Experimental Study on Compressive Strength Growth in Calcined Kaolin-Blended Portland Cement Mortars

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Abstract-In this paper**,** the study on growth of compressive strength in cement mortars blended with calcined-kaolin (MK) has performed. The preparation and Grinding of the kaolins was carried out at sistan cement factory. Calcination of clays was carried out in a kiln at central laboratory in S&B university.The blends produced were tested in the laboratory. Cement mortars containing 0, 5, 10 and 15% replacement of cement with calcined-kaolin and with a water/binder (W/B) ratio of 0.485 have been moist cured for periods from 3 to 28 days. Good results were obtained from the compressive strength tests, demonstrating the viability and robustness of this technology.

Keywords - calcined-kaolin, Cement mortars, compressive strength, metakaolin

1. Introduction

The use of metakaolin (MK) as a supplementary cementing material (SCM) has gained wide application in the productionof high strength and high performance concrete[1]. Like other pozzolanic admixtures, its contribution is mainly related to chemical (usually pozzolanic) and physical activity (microfiller and acceleration effect) for the cement hydration[2]. But, there are significant differences between MK and other pozzolanic additives. MK possesses high specific surface area and surface reactivity[3]. Therefore, when MK is used to replace part of the cement in concrete, hydration characteristics are changed, such as the relatively great water demand for standard consistency and the high reactive activity. Well ordered kaolinite have almost no hydration activity at room temperature[4]. If well ordered kaolinite is used to replace as part of cement, it is considered as an inert component. Its contribution is only reflected as physical activity. That is, it will act as nuclei for the formation of C-S-H gel during hydration of C3S and C2S, making the microstructure of cement paste dense[5]. Considering the great surface structure and specific surface area of MK prepared by calcining kaolin, similar results are observed. Thus, when MK is mixed into cement, its effect can be considered as the chemical activity of MK and the physical activity of kaolin that are superimposed onto each other at different hydration age. The aim of the current investigation is to determine the effectiveness of metakaolin as a replacement material in cement mortars.

2. MATERIAL

The cement used for this investigation was type-2 Portland cement from sistan cement factory and the kaolin was obtained from a mine near dalgan county in sistan and baluchestan province. The preparation and Grinding of the kaolins was carried out at sistan cement factory. Calcination of clays was carried out in a kiln at central laboratory in S&B university. The compositions of cement and metakaolin are given in Table 1. The specific surfaces of the cement and metakaolin were respectively 320 m2/kg and 12000 m2/kg and the specific gravities were 3180 kg/m3 and 2490 kg/m3.

3. MIX PROPORTION

Details of the four mortar mixes (A-D) are given in Table 2. The control mix (A) was of proportions by weight 1 cement : 2.75 sand and water/binder (W/B) ratio of 0.485. In mixes B, C and D, cement was partially replaced (by weight) with respectively 5, 10 and 15% metakaolin. Mixing was performed in a pan mixer. The dry sand was added first followed by the pre blended cement and metakaolin. The constituent materials were mixed dry for about 1.5 minutes. The water was then added slowly and mixing was continued for a total period of 4 minutes.

Table 1. Composition of Cement and Metakaolin.

oxide	Cement (%)	Metakaolin (%)
Si02	21.52	52.1
Al203	5.26	41.0
Fe203	3.62	4.32
CaO	62.34	0.07
MgO	1.76	0.19
SO3	2.88	----
Na2O	0.62	0.26
K2O	0.49	0.63
TiO2	----	0.81
L.O.I	1.51	0.6

4. SPECIMEN PREPARATION-CURING-TESTING

Specimens were cast in 50 x 50 x 50 mm moulds and compacted by vibration. A small amount of bleeding was observed during vibration. After casting, the cubes were covered with cling film to prevent water loss and after 24 hours the specimens were demoulded, weighed and quickly wrapped with cling film and placed in plastic bags. The bags containing the specimens were placed on a stand in a plastic container at a temperature of 20 + 2°C for periods of 3, 7, 14, 28 days. Before testing, the cubes were weighed to check that there was negligible moisture change during curing and they were then tested in compression at a loading rate of 40kN/min. Three cubes were tested at each curing time and the average strength determined.

Table 2. Mix Proportions of Mortar

Mix	MK(%)	PROPORTIONS (Kg/m3)			
		CEMENT	MK	SAND	WATER
A	0	540.0	0	1484.0	262.0
B	5	513.0	27.0	1425.0	262.0
C	10	486.0	54.0	1350.0	262.0
D	15	459.0	81.0	1275.0	262.0

5. RESULTS

The Strength Development of Metakaolin Mortars are given in Table 3. In mixes B, C and D, cement was partially replaced (by weight) with respectively 5, 10 and 15% metakaolin.

According to table, In control mix(A) , there is a increasing trend in compressive strength which leads to maximum strength about 43.3 MPa at the age of 28d.

