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MECHANICAL AND MICROSTRUCTURE STUDIES ON NANO-CLAY ADMIXTURED CEMENT MORTAR

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ABSTRACT

Microstructure and Compressive strength studies on Nano-clay admixtured cement mortar was investigated. The main objective of this research is the combination of Nano clay and cement mortar which produce high mechanical properties. The Nano-clay used in this investigation was Nano-metakaolin. The Nano-metakaolin (NMK) is prepared by thermal activation of kaolin clay for 2 hours at 750 ° C. The blended cement used in this investigation consists of ordinary Portland cement (OPC) and Nano-metakaolin. The OPC was partially substituted by NMK of 0 and 5% by weight of cement. The blended cement mortar was prepared using Cement - Sand ratio of 1:3 by weight with water-binder ratio (W/B ratio) as 0.4. The results showed that the compressive strength of the cement mortars with NMK were higher than plain cement mortar with the same W/B ratio.

Keywords: Compressive strength, microstructure, Nano metakaolin, pozzolanic effect

INTRODUCTION

In recent years, the use of Nano-particles has received particular attention in many fields of applications to fabricate materials with new functionalities. When ultra-fine particles are incorporated into Portland-cement paste, mortar or concrete, materials with different characteristics from conventional materials were obtained. Metakaolin differs from other supplementary cementitious materials (SCMs), like fly ash, silica fume, and slag. In that metakaolin is not a by-product of an industrial process; it is manufactured for a specific purpose under carefully controlled conditions. Metakaolin is produced by heating kaolin, one of the most abundant natural clay minerals in the temperature of 750 °C [1]. The hydration mechanism of cement and metakaolin admixtured cement using Differential Thermal Analyses, Thermogravimetric analysis, X-ray Diffraction, Fourier Transform Infrared Spectroscopy and Scanning Electron Microscopy are explained by number of authors' [2,3]. These different techniques have shown that, in the case of metakaolin cement paste, it has a greater influence on the hydration properties and improve the cementitious properties. The present research is thus aimed at investigating the effect of Nano-metakaolin (NMK) on mechanical properties and microstructure of Portland cement mortar.

EXPERIMENTAL

The materials used in this study were Nano-clay of Blaine surface area 48 m^2/g and average dimension 200*100*20 nm. The oxide composition of kaolin and ordinary ortland cement is shown in Table 1. The Nano clay used in this investigation is kaolin clay supplied by 20 microns limited, Vadodara, India. The Nano-kaolin was heated for 2 hours at 750^{o}C to give active amorphous NMK. In this investigation, OPC and 5% Portland cement is replaced by the NMK, 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[4]. The proportions of the cement, sand and water were calculated according to Indian standard (IS No. 650-1960). 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 Morphological study, the fractured surfaces of OPC and 5% replacement of OPC with NMK mortars were used.

RESULTS AND DISCUSSION

The results of compressive strength of OPC and 5% replacement of OPC mixed with NMK were shown in Table-2. The compressive strength of NMK mortar is found to increase with the increase in curing time. This may be due to NMK enhances the strength of hardened cement mortar by two mechanisms. The first mechanism is the packing effect of NMK as filler into interstitial spaces inside the skeleton of hardened microstructure of cement mortar and thus increasing its density as well as the strength. The second mechanism is the pozzolanic effect [5].

Table -1: Chemical composition of Portland cement and kaolin (mass %)

Chemical Composition	Portland cement	Kaolin
CaO	63.32	0.15
SiO_2	21.70	60.54
Al_2O_3	5.40	22.55
Fe_2O_3	3.40	2.58
MgO	2.69	0.40
SO_3	2.70	0.02
Loss on ignition	0.79	1.98

Table -2: Compressive strength of OPC and OPC + 5% NMK Mortar samples

Samples	Compressive strength (MPa)		
	3 days	7 days	28 days
OPC	11.7	32.6	47.7
OPC + 5%NMK	14.3	38.2	52.3

Figures-1 to 4 Show SEM observations of OPC and 5% replacement of OPC with NMK mortar in 7 days and 28 days. From Figures-1 and 2, the main constituents of 7 days OPC mortar are needle shape ettringite, clusters of C- S-H gel and 28 days OPC mortar shows (Fig. 2) hexagonal of plate shaped $Ca(OH)_2$ crystal. When part of 5% Portland cement is replaced by the NMK, the microstructure (Fig.-3 and 4) becomes denser and improves the Physical- chemical and mechanical properties. The improvement in physical and chemical properties by the addition of NMK explained as follows: ultra-fine particles of NMK filled the voids in cement thus making the microstructure of cement paste denser.

Fig.- 1: SEM image of OPC at 7 days

The pozzolanic reaction of NMK with free lime released during hydration process produces excess calcium silicate hydrate that gets deposited in pore system thus resulting in the improvement of mechanical properties [6].

