Cement and Concrete Research 41 (2011) 913–919

Contents lists available at ScienceDirect

Cement and Concrete Research

journal homepage: http://ees.elsevier.com/CEMCON/default.asp

Influence of the clinker SO_3 on the cement characteristics

Sayed Horkoss [a,b,*], Roger Lteif [a], Toufic Rizk [a]

[a] Saint Joseph University, Faculty of Sciences, Campus of Sciences and Technologies, Mar Roukos. Mkallès, P.O Box. 11-514 Riad El Solh, Beirut 11072050, Lebanon
[b] Cimenterie Nationale S.A.L., Plant-Laboratory Department, Old Tripoli Road, Chekka, North Lebanon. P.O. Box.11-5101 Riad El Solh, Beirut 11072180, Lebanon

ARTICLE INFO

Article history:
Received 26 July 2010
Accepted 27 April 2011

Keywords:
Strength development rate
Sulfate resistance
Clinker SO_3

ABSTRACT

This paper aims to clarify the influence of the clinker SO_3 on the cement characteristics. The impact on the strength development rate and the level of sulfate resistance were studied .The results show that increasing the amount of clinker SO_3 at low alkali level reduces the percentages of the tricalcium aluminate (C_3A) and alite as well as the alite/belite ratio, leading to a modification in the cement quality.
For these reasons cements produced from a clinker containing high sulfate and low alkali, have slower strength development and higher sulfate resisting level than that produced with low sulfate clinker.

1. Introduction

Portland cement clinker is a hydraulic material composed mainly of tricalcium silicate (C_3S), dicalcium silicate (C_2S), tricalcium aluminate (C_3A) and tetracalcium aluminoferrite (C_4AF). The abundance, size, reactivity and distribution of these phases are affected by complex interactions between the heating and cooling regime as well as the raw feed characteristics such as chemical and mineralogical composition, particles size distribution and homogenization.

The clinker nodules are ground with gypsum, which serves to control setting, to a fine powder named Portland cement.

The amount of cement SO_3 comprises the clinker SO_3 and that added during clinker grinding. In ordinary Portland cement clinker the SO_3 is usually below 1%. During the past years, the thermal valorization of industrial wastes, tires and solvents as well as the usage of high-sulfur fuel in the cement kilns have gained ground. This change has increased the sulfate levels in Portland cement clinker, which affects the chemical, mineralogical, physical and mechanical characteristics of the clinker and cement.

The objective of this paper is to evaluate the rate of strength development and the level of sulfate resistance for cements produced with high SO_3 clinker at low alkalis level.

2. Experiment and methods

Thirteen clinker samples were sampled during the production process at Cimenterie Nationale SAL. Based on the ASTM C150 requirements, the types of cement clinker samples were: Twelve moderates sulfate resistance (type II, the calculated $C_3A<8\%$) and one (number 6) high sulfate resistance (type V, the calculated $C_3A<5\%$). The clinker sulfate variation, in the type II clinker, was done by changing the fuel type from fuel oil (2% S) to petroleum coke (4.5 to 6% S).

In order to minimize the interaction of other factors with the influence of clinker sulfur on the clinker phases, the following parameters were monitored (Table 1):

1. The aluminum module in the Type II clinker was fixed at 1.2 ± 0.05 and that of type V at 1.1.
2. The SM was fixed at 2.40 ± 0.04.
3. The variation, in the percentages of P_2O_5, TiO_2, MgO, was controlled.
4. The percentages of alkalis were assured in the lowest level.

Due to the very low burnability of the kiln feed, the clinker was produced without any addition of fluxes or mineralizes. The sampling was done under stable kiln operation. The percentage of kiln inlet oxygen was maintained between 2 and 3%. The free lime of the clinker was $\leq 1\%$.

The clinker samples were crushed and ground in the laboratory mill. The evaluation of cement characteristics was done using the following standards:

1. ASTM C114 for the determination of the chemical composition. The chemical analysis was done using ARL 9800 – XRF machine, calibrated by NIST standard samples. The Claiss machine was used for samples preparation.
2. ASTM C1365 for the determination of the proportion of phases in Portland-cement clinker using X-Ray Powder. The ARL X'TRA Diffractometer with Copper tube, using Rietveld method was used.
3. ASTM C1356 for the evaluation of the clinker phases in clinker by microscope. The optic microscope (ZEISS – Axioskop 40) and the

* Corresponding author at: Cimenterie Nationale S.A.L., Plant-Laboratory Department, Old Tripoli Road, Chekka, North Lebanon. P.O.Box.11-5101 Riad El Solh, Beirut 11072180, Lebanon. Tel.: +961 3381527.
E-mail address: shorkoss@gmail.com (S. Horkoss).

0008-8846/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.cemconres.2011.04.015