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Metakaolin Influence on Concrete Durability Properties

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Abstract*: Mineral admixtures are being used today almost in all concretes partially, to improve workability, engineering properties and also to enhance durability of the concrete. These admixtures are industrial by-products. In the present study, mineral admixture such as metakaolin (MK) is replaced partially in cement to investigate permanence properties of concrete in terms of initial water absorption, final water absorption and confrontation to acid attack. Inorder to identify the durability properties, concrete of M30 grade was prepared. The mineral admixture content was varied from 0% to 30% by volume of cement with 10% gradient. In acid attack, 3% H_2SO_4 solution is used for curing of specimens and the corresponding weight losses (%) were evaluated for curing periods of 7 days, 14 days and 28 days. Both initial and final water absorptions of the metakaolin-modified concrete have been improved when metakaolin content was increased up to 10% advantageously. And, also weight loss was decreased when metakaolin content varied from 0% to 30%.

Keywords* : Concrete, Metakaolin, Initial water absorption, Final water absorption and Acid attack.

I. INTRODUCTION

Now-a-days, pozzolanic material based concretes are extensively used throughout the world. So, utilization of mineral admixtures in concrete may liable for enhancement in strength and permanence which also helps to environment by bringing solution to disposal problems of such materials. Therefore, it may be of assistance in decreasing global warming problems by dropping the practice of cement. Subsequently, the expenditure of cement may decrease by reason of such pozzolanic materials.

Incorporation of such materials in concrete not only reduces the pollution emission, but also helps in significant improvement of workability and durability.

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II. LITERATURE REVIEW

After intrusion of flyash in concrete by replacing up to 30%, drastic increase in compressive strength was observed at higher curing periods. The addition of flyash in concrete showed a good impression in durability properties like sorptivity , chloride ion permeability and drying shrinkage[1]
The fly ash effect on durability of concrete was studied. It was observed that the C-S-H gel is reacting with fly ash due to less calcium hydroxide availability resulting in decrease of permeability [2].
The utilization of GGBS in concrete also improved the strength and durability properties at 20% and 30% replacement levels[3].
The resistance to sulfate attack was depended on the amount of C_3A content and ratio of water to cement in concrete. It has experimentally proved that concrete with higher C_3A content failed to resist sulfate attack at higher time. But concrete with 25% and 45% flyash showed better results [4].
The rice husk ash didn't show any appreciable strength enhancement in concrete at early ages. Although, the concrete's density is reduced with increase in rice husk ash content, the compressive strength was found to be good at higher curing periods[5].
The replacement of rice husk ash in cement to the flyash modified concrete showed good results in development of flexural strengths at higher curing periods [6].
The silica fume showed a better result in strength and durability enhancement at lower contents in high performance concretes [7].
The durability property viz. water permeability was reduced by utilization of flyash and silica fume in concrete at lower percentages [8].
The concrete with 15% of silica fume showed a good performance in resistance to corrosion when tested under the chemical environments like ammonia nitrate, sulfate compounds, calcium chloride and various kinds of acids [9].
Incorporation of Metakaolin in concrete developed the mechanical properties, durability properties of concrete and decreased the chloride dispersion also. An exponential connection was observed between compressive strength and chloride permeability of concrete [10]. In addition to the partial replacement of cement with metakaolin in concrete, the effect of w/b ratio, curing period, air content and curing type on the durability properties of concrete was evaluated. Concrete modified with Metakaolin at lower w/b ratios, cured in autoclaved conditions with air entrainment shoed superior results in resistance to sulfate attack [11]. Similar behavior of concrete was observed in the experimental work performed by Erhan and kasim(2007).

Concrete prepared with Metakaolin showed a drop in sorptivity and chloride permeability [12].
The chloride permeability of concrete with flyash and metakaolin was evaluated at various temperatures. It was observed that the modified concrete with Metakaolin and flyash showed lower permeability at lower temperatures [13].

