DURABILITY OF THE SLAG RICH CEMENT PASTES IN SOME AGGRESSIVE MEDIA

BY

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A Thesis Submitted for Doctor of Philosophy
in
Science (Ph.D.), Chemistry

Department of Chemistry-Faculty of Science
Cairo University

2010

APPROVAL SHEET FOR SUBMISSION

Title of (Ph.D.) Thesis : "DURABILITY OF THE SLAG RICH CEMENT PASTES IN SOME AGGRESSIVE MEDIA "

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ACKNOWLEDGMENT

First of all, thanks and indebtedness are presented **ALLAH** that this work has been completed .

I did not find words to express my deep appreciation and gratitude to **Prof Dr. Hamdy El-Didamony (D.Sc)** Professor of Inorganic Chemistry, Faculty of Science, Zagazig University, for all authentic scientific guidance, starting from suggesting this work , continuous supervision, great support and encouragement in performing this work .

I wish to express my sincere thanks and appreciation to **Prof. Dr . Amin Mahmoud Baraka** Professor of Inorganic Chemistry, Faculty of Science, Cairo University, For his continued interest, helpful supervision, valuable assistance, useful cooperation and continuous supervision during this work .

Finally, a special word of thanks is directed to every body in Quality Control Department Company, Suez Plant, for all those participating in increasing my knowledge .

ABSTRACT

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Title of thesis : Durability of the Slag Rich Cement Pastes in Some Aggressive Media
Degree : Philosophy Doctor of Science (Ph.D.) Thesis , Faculty of Science – Cairo University , 2010 .

This study aims to utilization of two types of Imported and Egyptian granulated blast-furnace slag with Portland cement to produce slag rich cement and preparation of different blended cement from these tow types of slag with limestone. In general the hydraulic activity of Imported granulated slag is higher than Egyptian one. The blending of Imported and Egyptian granulated slag cement pastes with limestone develops strength gradually in fresh water due that the addition of limestone filler increases the rate of hydration and improves the compactness of composite cements .The durability of various slag rich cement pastes, prepared from different mixes of Imported-Egyptian granulated slag with ordinary Portland cement (OPC) as well as sulphate resisting cement (SRC), in seawater as an aggressive medium was studied. The various pastes are pre-cured in tap water for 28 days , then immersed in seawater for different periods between zero (28-days) and 12-months. The results showed that blending of Imported-Egyptian granulated slag in the slag rich cement pastes increases the resistance to chemical attack. The durability of slag rich cements made with different amounts of Imported and Egyptian slag with ordinary Portland cement (OPC) and limestone in comparison with sulphate resisting cement (SRC), in seawater as an aggressive medium were studied. The granulated slag-limestone cement pastes give lower sulphate and total chloride contents than sulphate resisting cement (SRC) and also, the decrease in compressive strength is not sharp as expected but is very low .From the results it can be concluded that the Imported and Egyptian granulated slag-limestone cement are suitable for all uses and the Imported and Egyptian granulated slag are more suitable in the preparation of slag rich cement for using in seawater structures than only sulphate resistance cement (SRC) .

Key words : Ordinary Portland cement, sulphate resisting cement, granulated slag, limestone, slag rich cement, seawater, aggressive media.

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1 - INTRODUCTION

1.1. Introductory Remarks

The name Portland cement is given originally due to resemblance of the color and quality of set cement to Portland stone (England). Portland cement clinker is manufactured by mixing finely ground calcareous (like limestone) and argillaceous (such clay) materials that can be done either in water or in dry conditions, hence the name "Wet" or "Dry" processes. The mixture is burned to very high temperature up to 1450 ^0C, that undergoes chemical reactions in a rotary kiln to give clinker . The cooled clinker is ground to a very fine powder in a ball mill with 4-6 % of gypsum as a setting regulator.

