



Effect of thermally activated clay on corrosion and chloride resistivity of cement mortar



Noor-ul Amin ^{a,*}, Sultan Alam ^b, Saeed Gul ^c

^a Department of Chemistry, Abdul Wali Khan University, Mardan, Pakistan

^b Department of Chemistry, University of Malakand, Chakdara, Dir (L), Pakistan

^c Department of Chemical Engineering, University of Engineering & Technology, Peshawar, Pakistan

ARTICLE INFO

Article history:

Received 28 December 2014

Received in revised form

7 June 2015

Accepted 22 June 2015

Available online 30 June 2015

Keywords:

Clay

Metakaolin

Compressive strength

Corrosion resistance

Chloride attack

ABSTRACT

Corrosion and chloride attack are the two important issues of cement mortar and concrete. The aim of this study is to design corrosion and chloride resistive cement mortar, by incorporating thermally treated clay available at Khyber Pakhtunkhwa, Pakistan. The clay containing low kaolinite content was converted to metakaolinite and characterized by X-ray diffraction (XRD), Differential thermal analysis (DTA) and Scanning electron microscopy (SEM). Six types of mortars containing 5, 10, 15, 20, 25 and 30% of metakaolin were made and studied for different parameters including compressive strength, corrosion resistance and chloride diffusion coefficients for the evaluation of the performance of metakaolin. Mortar specimens were then exposed to the corrosive environment of 3% w/w NaCl solution. It is concluded that metakaolin improves the compressive strength and 20% w/w replacement of cement in mortars show optimum contribution to the strength development, corrosion resistance and chloride attack resistance. Excess amount of metakaolin in mortar has no positive effect.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

The most common supplementary cementing materials that are used as a cement replacement in mortar and concrete are fly ash, Ground Granulated Blast Furnace Slag and silica fume for multiple purposes including energy saving conserve resources and a lot of other technical benefits. Metakaolin, which is obtained by the controlled thermal treatment of kaolin, may exhibit such potential for having good pozzolanic properties (Amin, 2014; Gartner, 2011; Kim, 2015; Zuhua et al., 2009).

It is clear from the literature that researchers working on metakaolin have focused on two main areas. The first area includes the structural studies of kaolin and meta-kaolinite, the conversion of kaolinite to metakaolinite and different analytical techniques for the thermal treatment of kaolinite (Habert et al., 2011; Hossain and Mol, 2011; Gao et al., 2015). The second area includes the study of pozzolanic behavior of metakaolin and its effect on the physical and chemical parameters of cement mortar and concrete (Gul et al., 2014; Kaps and Hohmann, 2010; Amin et al., 2014).

Out the properties of cement and concrete, corrosion and chloride permeability is the main issue which is to be addressed by the cement researchers (García-Gusano et al., 2015; Amin, 2011a; Sinthaworn and Nimityongskul, 2011). The durability of the cement products depends upon the corrosion and chloride resistance. The performance of mortar and concrete depends mainly on the microstructure and the chemistry of the concrete, which are mainly affected by the components of the blend in mortar and concrete (Diaz et al., 2010; Amin, 2011b). Different materials have been used in mortar and concrete to make it corrosion and chloride resistant (Guo et al., 2010; Temuujin et al., 2009; Renata et al., 2015). Metakaolin produced at high temperature may exhibit pozzolanic properties and can be used to make the mortar and concrete resistive and so durable. Moreover, calling is easily and abundantly available mineral. The present study deals with the use of metakaolin obtained from locally available kaolinite in cement mortar and study the corrosion and chloride resistance.

2. Experimental

The chemical composition, clinker moduli and clinker potential of Portland cement used in this study is given in Table 1. Kaolinite clay was collected from different areas of Khyber pakhtunkhwa

* Corresponding author.

E-mail address: noorulamin_xyz@yahoo.com (N.-u. Amin).

Table 1
Chemical composition of high strength portland cement.

Major oxides (% wt)					Moduli			Clinker phases			
SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	MA	MS	LSF	C ₃ S	C ₂ S	C ₃ A	C ₄ AF
21.55	5.69	3.39	64.25	0.85	1.68	2.37	0.93	47.61	25.90	9.35	10.30

Where MA = modulus of alumina, MS = modulus of silica, LSF = lime saturation factor, C₃S = tricalcium silicate, C₂S = dicalcium silicate, C₃A = tricalcium aluminate and C₄AF = tetra calcium aluminoferrate.

used as a source of aluminosilicate and thermally activated at 600 °C for 3 h and the produced metakaolin was ground to the appropriate fineness (20% residue at 13.6 μm).

The X-ray diffraction (XRD) pattern of the as received clay sample and that of thermally activated at 600 °C is shown in Fig. 1. Clay under study contains kaolinite (K) and some amount of quartz (Q) as seen in Fig. 1A. The treated sample at 600 °C is shown in Fig. 1B, which shows that the mineralogical transformation from kaolinite to amorphous form has occurred. It can be seen in the figure that the peaks corresponding to kaolinite disappear which shows that kaolinite has been converted into amorphous form.