Concrete made of partially replaced Metakaolin with increased water binder ratio showed a reduction in compressive strengths after subjected to hydrochloric acid curing [14].

III. EXPERIMENTAL PROGRAM

A. Materials used

The usual construction materials like cement, aggregates and water were used in the preparing the specimens for durability tests. In addition to above mentioned materials metakaolin was also used as partial substitute of cement to study its influence on durability properties. Tests on the material were performed to identify their properties.
The physical properties of cement viz., specific gravity, consistency, initial and final setting times were calculated and their values are 3.15, 33%, 86 minutes and 254 minutes respectively.
The specific gravities of fine and coarse aggregate were found to be 2.55 and 2.65 respectively.
The pH value of water was observed to be in permissible limit to use in concrete making.
The specific gravity of metakaolin was calculated as per IS 1727 and the values were 2.77 and 2.60 respectively.

B. Durability tests performed

To evaluate the concert of concrete in durability criteria some tests were conducted viz., water absorption and resistance against acid attack.

IV. RESULTS AND DISCUSSIONS

A. Water absorption

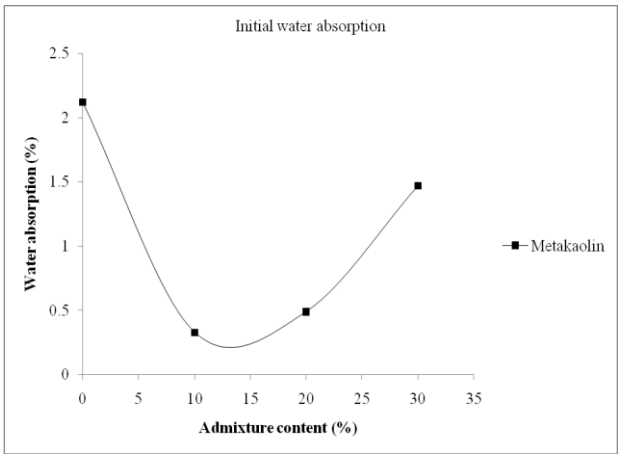

Fig. 1. Initial water absorption

The variation of initial water absorption (%) with admixture content (%) was showed in Figure 1. When metakaolin content raised from 0% to 30%, initial water absorption was reduced. For instance, when metakaolin content augmented from 0% to 30%, initial water absorption was reduced from 2.12% to 1.47%. The maximum decrement of initial water absorption for metakaolin content of 10% is 0.33% .

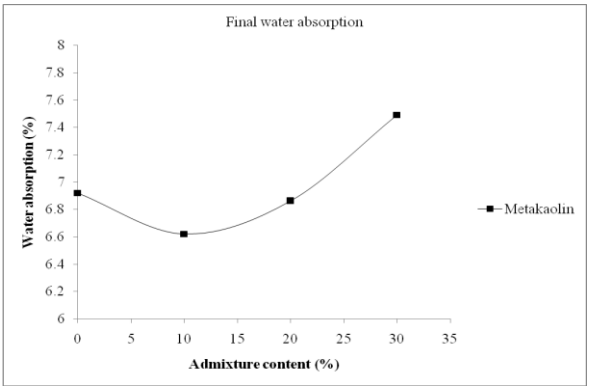

Fig. 2. Final water absorption

Figure 2 shows the variation of 96 hours of final water absorption (%) with admixture content (%). The final water absorption value was increased when mineral admixture content augmented from 0% to 30%. For example, when metakaolin content augmented from 0% to 30%, the final water absorption was increased from 6.92% to 7.49%. But, the final water absorption was decreased from 6.92% to 6.62% when metakaolin content increased up to 10% and thereafter it increased at higher content of metakaolin.