In mix (B) with replacement of 5 percent ,similarly there is a increasing trend in strength, but its maximum strength at the age of 28d in comparison with control mix(A) has improved about 9 percent.

In mix (C) with replacement of 10 percent , there is a same incremental pattern, but its maximum strength at the age of 28d in comparison with control mix(A) has improved about 23 percent while, This growth for mix (D) with replacement of 15 percent is about 17 percent.

Also, with increasing of MK from 10 to 15 percent, a reduction in compressive strength has occurred. According to table, maximum strength at the age of 3d, 7d, 14d, 28d, is related to mix (C). The results are given in figures 1 to 4.

Table 3. Strength Development of Metakaolin-cement Mortar

Mix	MK(%)	COMPRESSIVE STRENGTH (N/mm2)			
		3d	7d	14d	28d
A	0	26.8	37.0	41.0	43.3
B	5	29.3	38.4	43.1	47.4
C	10	31.4	47.2	51.8	53.4
D	15	29.6	46.0	49.4	50.8

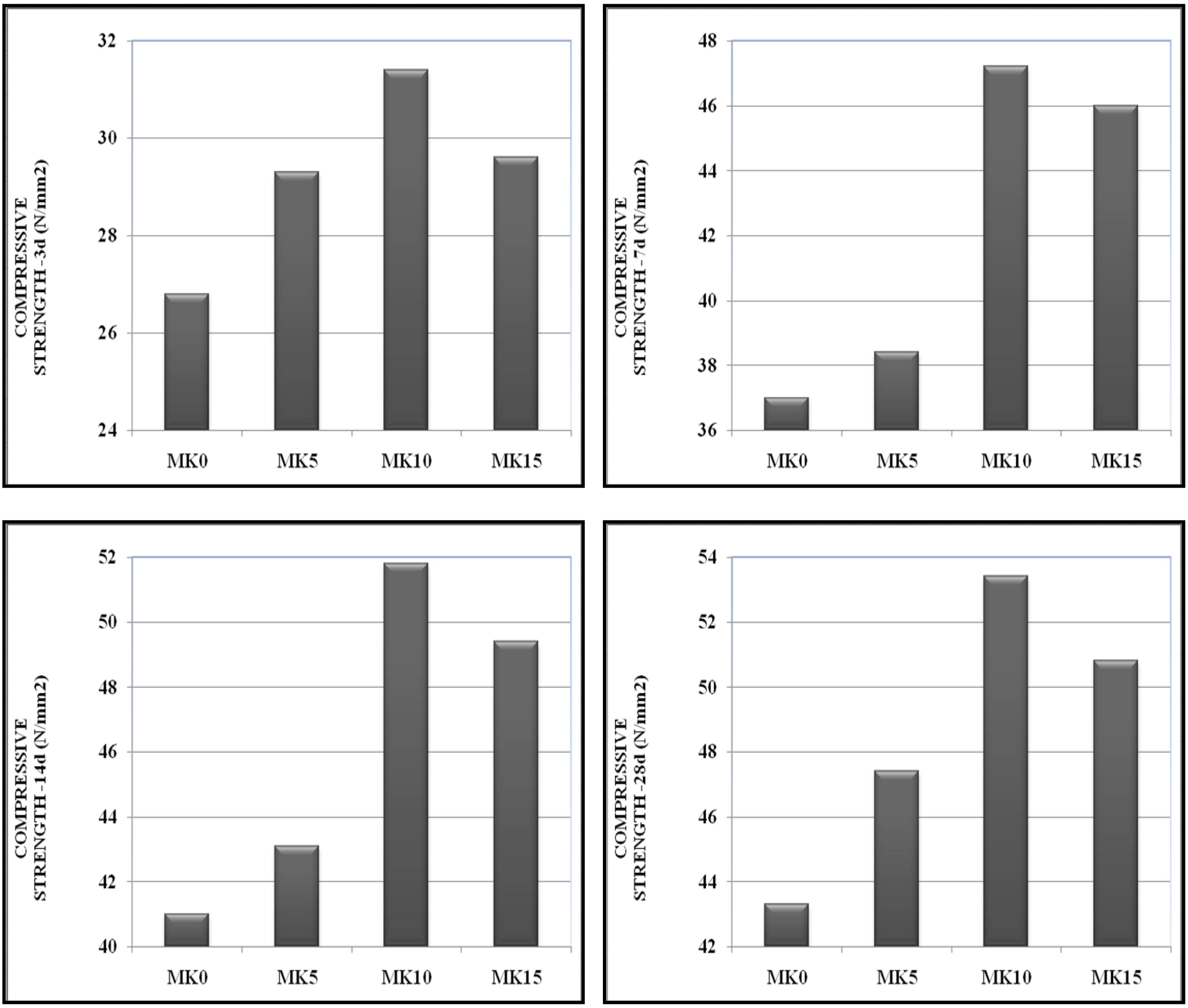

Fig. 1-4. Comparison of compressive strength at different ages.

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