The DTA curve of the clay is shown in Fig. 2. Fig. 2a shows the DTA of the natural clay. The figure shows three endothermic peaks at 100, 560 and 970 °C: the first peak corresponds to the dehydration and the second peak appearing at about 560 °C is endorsed to the removal of hydroxyl groups (de-hydroxylation) from the kaolinite present in the clay (Temuujin et al., 2009; Caglar et al., 2007). The last peak appearing at about 970 °C may corresponds to the development of new and extra stable phases which is due to amorphous materials like mullite and metakaolinite.

Fig. 2b shows the DTA curve of the thermally activated clay. Three endothermic peaks are very obvious. The one appears in the range of 90–350 °C which is due to the loss of water. The second endothermic peak appears at about 700 °C which may be due to the conversion of kaolinite to meta-kaolinite. This indicates that there is some unreacted kaolinite in the material which is dehydroxylated above 700 °C. A rough quantitative estimation of the unreacted kaolinite is possible from the mass loss but the accurate measurement is not possible due to the development of some new phases at this temperature which overlaps the peak at this temperature range. The last peak at about 970 °C may be considered to the formation of comparatively more stable phases from the meta-kaolinite, and the breakdown of different sulfates and carbonates present in the clay (Criado et al., 2007; Steveson and Sagoe-Crentsil, 2005).

2.1. Preparation of blends

The chemical analysis of local kaolin used in the work is given in Table 2. For the evaluation of metakaolin cements properties, seven

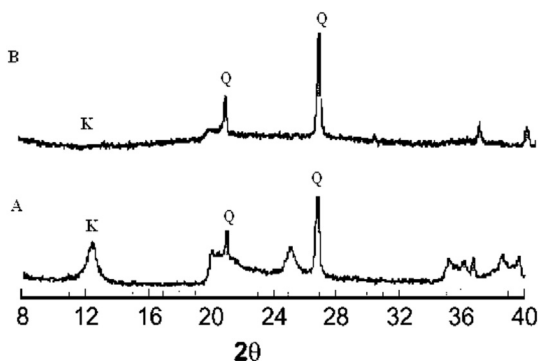


Fig. 1. XRD pattern of (A). Natural clay (B). Thermally treated clay at 600 °C.

blended cements were produced by replacing Portland cement with 0, 5, 10, 15, 20, 25 and 30% w/w metakaolinite clay and were named as MC-0, MC-5, MC-10, MC-15, MC-20, MC-25 and MC-30 respectively. MC-0 contains no clay and was used as a reference (control). For the corrosion measurements, six mortar mixes of PCs with metakaolin were tested and compared to specimens with pure PC. Metakaolin replaced part of PC and the mortar mix proportions are given in Table 3.

2.2. Determination of compressive strength

The compressive strength of the blended cement mortars was determined according to EN196-1 and the consistency and setting time according to EN 196-3.

2.3. Corrosion of reinforced steel

Mortar cylinders having length of 100 mm and diameter 40 mm were cast in which the steel rebars were axially embedded according to procedure (Temuujin and Riessen, 2009). The specimens after being de-molded were cured in water for one day and then immersed up to 20 mm height of the mortar cylinder for 180 days in 3% w/w NaCl solution in order to provide a corrosive

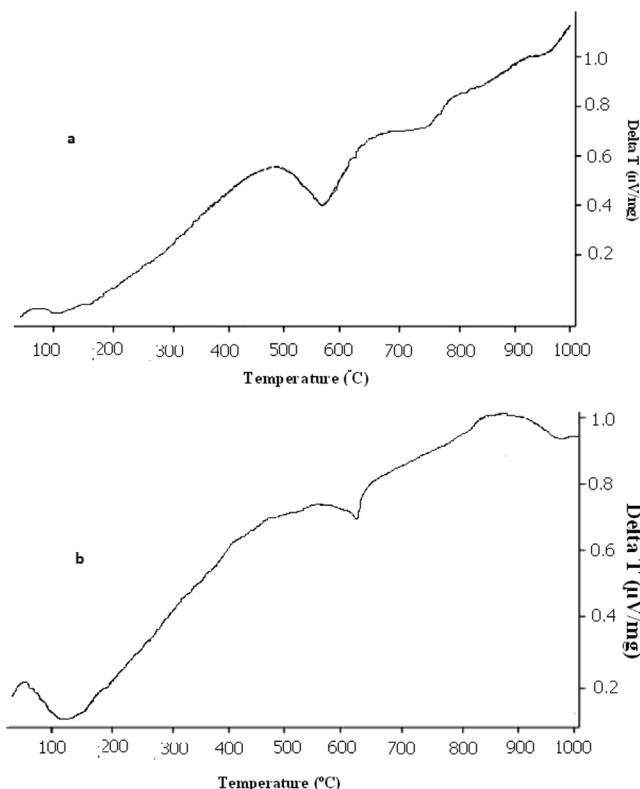


Fig. 2. DTA curve of (a). Natural clay (b). Thermally activated clay.

Download English Version:

<https://daneshyari.com/en/article/1744376>

Download Persian Version:

<https://daneshyari.com/article/1744376>

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