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The Effect Of Metakoline And Rice Husk Ash On High Strength Concrete

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Abstract

Concrete has become basic material in day to day life of humans. In recent years lot of research is going on the development of high strength concrete by using supplementary materials for cement and aggregates. The present investigation is mainly focused on the effect of mechanical properties and durability of high strength concrete with supplementary materials. In this investigation concrete having compressive strength M70 with rice husk ash (RHA) and Metakoline as supplementary materials. RHA added to the concrete with 0 to 20 % by weight of cement. Metakoline is replaced by 0 to 20%. Fresh properties of concrete like slump and hardened properties like compressive strength, split tensile, flexural strength after 28 days of curing are conducted along with durability. Mechanical properties were conducted for 7 and 28 days. Sorpitivity, Sulphate (H_2SO_4) and chloride (HCl) attack were conducted to study the effect on durability. The results show that FA and RHA can be used as supplementary cementitious material with optimum dosages.

1.0 INTRODUCTION

The ability to mould concrete into any shape and size, because of its plasticity in green stage and its subsequent hardening to achieve strength is particularly useful. Concrete like other engineering materials

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needs to be designed for properties like strength, durability, workability and cohesion. Concrete is basic engineering material used in most of the civil engineering structures. Its popularity as basic building material in construction is because of, its economy of use, good durability and ease with which it can be manufactured at site. Concrete mix design is the science of deciding relative proportions of ingredients of concrete, to achieve the desired properties in the most economical way. With advent of high-rise buildings and pre-stressed concrete, use of higher grades of concrete is becoming more common. Even the revised IS 456–2000 advocates use of higher grade of concrete for more severe conditions of exposure, for durability considerations. Rice husk is a potential material, which is amenable for value addition. The exterior of rice husk are composed of dentate rectangular elements, which themselves are composed mostly of silica coated with a thick cuticle and surface hairs. The mid region and inner epidermis contain little silica confirmed that the presence of amorphous silica is concentrated at the surfaces of the rice husk and not within the husk itself.

2.0 LITERATURE REVIEW

Rands et al. [3] found that both the acidity and ionic strength in rainwater played an important role in limestone deterioration. Shadong et al [4] conducted the laboratory experiments on the acid rain effect on cement concrete. They have concluded that the deterioration of acid rain on the concrete specimen is caused by both H+ dissolution and SO_4^{2-} expansion. Rostami and Brendley [5] tested the acid resistance of alkali fly ash concrete (cured at 40–90˚C) in terms of mass loss. Marble and limestone specimens were exposed for one year by Young dall and Doe [1] to ambient atmospheric conditions in four cities of Eastern USA. The results show that the specimens were damaged by calcium loss due to acid deposition. Neal et al. [2] conducted the experiments on marble were exposed to simulated acid rain of different pH values by to corrosion levels equivalent to exposure to ambient atmosphere for a 10 – year period. Results shows the dissolution rate decreased logarithmically with time and was determined by the transport rate of dissolved ions. Torii and Kawamura [6] investigated the effect of using silica fume and fly ash as partial replacement for cement on the resistance of concrete to a 2% solution of sulphuric acid. They concluded that such a partial replacement for cement could not effectively prevent the acid-type deterioration involving surface scaling and softening of mortar. Ali Reza [7] investigated mechanical and durability properties of ternary concrete by combining silica fume and low blast furnace reactive slag with different mix proportions. By the use of ternary mixes, 28 day durability properties of slag based blended concrete was increased compare to the conventional concrete with addition of silica fume. The present investigation mainly focused on the curing of concrete in acid environment. In this investigation two types of acids i.e., HCl and H_2SO_4 are used and concrete having compressive strength 70MPa has been used.

3. MATERIALS USED

3.1 Cement

Ordinary Portland cement of 53 grades available in local market is used in the investigation. The cement used has been tested for various proportions as per IS: 4031-1988 and found to be conforming to various specifications of IS: 12269-1987. The specific gravity was 3.16

3.2 Fine aggregate

River sand procured from Karimnagar has been used. The fine aggregate having specific gravity 2.62. The sample is confirming to zone II and fineness modulus is 3.16.

3.3 Coarse aggregate

10 mm and 20 mm crushed gravel of 2.69 specific gravity was used. The coarse aggregate was air-dried in the laboratory and sieve analysis was carried out.

3.4 Rice husk

The chemical composition of rice husk is similar to that of many common organic fibres and it contains of cellulose 40–50%, lignin 25–30%, ash 15–20% and moisture 8–15%. Rice husk ash contains 87–97% of silica with small amount of alkalis and other trace elements.

3.5 Super plasticizer

High Range Water Reducing Admixture (HRWRA) confirming to ASTM C 494 commonly called as super plasticizers, are

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used for improving the flow or workability for decreased water-cement (w/c) ratio without sacrifice in the compressive strength. These admixtures when they disperse in cement agglomerates significantly decrease a viscosity of the paste by forming a thin film around the cement particles. In the present investigation water-reducing admixture CONPLAST SP430 obtained from FOSROC Chemicals, Bangalore was used.