The Portland cement clinker oxides are mainly of CaO, SiO_2, Al_2O_3 and Fe_2O_3. These four oxides account for approximately 95 % of the chemical composition of a typical Portland cement clinker. The main phases exist in the Portland cement clinker are Tricalcium silicate, $3CaO.SiO_2(C_3S)$ "Alite", β-Dicalcium silicate, β-$2CaO.SiO_2(C_2S)$ "Belite", Tricalcium aluminate, $3CaO.Al_2O_3$ (C_3A) and Tetracalcium aluminoferrite, $4CaO.Al_2O_3.Fe_2O_3$ (C_4AF). Approximately 70-80 % of the clinker consists of C_3S and β-C_2S phases **[1,2]**

1. 2. Portland Granulated Blast-Furnace Slag Cement

Portland blast-furnace slag cement is made by intergrinding clinker, granulated blast furnace slag and gypsum . It is a mixture of Portland cement and granulated blast-furnace slag containing not more 65 % of granulated slag . The hydration of Portland granulated slag cement is more complex than that of Portland cement, since both constituents react with water. No hydration products can be observed when ground granulated slag is placed in water due to the formation of acidic films as small amount of Ca^{2+} ions is released into the solution. In a calcium hydroxide solution, the hydration reaction occurs removing this film and continued hydration, as the lime breaks into the silica framework of the slag, takes place. It was formerly considered that little combination occurred between lime in solution and the slag, but later work has shown that there is a progressive take-up of lime and that the hydration products are richer in lime than the slag **[2]** .

Timashev and Konzhemyakin [3] found that the hydration and hardening of Portland cement and Portland slag cement containing 30 % granulated slag accelerated by the addition of 3 % $CaCO_3$ or $MgCO_3$ during grinding. A significant increase in compressive strength was attributed to the formation of a dense microstructure and the crystallization of calcium silicate hydrate with highly polymerized silicate anions.

Frigione and Sersale [4] correlated the chemical composition of Portland cement clinker with the compressive strength of Portland slag cements. The results showed that the main constituents of Portland cement clinker do not influence mainly by the alkalis in the clinker fraction . Alkalis accelerate the strength development of the slag fraction but retard the strength of the clinker fraction. These opposing effects determine the overall strength of Portland slag cement, i.e. at medium and long ages the strength contribution by the clinker fraction of the cement is negatively(undesirable) affected by the alkalis content, whereas that of the slag fraction is positively(desirable) affected.

Cook et al., [5] used two Australian slags to make blended cements containing 20 to 80 % slag. The heat of hydration , strength and microstructure of hydrated cements were investigated. The results indicated that although the strength rates of blended cements were slower than the Portland cement. The formation of ettringite which was mainly responsible for early strengths, was influenced by the slag reactivity and the sulphate content of the cement. At later ages, C-S-H with a low C/S ratio was the dominant for a very dense microstructure.

Talero [6] demonstrated that the formation rate of ettringite from granulated blast-furnace slag is notably higher than that from Ordinary Portland Cement(OPC). Also, the topochemical mechanism of the ettringite formation can proceed when all the necessary reactive materials, including the "reactive alumina," Al_2O_3 "aluminate anion" or "amorphous alumina" are in the solution.

The heat of hydration of cement is of great importance to civil engineers. **Alshamsi [7]** found that granulated slag (reduced the temperature rise in cement paste. Also, it had clear effect on the time needed to reach the peak temperature and delayed the arrival time at peak temperature.

Blended cement pastes and mortars incorporating ground slag powder were tested for strength and mercury intrusion **[8]**. The results indicated that the porosity and pore size distribution of the pastes were improved because of the more complete hydration of the slag. In addition, the strength of the mortars increased and had good correlation with the hydration degree of the slag powder.

Hill and Sharp [9] reported the hydration products of three composite cement pastes, Portland cement mixed with 75 % and 90 % ground granulated blast furnace slag (GBFS) and 75 % pulverised fuel ash (PFA), and compared with 100 % ordinary Portland cement (OPC) paste. The hydration products were identified by means of (XRD) and their microstructure by (SEM). The results showed that