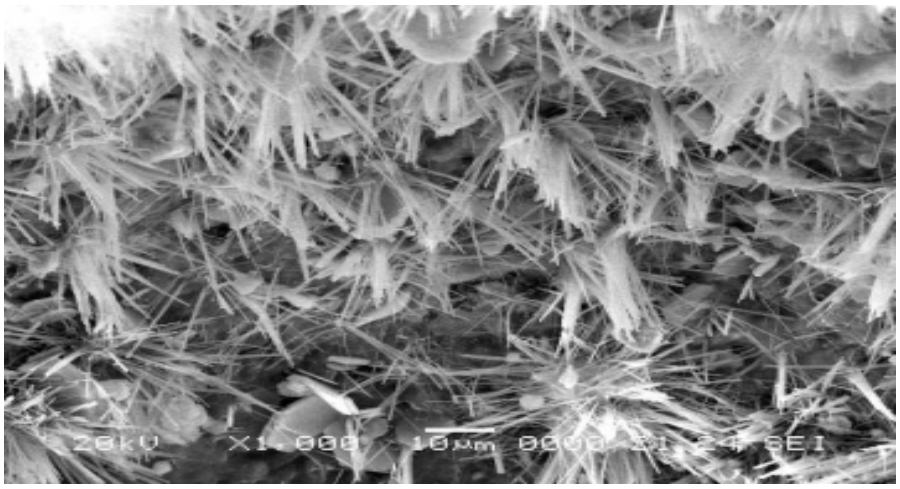

Fig. - 2: SEM image of OPC at 28 days

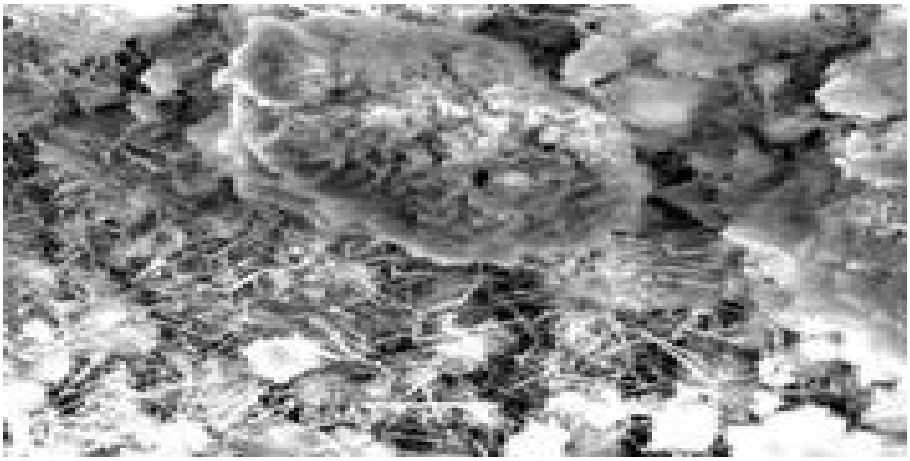

Fig.-3: SEM image of OPC+5% NMK at 7 days

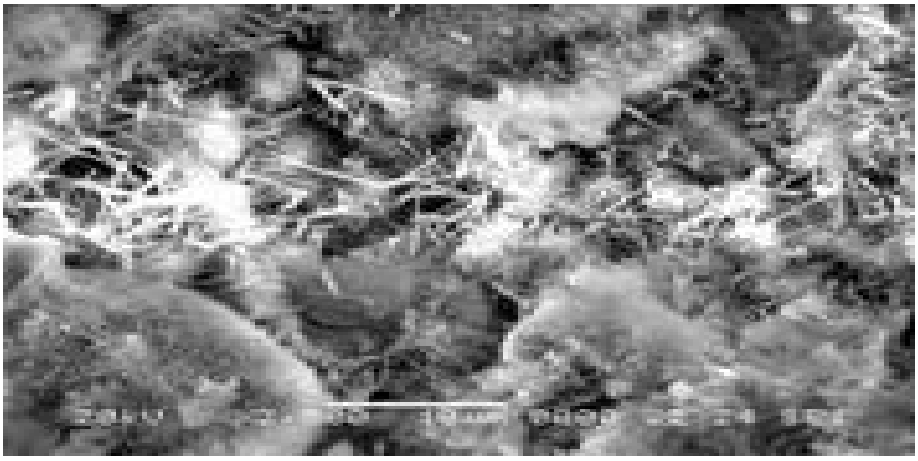

Fig. - 4: SEM image of OPC+5% NMK at 28 days

CONCLUSION

Experimental results indicate that the 5% replacement of Portland cement by the NMK can change the compressive strength and shape of the hydrated products of cement. The SEM observations confirmed that the NMK was not only acting as filler, but also as an activator to promote hydration process. Further research needs the study of optimum replacement of nano-metakaolin in cement.

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