3.6 Sulphuric acid

Historical name of this acid is oil of vitriol. Sulphuric acid is a highly eroding, tough mineral acid with the molecular formula H_2SO_4. It is a pungent-ethereal, colourless to slightly yellow viscous liquid which is soluble in water at all concentrations. Sometimes, it is dyed dark brown during production to alert people to its hazards. Sulphuric acid at a high concentration can cause very serious damage upon contact, as it not only causes chemical burns via hydrolysis, but also secondary thermal burns via dehydration. It burns the cornea and can lead to permanent blindness if splashed onto eyes.

3.7 Hydrochloric Acid

Hydrochloric acid is a clear, colourless, highly pungent solution of hydrogen chloride (HCl) in water. It is a highly corrosive, strong acid with many industrial uses. Hydrochloric acid is found naturally in gastric acid. Historically called spirits of salt, hydrochloric acid was produced from vitriol (sulphuric acid) and common salt. We poured 1ml acid for 1 litre of water to dilute the both acids. So that it could not harmful for the skin while putting and taking of specimens.

3.8 Water

Potable water was used in the experimental work for both mixing and curing.

3.9 Metakoline: specific gravity of metakoline was found to be 2.56.

Figure – 1: Rice Husk Ash

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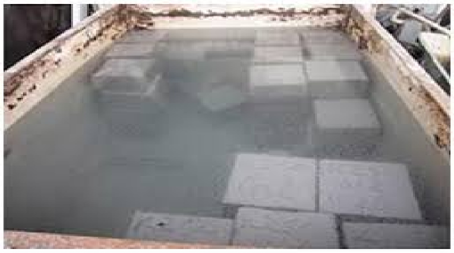

Figure – 2: Curing of the specimens

4. EXPERIMENTAL PROCEDURE

The investigation was aimed at studying the effect of RHA and metakoline on compressive strength, split tensile strength, flexural strength of M70 grade of concrete. Mix proportioning of concrete will be done based on IS 10262: 2009. To study on effect on early strength of concrete the specimens will be tested for 28 days. Standard cubes (150x150x150 mm), cylinders (150 mm diameter, 300 mm height), prisms (100x100x500 mm) will be cast to investigate the behaviour on mechanical properties. Slump and Compaction factor will be done to test the effect on workability of concrete due to RHA and metakoline. The replacement of Rice husk ash will be varied from 0 to 20% with an increment of 10 % i.e 0, 10% and 20% replacement to cement. The replacement of metakoline will be varied from 0 to 20% with an increment of 10% i.e 0, 10% and 20% replacement to cement. The experimental investigations are conducted on M70 grade with different dosages of metakoline and RHA have been analysed. In the present work, to study the workability of fresh concrete with slump cone test and compaction factor, hardened properties with compressive strength, split tensile strength and flexural strength were conducted in first phase of experimental investigation on two grades of concrete are considered and the results of the tested specimens are presented in this chapter. Durable properties were studied for optimized dosages of metakoline and RHA from phase-I and phase-II of the experimental investigation. Durability of blended concrete is studied by acid attack of Hydro Chloric acid and Sulphuric acid along sorpitivity.

4.1 Phase – I: The effect of metakoline on mechanical properties of concrete were examined by conducting compressive test on cubes, split tensile strength (indirect tension test), flexural test on prisms as per Indian standard testing procedure for hardened

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concrete. Standard concrete specimens were cast in different dosages of metakoline varying from 0 to 20% by replacing cement. Dosages were incremented at regular interval of 5% from 0 to 20% which include 0, 5%, 10%, 15% and 20%. 60 standard cubes of size150x150x150mm, 60 standard cylinders of 300mm height and 150mm diameter and 60 standard prisms of size 100x100x500mm were cast to evaluate compressive strength, split tensile strength and flexural strength (rupture strength of concrete) respectively.

4.2 Phase-II: It is been determined from the phase-I of the experimental investigation that replacement of cement with fly ash can be restricted to only 15% to obtain a concrete with good workable properties as well as mechanical properties. In phase-II of experimental investigation is conducted by adding supplementary cementitious material Rice husk ash (RHA). A triple blended concrete is obtained in this phase with cement, metakoline, RHA. Standard concrete specimens were cast in different dosages of RHA varying from 0 to 20% by replacing cement along optimized metakoline dosage 15%. Dosages were incremented at regular interval of 5% from 0 to 20% which include 0, 5%, 10%, 15% and 20%. 60 standard cubes of size150x150x150mm, 60 standard cylinders of 300mm height and 150mm diameter and 60 standard prisms of size 100x100x500mm were cast to evaluate compressive strength, split tensile strength and flexural strength (rupture strength of concrete) respectively. The effect of RHA on properties were being experimentally investigated in phase-II of the study. The effect of RHA on workability is determined by performing slump cone test and compaction factor test as per Indian standards on fresh concrete.

