

Characteristics of cement pastes containing sulphoaluminate and belite prepared from nano-materials

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HIGHLIGHTS

- Substitution of OPC with $C_4A_3\bar{S}$ or $C_4A\bar{S}$ + β -C₂S tends to shorten the setting times.
- The fast setting of cement pastes is due to the formation of Aft and AFm.
- Substitution of OPC with $C_4A_3\bar{S}$ or $C_4A\bar{S}$ increases the chemically combined water.
- The addition of $C_4A_3\bar{S}$ or $C_4A\bar{S}$ with belite decreases the free portlandite.
- Pastes containing $C_4A_3\bar{S}$ or $C_4A\bar{S}$ give higher compressive strength.

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ABSTRACT

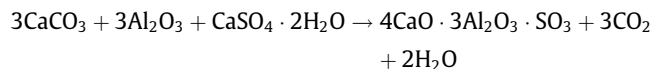
The sulphoaluminate phase $C_4A_3\bar{S}$ as well as β -C₂S represent an important factor for the preparation of rapid hardened sulphoaluminate–belite cement. The hydration of $C_4A_3\bar{S}$ forms ettringite and monosulphate hydrates in addition to the liberation of aluminium hydroxide. The hydration rate of belite is much slower than that of $C_4A_3\bar{S}$, but becomes significant at later ages. Two mixes containing sulphoaluminate ($C_4A_3\bar{S}$) and monosulphate mix ($C_4A_3\bar{S}$, with $8\bar{C}\bar{S}$ + $6\bar{C}$) in addition to belite (β -C₂S) were synthesized from nano-materials after firing at 1250 °C. The hydration characteristics of 10% $C_4A_3\bar{S}$ or 10% $C_4A\bar{S}$ in addition to 10% β -C₂S on the expense of OPC were studied. The results revealed that the substitution of OPC with sulphoaluminate mixes as well as belite shortens the setting times. The rate of hydration of OPC with sulphoaluminate–belite phases is increased from the formation of more sulphoaluminate hydrates and the consumption of portlandite. Also, these mixes give higher chemically combined water contents. The monosulphate hydrate is deposited in some of open pores in the dormant period of hydration that tends to increase the compressive strength of sulphoaluminate–belite cement pastes.

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1. Introduction

Calcium sulphoaluminate, $C_4A_3\bar{S}$, is an important phase for the rapid hardened sulphoaluminate cement. Its formation from molar mixes of the oxides of calcium, aluminium and sulphur derived from synthetic pure chemicals and commercial grade natural minerals, such as limestone, bauxite and gypsum have been studied. The degree of formation of $C_4A_3\bar{S}$ phase in the temperature range of 1100–1325 °C is comparatively higher from pure chemicals. This is due to increased solid state reaction between these oxides [1].

Calcium sulphoaluminate may be also, produced from a starting blend of an appropriate oxide composition by burning at a temperature of about 1250–1300 °C [2,3]:



The sulphoaluminate phase is stable up to about 1350–1400 °C. Its crystalline structure consists of a three-dimensional framework of AlO_4 tetrahedra sharing corners, with Ca^{2+} and SO_4^{2-} ions located in the existing cavities. It belongs to the tetragonal system. Above about 1350 °C this phase becomes unstable and starts to decompose [4]. The Al^{3+} within the structure of the $C_4A_3\bar{S}$ phase may be partially substituted by Fe^{3+} ions. The reactivity of this phase will decline with iron content in the crystalline lattice.

The hydration of $C_4A_3\bar{S}$ depends on whether calcium sulphate and calcium hydroxide are also present, and progresses at temperatures up to 75 °C [2,5,6]. In pure water $C_4A_3\bar{S}$ yields $C_4A\bar{S}H_{12}$ and AH_3 as products of hydration. Two mixes of $C_4A_3\bar{S}$ and $\bar{C}\bar{S}H_2$ yield ettringite alone, if mixed at a molar ratio of at least 1:2, and a combination of ettringite and monosulfate if the amount of gypsum is

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