B. Acid attack

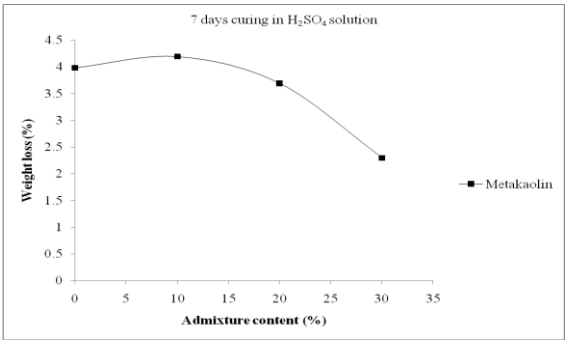

Fig. 3. The variation of percentage weight loss with the admixture content (%) (7 days)

The variation of percentage weight loss with the admixture content (%) at 7 days curing in H_2SO_4 solution was shown in figure 3. The weight losses (%) of specimens were calculated. With increase in the metakaolin content from 0% to 30%, the weight loss (%) was decreased gradually from 3.98% to 2.3%.

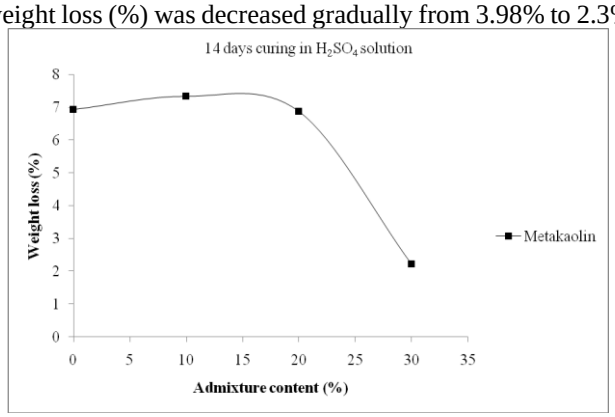

Fig. 4. The variation of percentage weight loss with the admixture content (%) (14 days)

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The variation of percentage weight loss with the admixture content (%) at 14 days curing in H_2SO_4 solution was shown in figure 4. The weight losses (%) of specimens were calculated. The weight loss (%) was decreased from 6.93% to 2.22% when metakaolin content increased from 0% to 30%.

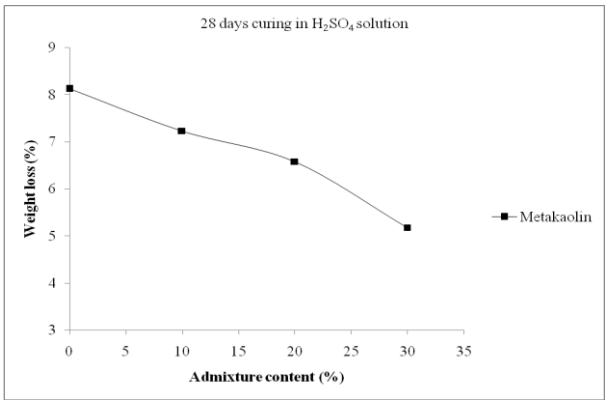

Fig. 5. The variation of percentage weight loss with the admixture content (%) (28 days)

The variation of percentage weight loss with the admixture content (%) at 28 days curing in H_2SO_4 solution was shown in figure 5. The weight losses (%) of specimens were calculated. The weight loss (%) was decreased from 8.12% to 5.18% when metakaolin content augmented from 0% to 30%.

V. CONCLUSIONS

- The reduction in initial water absorption was about 84.40% when the metakaolin content augmented from 0% to 10%
- For 96 hours of final water absorption, the reduction was about 4% when the metakaolin content (%) augmented from 0% to 10%
- The concrete deterioration pertains to 3% H_2SO_4 solution has shown that the weight loss reduced gradually with the increase in metakaolin content (%). The reduction losses of weights were about 42.2%, 67.9% and 36.2% for curing periods of 7, 14 and 28 days respectively when metakaolin content (%) increased from 0% to 30%.

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