INFLUENCE OF STRONG ACIDIC COMPOUNDS ON METAKAOLIN BLENDED CEMENT MORTARS

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ABSTRACT

In India, the manufacturing of Portland cement commenced around the year 1912.Since then the usage of cement developed rapidly. Many modern concrete mixtures use pozzolanic admixtures in concrete. The use of pozzolanic materials in cement concrete paved a solution for modifying the properties of the concrete, controlling the concrete production cost, overcoming the scarcity of cement, the economic and advantageous disposal of industrial wastes. Metakaolin is a pozzolona material which is formed from kaolin clay that is fired (calcined) under carefully controlled conditions to create an amorphous alumino-silicate that is reactive in concrete. Metakaolin reacts with the calcium hydroxide (lime) which is a byproduct, produced during cement hydration. Calcium hydroxide accounts for up to 25% of the hydrated Portland cement, and calcium hydroxide does not contribute to the concrete's strength or durability. Metakaolin combines with the calcium hydroxide to produce additional cementing compounds, which are responsible for holding concrete together. Less calcium hydroxide and more cementing compounds means stronger concrete. Because of rapid industrialization, now a days water is being contaminated by many acidic compounds .Therefore, it is essential to examine and interesting to know the effect of individual chemical compounds on the strength and durability of concrete.

Keywords: Admixture, Calcium Hydroxide, Kaolin Clay, Metakaolin, Pozzolana Material

I. INTRODUCTION

With the advancement of technology and increased field of applications of concrete and mortars, the strength, workability, durability and other characteristics of the ordinary concrete needed modifications to make it more suitable for various situations. Added to this it is necessary to combat the increasing cost and scarcity of cement. Under these circumstances the use of admixtures is found to be an important alternative solution. Metakaolin which is a pozzolonic admixture renders concrete more durable. The Metakaolin can be advantageously utilized for preparing concrete mixes, which are stronger, more durable and also economical. The addition of Metakaolin does improve the performance of the concrete substantially. The Metakaolin mixed concrete is finding place in the following applications.

* In tall and heavy structures where high strength concretes are required.
* In PSC works where too high strength concretes are essentially required.
*In concrete works where corrosion problem is more, i.e. in coastal areas and marine works.
*Being a highly fine material, it is found a gainful use in shot Crete applications in chemical, mining, paper and pulp industries.

*In combination with other chemical admixtures and steel fibres,it is suitable for repair works.

*Metakaolin will have improved resistance to freezing, thawing, and chloride penetration, making it useful for road construction. It also reduces permeability.

*Metakaolin blended cement is used in Ferro cement products and Glass Fibre Reinforced concrete, Mortars, stuccos, Repair materials, pool plasters , color industrial floorings etc..,

The ground water is sustainable source of fresh water for drinking, agricultural and industrial purposes and it has to meet all physical and chemical parameters for its safe use. Quality of ground water of any area depends on many factors such as geological characteristics of land, land use pattern, topography etc., but in urban areas and industrial areas, the ground water quality has been deteriorating day by day because of disposal of swage wastes and industrial effluents into the environment. Industrial wastes are potential sources of ground water contamination and make it unfit for drinking and other purposes. Impurities present in water used for mixing concrete, exceeding the tolerable limits, may affect not only the concrete strength and durability but also setting time , soundness, efflorescence (deposits of white salts on the surface of concrete) and corrosion of reinforcing or pre-stressing steel (ACI,1978). In general, mixing water is rarely a factor in concrete strength. I.S. Code 456-2000 stipulates that the acidity of water should not be more than 50 mg/L. The I.S Code 456-2000 also specifies the minimum pH- value as 6.0 and also permissible limits for solids of the water to be used for construction purposes. Experimental studies were carried out in the present investigation to asses and analyze the influence of strong acidic compounds like hydrochloric acid and sulphuric acid on hardening, compressive strength and durability of cement.

II. MATERIALS

The materials used in the experimental investigation include: 53- Grade Ordinary Portland Cement, Fine aggregate (sand), Distilled water, High Reactivity Metakaolin, strong acidic compounds (hydrochloric acid and sulphuric acid).

The properties of these materials are given in the following sub sections.

2.1 Cement

A 53-grade Ordinary Portland Cement, which conforms to IS: 12269-1987 was used for the present experimental investigation. All the tests for the physical properties of the cement were conducted in accordance with the IS: 4031-1968.

2.2 Sand

The sand used in the experimental work has the following particle size distribution and mixed in the proportion 1:1:1.

* Passing through 2mm and retained on 1mm

*Passing through 1mm and retained on 0.5mm

*Passing through 0.5mm and retained on 90 µm.

2.3 Water

Distilled water was used for mixing and curing of cement mortar test specimens.

2.4 Metakaolin

The Metakaolin is in conformity with the general requirements of pozzolana.

2.4 Strong Acidic Compounds

The strong acidic compounds like HCL and H_2SO_4 were found to be more predominant in the areas where the ground water is polluted from the industry effluent. As such the effect of strong acidic compounds on the strength and setting times were found using hydrochloric acid (HCL) and sulphuric acid (H_2SO_4).

III. METHODS EMPLOYED

The experimental methods adopted were in accordance with the I.S standards. They are briefly presented in the following sub sections.

