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Compressive strength and scanning electron microscopy studies on metakaolin admixtured cement

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ABSTRACT

The hydration products, microstructure of paste with part of Portland cement replaced by metakaolin were investigated by Compressive strength and Scanning electron microscopy in this article. The results shown that the replacement of Portland cement by metakaolin can decrease the amount of $Ca(OH)_2$, increase the amount of C-S-H gel, make the structure denser and improve the microstructure and compressive strength of cement paste.

INTRODUCTION

The uses of various reactive pozzolans as supplementary cementitious materials are fast growing in the development of more durable and high performance concrete[1]. Slag, fly ash, metakaolin, silica fume, Rice husk ash etc., are being used as blended mineral admixtures in cement. Now a day's, the use of pozzolanic material such as metakaolin are increased in Portland cement. It offers cost reduction, energy savings, superior quality and also one way to reduce green house effect and global warming. Metakaolin (MK), produced by thermal activation of kaolinite clay in the temperature range of 650-850°C, is an established pozzolana[2]. The hydration mechanism of cement and metakaolin cement using Differential Thermal Analyses, Thermogravimetric analysis, X-ray Diffraction, Fourier Transform Infrared Spectroscopy and Scanning Electron Microscopy were explained by number of authors[3-5]. These different techniques have shown that, in the case of metakaolin cement paste has a greater influence on the hydration properties and improve the cementitious properties. The purpose of this paper is to present a detailed hydration study on MK admixtured cement paste hydrated for different intervals of time.

MATERIALS AND METHODS

43 grade Portland cement (OPC) and the metakaolin are used their compositions of which are given in TABLE 1.

In this investigation, OPC and 10% Portland cement is replaced by the metakaolin, in a water to cement ratio (W/C) of 0.4 were used. 7×7×7 cm of mortar cube specimens were used in the compressive strength test[6]. Demoulded at one day, the specimens were cured in water at 27 ± 3°C until 3, 7 and 28 days age, and then tested. For microstructure study, the fractured surfaces of hydrated OPC and 10% replacement of OPC with metakaolin paste were coated with the

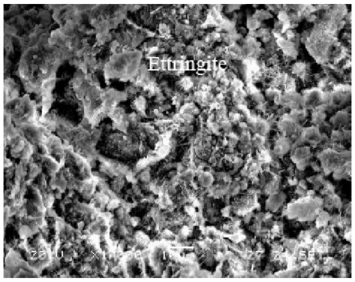

Figure 1 : Micrograph of OPC hydrated with 7 days

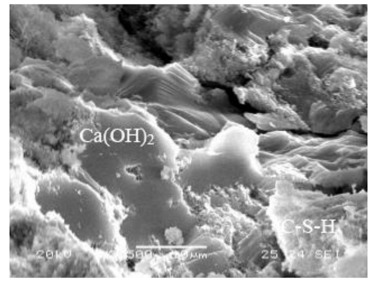

Figure 2 : Micrograph of OPC hydrated with 28 days

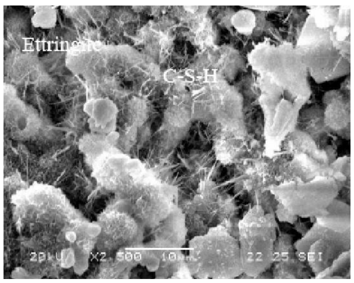

Figure 3 : Micrograph of OPC + 10% Metakaolin hydrated with 7 days

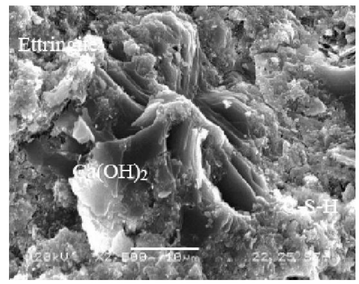

Figure 4 : Micrograph of OPC + 10% Metakaolin hydrated with 28 days

TABLE 1 : Chemical composition of portland cement and metakaolin (mass %)

Samples	CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3	MnO	Loss on ignition	Insoluble residue
Portland cement	63.32	21.70	5.40	3.40	2.69	2.70	-	0.79	-
Metakaolin	0.50	68.54	23.55	0.58	0.60	-	0.02	3.98	1.20

TABLE 2 : Compressive strength of OPC and OPC + 10% MK Mortar samples

Samples	Compressive strength (MPa) 3 days 7 days 28 days
OPC	11.7 32.6 47.7
OPC + 10% MK	20.3 41.2 55.3

help of gold coater (JEOL auto fine coater model JFS-1600) for a time of 150 seconds with 10 mA.

RESULTS AND DISCUSSION

Compressive strength results

The results of compressive strength of OPC and 10% replacement of OPC mixed with metakaolin are shown in TABLE 2.

When 10% cement replaced by the metakaolin, the compressive strength of 3 days increases in 73.50 %, 7 days increases in 26.38% and increases 15.93% in 28 days, when compared to OPC mix. The results show that the part of replacement of Portland cement by the metakaolin mixes can increase the early strength and also increase the latter strength. This is close agreement with previous results[7].

SEM results

Figure 1-4 Shows SEM observations of OPC and 10% replacement of OPC with metakaolin paste hydrated in 7 days and 28 days. From figure 3 and 4 the main constituents of 7 days OPC paste of hydrated products are needle shape ettringite, fibers of C-S-H gel and 28 days OPC paste (Figure 5) constituents of plate shaped $Ca(OH)_2$ crystal[8].

When part of 10% Portland cement is replaced by the metakaolin, ettringite and C-S-H are greatly increases and $Ca(OH)_2$ decreases, when increasing the hydration periods due to the pozzolanic reaction . This fact increases the compressive strength when part of cement was replaced by the metakaolin[9]. Therefore, the microstructures of cement have been improved, due to the reaction of the active metakaolin with $Ca(OH)_2$ in the cement paste. These findings are totally agreed with compressive strength results.

CONCLUSIONS

All the experimental results indicate that the 10% replacement of Portland cement by the metakaolin can change the compressive strength and shape of the hydrated products of cement. By Scanning electron microscopy we can observe that the $Ca(OH)_2$ content is reduced, the amount of C-S-H gel is increased. The metakaolin replacing some of Portland cement is not only environmental benefits but also beneficial for the improvement of microstructure and the increase of compressive strength of cement paste.

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