



An investigation on alkali-activated fly ash pastes modified with quartz powder subjected to elevated temperatures



Alaa M. Rashad ^{a,*}, Ahmed S. Ouda ^{b,1}

^a Building Materials Research and Quality Control Institute, Housing & Building National Research Center, HBRC, Cairo, Egypt

^b Raw Building Materials Technology and Processing Research Institute, Housing & Building National Research Center, HBRC, Cairo, Egypt

HIGHLIGHTS

- The presence of QP improved workability and strength of AAFA pastes.
- The presence of QP showed higher remaining strength than the neat AAFA paste.
- The remaining strength of all types of pastes increased with elevated temperatures.
- The maximum residual strength was obtained at 1000 °C.

ARTICLE INFO

Article history:

Received 12 March 2016

Received in revised form 30 May 2016

Accepted 14 June 2016

Available online 9 July 2016

Keywords:

Activated fly ash

Quartz powder

Workability

Thermal loads

Remaining compressive strength

ABSTRACT

In this study, the opportunity of employing quartz powder (QP) to improve the workability as well as the compressive strength of alkali-activated fly ash (AAFA) pastes before and after exposure to thermal loads has been investigated. Fly ash (FA) was partially substituted with QP at percentages ranging from 0% to 30% with an interval of 5%, by weight. After curing, specimens were exposed to different thermal loads ranging from 400 °C to 1000 °C with a step of 200 °C with a heating rate of 6.67 °C/min for 2 h. Weight and compressive strength of the investigated specimens before and after being heating were exhaustively conducted. The different decomposition phases formed upon exposure to thermal loads were detected using X-ray diffraction (XRD) and thermogravimetric (TGA) techniques. The microstructure of the formed hydration products was determined by scanning electron microscopy (SEM). The results showed that the workability as well as compressive strength before and after firing improved by increasing QP content.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

Alkali-activated binders are cementing materials which can be used instead of Portland cement (PC) in construction [1–3]. The reaction of alkali source with silica and alumina containing solid precursor as a means of forming a solid material was patented by Kühl in 1908 [4]. Whatever, since Glukhovskiy found the opportunity of manufacturing binders with low basic calcium or calcium-free aluminosilicate and solutions of alkali metal in 1957 [5], the development of alkali-activated aluminosilicate is continued to produce new binders which are durable, strong and non-flammable [3,6,7]. Alkali-activated aluminosilicate materials have moved into front as green building materials, of which they can

be made from waste materials such as FA. FA is a waste from coal fired power stations [8] and has been shown to be highly suitable for producing geopolymers, including the production of thermally resistant binder [9–11]. Currently the attention is not finding new binders, but on evolving sustainable durable materials with advanced mechanical strength, higher fire resistance and other properties. One option to modify some exceptional properties of AAFA system is to substitute part of FA with other available materials such as ground granulated blast-furnace slag (GGBS), meta-kaolin (MK), phosphogypsum (PG) etc.

Most of the previous studies reported good fire performance of AAFA system, of which Rashad and Zeedan [10] concluded that AAFA pastes incorporating 20% or 30% sodium silicate, by weight, displayed higher residual compressive strength after exposure to elevated temperatures up to 1000 °C in comparison with the initial compressive strength. Choi et al. [12] reported higher residual compressive strength of AAFA pastes activated with different concentrations of sodium silicate solution after being exposed to 300,

* Corresponding author.

E-mail addresses: alaarashad@yahoo.com, a.rashad@hbrc.edu.eg (A.M. Rashad).

¹ Current address: The University College of Taimaa, Tabuk University, Saudi Arabia.

600 and 900 °C. Fernández-Jiménez et al. [13] reported that AAFA paste activated with 8 M NaOH displayed higher residual compressive strength at 600 and 800 °C in comparison with the initial compressive strength ones. Kong et al. [14] found 6.44% enhancement in the initial compressive strength of the AAFA pastes after being exposed to 800 °C. Vickers et al. [15] reported an increase in the initial compressive strength of AAFA pastes after being exposed to 200, 400, 800 and 1000 °C and reached the highest value at 1000 °C. The inclusion of 10% wollastone or α -alumina as FA replacement, by volume, remarkably enhanced the residual compressive strength in comparison with the neat AAFA paste. Dombrowski et al. [16] reported that partially substituting FA with 8% Ca(OH)₂, by weight, enhanced the residual compressive strength at 600, 800 and 1000 °C when the specimens dimensions were 40 × 40 × 160 mm. Zhang et al. [17,18] reported that the residual compressive strength at 500 °C of the neat AAFA paste reinforced with 2% chopper carbon fibers can be enhanced by partially substituting FA with 50% MK, by weight. Recently, Rashad [19] reported that partially substituting FA with 5% and 10% phosphogypsum, by weight, in AAFA matrix demonstrated higher remaining compressive strength after being exposed to elevated temperatures of 400, 600, 800 and 1000 °C.

In the review of the electronic library, it can be noted that there are few research papers regarding to the behavior of AAFA pastes blended with other materials under the effect of thermal loads. In fact, up to this moment, there has not been any research paper studied the effect of thermal loads on the AAFA pastes blended with different amounts of QP. Therefore, the prime objective of the current study is to investigate the behavior of AAFA pastes containing different ratios of QP before and after being exposed to thermal loads, and then comparing them with those blends of free QP. In the current study, the workability as well as compressive strength before and after firing of alkali-activated FA/QP pastes have been explored, then compared with the neat AAFA paste. FA was partially substituted by QP at percentages ranging from 0% to 30% with a step of 5%, by weight. The specimens were being exposed to thermal loads ranging from 400 °C to 1000 °C with a step of 200 °C for 2 h. The current results are proposed to supply new and valued development to fire resistance field of AAFA system.

