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Reactivity of dealuminated kaolin and burnt kaolin using cement kiln dust or hydrated lime as activators

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HIGHLIGHTS

- DK has a much higher surface area than BK and SF, which exhibits much higher pozzolanic activity.
- Suspensions containing DK–CKD mixes possess lower values of free lime contents.
- DK has higher lime fixation ability than BK and SF.
- The microstructure of DK–BK–CKD mix displayed crumpled particles of CSH as the main hydration product.

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ABSTRACT

Pozzolanic activity of dealuminated kaolin (DK) and burnt kaolinite clay (BK) was studied using cement kiln dust (CKD) or hydrated lime (CH) as activators. The different solid dry mixtures made of DK–CKD, BK–CKD, DK–CH, BK–CH, SF–CKD and SF–CH were hydrated in the suspension form, while paste hydration was done using DK–BK–CKD mix. Chemically combined water and free lime contents were determined at various ages of hydration and the hydrated samples were characterized using DSC, XRD and FTIR techniques. Combined water contents of the blends containing DK activated with CKD or CH are higher than those of mixes containing BK and SF activated with CKD or CH. Evidently, the suspensions containing DK possess relatively lower values of free lime contents than those of mixes containing BK and SF; this is due to the higher pozzolanic activity of DK as compared to BK and SF. The results of DSC and XRD analysis of suspension hydrated samples indicated the formation and later stabilization of calcium silicates hydrates (CSH) and calcium aluminosilicate hydrates (C_3ASH_4 and C_2ASH_8) as the main hydration products in addition to free calcium hydroxide (CH), which is completely consumed at 12 h for mixes containing DK. Compressive strength and SEM examination were done for paste hydrated specimens made of mix IV (35% DK, 35% BK and 30% CKD) as an application. The microstructure of the hardened paste after 7 days of hydration displayed the formation of nearly amorphous and microcrystalline CSH products as well as rod-like crystals of ettringite with a partial filling of the available pore spaces of the hardened paste. On prolonged hydration the microstructure displayed crumpled foils and dense structure of tobermorite-like CSH as the main hydration product which deposited in the originally water-filled space; this kind of CSH product is mainly formed as a result of interaction of active DK and BK with CH of CKD.

1. Introduction

Environmental pollution, including the generation of waste by-products from different industrial sectors, is a serious problem in Egypt. These include: cement kiln dust (CKD), silica fume (SF) and dealuminated kaolin (DK) which is produced as a solid waste of ferric aluminum sulfate (ferric alum) industry. Our approaches are to use these by-products as building materials in Egypt. Kaolin clay materials contain the basic ingredients needed for the production of various types of catalysts including zeolites and/or supports. Even though processing improves the quality of clay to some extent, traces of chemically bonded impurities still remain, which tend to negatively affect the synthesis conditions and properties of the products. At 600 °C, kaolin is transformed to metakaolin, while losing its structural water and reorganization of structure. A small part of AlO_6 octahedra is maintained, while the rest is transformed into much more reactive tetra- and penta-coordinated units. Metakaolin has been used as a source of active silica and alumina. Dealumination is the removal of alumina [1] from the

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