrupt the cement paste, resulting in disintegration of the concrete (loss of paste cohesion and strength). The deterioration of concrete due to sulphate attack is considered a complex problem [1]. Excessive amounts of sulphates in soil or water can attack and destroy a concrete that is not properly designed.

Sodium sulphate reacts with calcium hydroxide and calcium aluminates hydrate forming ettringite and gypsum. Magnesium sulphate attacks in a manner similar to sodium sulphate and forms ettringite, gypsum, and also brucite (magnesium hydroxide). Brucite forms primarily on the concrete surface; it consumes calcium hydroxide, lowers the pH of the pore solution, and then decomposes the calcium silicate hydrates[2]. The chemical reactions associated with Sulphate attack are as follows [1]:

$$Na_2SO_4 + Ca(OH)_2 + 2H2O \Rightarrow CaSO_4.2H_2O + 2NaOH \quad \ldots\ldots(1)$$

$$MgSO_4 + Ca(OH)_2 + 2H_2O \quad MCaSO_4.2H_2O + Mg(OH)_2 \quad \ldots\ldots(2)$$

$$3CaO.Al_2O_3.12H_2O + 3(CaSO_4.2H_2O) + 13H_2O \quad M\Rightarrow 3CaO.Al_2O_3.3CaSO_4.32H_2O \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$MgSO_4 + C\text{-}S\text{-}H \quad M \quad CaSO_4.2H_2O + M\text{-}S\text{-}H \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Many experimental studies have carried out to explain the sulphate attack and the role of silica fume on resisting of concrete deteriorations. All these investigations emphasize that in order to understand the deterioration of concrete due to sulphate attack, it is necessary consider the type of the accompanying cation as well as the degree of concentration of the sulphate solution[3].

Concrete exposed to sodium sulfate solution, durability of concrete is enhanced by addition of silica fume (Mather 1982, Mehta 1985, Hooton 1993, Cohen and Bentur 1988, Lee et al 2005) [4, 5]. The good resistance of silica fume to sodium sulphate solution is due to the filler action of silica fume because of its fine particle size, and the pore refinement process occurring due to the conversion of portlandite into C-S-H gel, through strong pozzolanic reaction [6].

In high concentrations of magnesium sulphate silica fume impaired the concrete performance(Cohen and Bentur 1988, Torri and Kawamura 1993, and Lee et al 2005) [3, 5, 7]. SF reduces calcium hydroxide availability due to the pozzolanic reaction and allows the magnesium sulphate to more easily attack the C-S-H, leading to decalcification, M-S-H formation and destruction of the cement bond [5].

In this study, the effect of silica fume in concrete attacked by ground water, sodium sulphate, and magnesium sulphate was investigated. The experimental study was developed to obtain conclusive data on any effects of using silica fume with local materials (Cement, sand, and gravel) in internal and external sulphate environments.