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Structural investigation relating to the cementitious activity of bauxite residue — Red mud

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ABSTRACT

The cementitious behavior of red mud derived from Bauxite-Calcination method was investigated in this research. Red mud were calcined in the interval 400–900 °C to enhance their pozzolanic activity and then characterized in depth through XRD, FTIR and ^{29}Si MAS-NMR techniques with the aim to correlate phase transitions and structural features with the cementitious activity. The cementitious activity of calcined red mud was evaluated through testing the compressive strength of blended cement mortars. The results indicate that red mud calcined at 600 °C has good cementitious activity due to the formation of poorly-crystallized Ca_2SiO_4. The poorly-crystallized Ca_2SiO_4 is a metastable phase which will transform into highly-crystallized Ca_2SiO_4 with the increase of calcination temperature from 700 °C moving to 900 °C. It is the metastable phase that mainly contributes to the good cementitious activity of red mud. This paper points out another promising direction for the proper utilization of red mud.

1. Introduction

Red mud is an alkaline leaching waste with pH typically 10–12.5. It is generated during Bayer process or Bauxite-Calcination method for alumina production. The disposal of red mud has caused serious environmental problems due to its high alkaline content (Na_2O 2.0–6.0%). Red mud contains major oxides of CaO, SiO_2, Fe_2O_3, Al_2O_3, TiO_2 and Na_2O, and it can be used as an additive to cement, resulting in a good potential for the utilization of red mud in large quantities. The chemical and mineralogical compositions of red muds all over the world are widely different depending on the sources of bauxite, the technological process (Bayer process or Bauxite-Calcination method) and storing ages. However, as a main constitute, iron oxide is generally occurring in red mud, and it is distributed in mineral phases of hematite (Fe_2O_3) or/and goethite (FeOOH). These iron phases mainly control the color and settling properties of red muds [1]. Goethite can be transformed into hematite during a high-temperature calcination process, accompanying with the reinforcement of red color and increase of settling rate [1]. As source of iron oxide, red mud has been investigated in the production of special iron rich cement clinkers [2], or been used as a pozzolanic pigment for colored concrete [3].

Recently, replacing clinker by pozzolanic materials and using new alternative binders produced by industrial solid wastes have become a prime interest in cement industry with attempts to lower CO_2 emissions and decrease the production cost of cement. Some materials with good pozzolanic properties such as fly ash and slag can be utilized directly without heat treatment for the production of blended cement [4–7]. Whereas for other materials such as coal gangue and red mud, their aluminosilicate minerals are expected to be partially destructed and become less crystalline at a relatively higher temperature, so that their pozzolanic properties could be enhanced before being used for the preparation of blended cement [8–10]. Zhang et al. [11] investigated the correlation between silicate polymerization and cementitious activity of coal gangue calcined at different temperatures, and it has been found that phase transitions of clay minerals caused the silicate polymerization degree of coal gangue to change with the increase of temperature, and coal gangue calcined at 600 °C had good pozzolanic property due to the decomposition products of clay materials to form active silica and alumina. Several papers [12–16] have been written on the characterization of red mud through heat treatment. Sglavo et al. [12] carried out a detailed investigation on the thermal behavior of red mud, including phase transformations of the red mud sintered in air for 8 h within the interval 300–1400 °C. Srikanth et al. [13] studied the phase constitution during sintering of pure red mud and red mud–fly ash mixtures in the temperature range of 900–1250 °C. Jobbagy et al. [14] reported the dependence of radon emanation of red mud and red mud–sawdust on heat treatment in the temperature range of 100–1000 °C. Zhang and

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