3.1 Normal Consistency Test

Vicat's apparatus conforming to IS 5513-1976 consists of a frame to which a movable rod having an indicator is attached which gives the depth of penetration. About 300g of cement was initially mixed with 27% mixing water. The test is carried out with different specimens and results were noted. Fresh cement was taken for each repetition of the experiment. The plunger was cleaned each time the experiment is done.

3.2 Initial and Final Setting Times

By using the Vicat's apparatus the initial and final setting time tests were conducted at room temperature, and at a relative humidity of 90%.By following the whole procedure, with many specimens, the initial and final setting times were noted with the help of the stop watch.

3.3 Soundness Test

Le-chatelier's apparatus is used for the determination of soundness of cement (IS 5514: 1969).For each concentration of the mixing water, three samples were tested and the mean value was taken as the soundness of cement sample.

3.4 Compressive Strength Test

Three cubes were tested for compressive strength each time in the 40-tonne universal testing machine at 3-day, 7-day, 14-day, 28-day and 90-day periods. The periods are being reckoned from the completion of compaction. The cubes were tested on their sides without any packing between the cube and the steel platens of the testing machine.

IV. TEST RESULTS

Table 1 Cube Compressive Strength of Cement Mortar with % of Metakaolin

Sl. No.	Materials	Compressive Strength (Mpa)				
		3 - day	7 - day	14 - day	28 - day	90 - day
1	0% Metakaolin or 100% cement	33.13	41.63	47.87	54.13	63.62
2	5 % Metakaolin	32.90	42.14	55.16	63.91	70.13
3	10 % Metakaolin	30.70	42.97	57.21	66.85	72.83
4	15 % Metakaolin	30.16	42.6	56.83	65.74	72.13
5	20 % Metakaolin	28.75	41.9	55.91	64.86	71.62

Table-2

Initial and Final setting times, soundness of cement and compressive strength of zero percent Metakaolin and optimum percent Metakaolin (10% MK) replacement of cement mortar cubes at different ages using distilled water.

Sl. No.	Materials	Initial Setting Time (minutes)	Final Setting Time (minutes)	Soundness (mm)	Compressive Strength (Mpa)				
					3 - day	7- day	14- day	28 - day	90- day
1	0 % MK	143	256	0.50	33.13	41.63	47.87	54.13	63.62
2	10 % MK	127	229	0.50	30.70	42.97	57.21	66.85	72.83

Table 3

Initial and final setting times, soundness of cement and compressive strength of blended cement (10%MK) mortar cubes of various concentrations of Hydrochloric acid at different ages

Sl. No.	Water Sample	Initial Setting Time (minutes)	Final Setting Time (minutes)	Soundness (mm)	Compressive Strength (Mpa)				
					3 - day	7- day	14- day	28 - day	90- day
1	Distilled Water	127	229	0.50	30.70	42.97	57.21	66.85	72.83
2	Hydrochloric Acid (HCL),N								
	a) 0.01 N	128	231	0.50	30.37	43.21	50.98	52.93	60.75
	b) 0.02 N	131	243	1.00	29.88	42.61	49.93	51.95	59.74
	c) 0.03 N	136	255	1.50	29.41	42.12	49.00	50.93	58.81
	d) 0.04 N	152	278	2.00	28.94	41.63	48.07	49.96	57.81
	e) 0.05 N	164	303	2.50	28.41	41.14	47.02	49.00	56.83

Table 4

Initial and final setting times, soundness of cement and compressive strength of blended cement (10%MK) mortar cubes of various concentrations of sulphuric acid at different ages

Sl. No.	Water Sample	Initial Setting Time (minutes)	Final Setting Time (minutes)	Soundness (mm)	Compressive Strength (Mpa)				
					3 - day	7- day	14- day	28 - day	90- day
1	Distilled Water	127	229	0.50	30.70	42.97	57.21	66.85	72.83
2	Sulphuric Acid(H_2SO_4),N								
	a) 0.01 N	129	232	0.50	30.39	42.58	45.09	49.99	55.87
	b) 0.02 N	135	246	1.30	29.87	42.12	44.11	48.01	53.92
	c) 0.03 N	153	257	1.60	29.41	41.15	43.16	46.07	51.93
	d) 0.04 N	168	282	2.20	28.92	40.16	42.18	44.13	49.95
	e) 0.05 N	183	309	2.80	28.46	39.22	41.13	42.17	48.05

V. CONCLUSIONS

Based on the results obtained in the present investigation the following conclusions can be drawn:

* The compressive strength of mortar increased with increasing Metakaolin content.

*Maximum improvement in the compressive strengths of cement mortar can be achieved for a replacement of 10% Metakaolin.

*The compressive strength of mortar increase with replacement of Metakaolin content especially at the later ages (after 7 days)

*Metakaolin accelerates the initial and final setting of cement.

*Presence of HCL in water in concentrations more than 0.04N and 0.03N retards significantly the initial and final setting times respectively. Further a concentration higher than 0.005N results in significant decrease in compressive strength.

*Presence of H_2SO_4 in concentrations more than 0.03N and 0.03N retards significantly the initial and final setting times respectively. Further a concentration higher than 0.004N results in significant decrease in compressive strength.

*Strong acidic substances under consideration (HCL and H2SO4) in water reduce the compressive strength significantly right from 14-days to 28-days age, thus requiring caution in the use of water containing these substances.

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