2. Experimental program

2.1. Materials

The employed FA in the recent study was brought from waste disposal resulting from the consumption of pulverized coal in the coal-fired furnace. It conforms with BS3892: Part 1 (BSI 1992) requirements and categorized as low calcium Class F fly ash according to ASTM-C618. Its Blaine specific area was 400 m²/kg, whilst its specific weight was 2.4. The QP was supplied from the Egyptian Company for Manufacturing Electrical Insulators. Its bulk density was 1.04 g/cm³, whilst its specific weight was 2.46. Table 1 shows the sieve analysis of the QP. The chemical composition of the starting materials as evaluated by X-ray fluorescence (XRF) spectrometry are given in Table 2. Liquid sodium silicate which had a density of 1.38 g/cm³ and a composition comprising of 27% SiO₂, 8.2% Na₂O and 64% H₂O was used as an alkaline activator. Figs. 1 and 2 show the X-ray diffraction (XRD) analysis results of the raw FA and QP, respectively.

2.2. Mix proportions

Seven alkaline-activated mixtures were designed. The first one was set from the neat AAFA without any amount of QP. This mixture was designed as QP0. The remaining six mixtures were set by partially substituting FA by different percentages of QP ranging from 5% to 30% with an interval of 5%, by weight. These mixtures were designated as QP5, QP10, QP15, QP20, QP25 and QP30, respectively. For each mixture, 25 wt% of sodium silicate calculated from the total weight of FA along with QP was used as an alkali activator. The water/binder (w/b) ratio was fixed for all studied mixtures at 0.15, by weight. This ratio did not include the crystalline water from sodium silicate solution. The proportions of each mixture are presented in Table 3.

Table 1
Sieve analysis of QP.

Residue on sieve %	Particle size distribution	
90 μm \leq 1	>90 μm	1
63 μm 2–4	63–90 μm	1–3
45 μm 7–10	45–63 μm	5–6
32 μm 15–20	32–45 μm	8–10
	<32 μm	80–85

Table 2
Chemical composition of the starting materials.

Oxide composition	FA (%)	QP (%)
SiO ₂	55.95	98.81
Al ₂ O ₃	23.3	0.14
Fe ₂ O ₃	4.84	0.05
CaO	4.84	0.51
MgO	1.85	0.02
Na ₂ O	0.91	0.04
K ₂ O	1.82	0.03
SO ₃	0.65	0.03
TiO ₂	1.03	0.02
P ₂ O ₅	0.73	0.32
MnO	0.05	0
L.O.I.	3.47	0.32

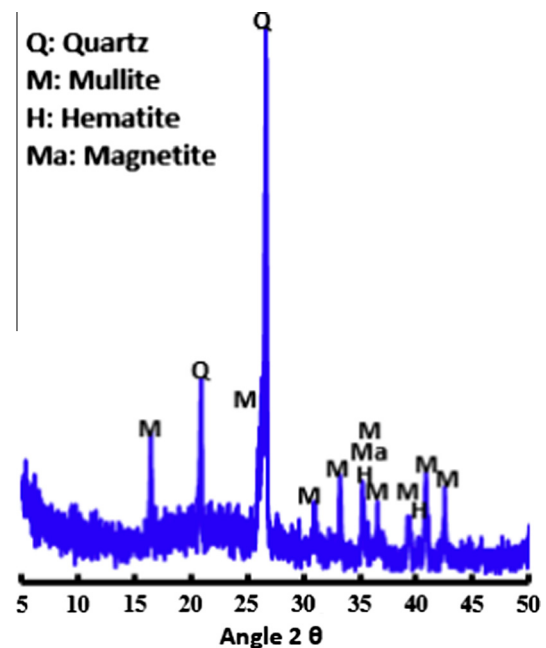


Fig. 1. XRD pattern for raw FA.

2.3. Casting, curing, heat regimes and testing

The starting raw FA was substituted with QP at levels of 5%, 10%, 15%, 20%, 25% and 30%, by weight. The dry powders were mixed for 4 min in mechanical mixer with a speed of 80 rpm to achieve a homogenous mixing. The solution of sodium silicate was dissolved in mixing water. This solution was mixed with the FA/QP for 5 min, sequenced by 2 min resting duration to scratch off unmixed powders from the mixer sides of the paddle and placing them inside the bowl. Before casting, the mixture was mixed for additional 5 min. Immediately after mixing, the flow value for each mixture was determined by hand-driven flow table according to ASTM C230-83. Then, the fresh paste was cast inside 20 mm cube moulds and vibrated for 1 min to remove air bubbles. Immediately after casting, the polyethylene sheet was used to cover the moulds to avoid the evaporation of water. All the specimens were cured at 50 ± 1 °C inside special environmental chamber until they were tested.

Download English Version:

<https://daneshyari.com/en/article/6718148>

Download Persian Version:

<https://daneshyari.com/article/6718148>

[Daneshyari.com](https://daneshyari.com)