Table 1 - Mix Proportions of mixes M70 grade in kg/m^3

Cement	**Fine Aggregate**	**Coarse Aggregate**	**Water**	**Super Plasticizer**
440	847	970	144	1.7

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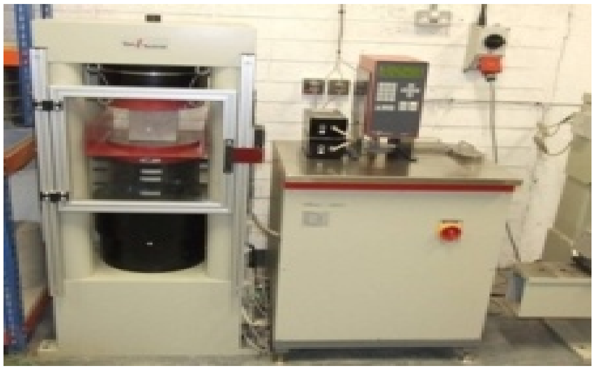

Figure – 3: Testing of specimens

5. RESULTS AND DISCUSSION

5.1 Workability:

Workability test is performed on the fresh concrete by slump cone and compaction factor test. Slump cone test and compaction factor were conducted as per Indian standards as explained in previous chapter. The results of slump cone and compaction factor test for M70 grade of concrete with replacement of metakoline in Phase-I and with RHA in phase-II of the experimental investigation for different dosages are shown in table 2 and 4.

Table 2 – Slump and compactor factor test values of concrete with metakoline replacement

Replacement of metakoline	Slump (mm)	Compaction Factor Test
0	106	0.91
5	110	0.92
10	115	0.95
15	122	0.96
20	128	0.97

Table 4 –Workability results of concrete with RHA & optimised metakoline

Replacement of RHA	Slump (mm)	Compaction Factor Test
0	98	0.93
5	102	0.94
10	104	0.95
15	106	0.95
20	110	0.96

5.2 Mechanical Properties:

Fresh properties of concrete like workability has performed using slump test. Slump is decreasing as the percentage of rice husk increases. Compression testing machine of 2000 kN used for the compression test and 600 kN UTM has been used for the split tensile test and flexural test. The results of compressive strength, split tensile strength and flexural strength are given in the Table 3 and 5 respectively.

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Table 3 - Compressive strength of concrete with metakoline replacement

Replacement of Metakoline	Compressive Strength (MPa)	Split Tensile Strength (MPa)	Flexural Strength (MPa)
0	70.5	4.06	5.72
5	73.1	4.19	5.86
10	74.6	4.22	5.92
15	78.2	4.32	6.21
20	73.8	4.21	5.96

Figure 4: Variation of compression strength with RHA and optimized metakoline

Table 5 - Compressive strength of concrete with RHA & optimised metakoline

Replacement of RHA	Compressive Strength (MPa)	Split Tensile Strength (MPa)	Flexural Strength (MPa)
0	74.6	4.22	5.92
5	76.7	4.33	5.97
10	84.4	4.41	6.34
15	79.3	4.27	6.18
20	75.2	4.17	6.06

Figure 5: Variation of split tensile strength with RHA and optimized metakoline

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Figure 6: Variation of flexural strength with RHA and optimized metakoline

5.2 Durability:

5.2.1 Chloride and Sulphate Attack: The specimens are weighed before drying. The drying was carried out in a hot air oven at a temperature of 105ºC. The drying process was continued until the difference in mass between two successive measurements at 24 hours intervals agreed closely. The dried specimens were cooled at room temperature and then immersed in acid. The specimens were taken out at regular intervals of time, surface dried using a clean cloth and weighed. This process was continued till the weights became constant (fully saturated). The difference between the measured acid saturated mass and oven dried mass expressed as a percentage of oven dried mass gives the absorption of acid. The acid solution becomes less acidic after a concrete specimen has been submerged in it for a period of time. The reason for decrease in acidity is that concrete is an alkaline material. Acid attacks are done with 5% acid conditions. The results of acid attacks are shown in Table 7 and 8.

When the concrete is exposed to sulphuric acid solution, hydrogen ions and sulphate ions deteriorate the concrete properties by reacting with hydration products to make cement matrix more porous and/or expansive (Joong-KyuJeon 2006). Concrete is chemically stable in an alkaline environment, but unstable in neutral or acidic environment. Hydrogen ions in sulphuric acid usually react with calcium ions in cement matrix then to decompose the hydration products as seen in the following chemical equations.

$Ca\ (OH)_2 + 2H+\ Ca_2+ + 2H_2O$

CSH gel: $3CaO \cdot 3H_2O + 6H+\ 3Ca_2+ +2SiO_2 + 6H_2O$

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Ettringite: $3CaO \cdot Al2O_3 \cdot 3CaSO_4 \cdot 32H_2O + 6H+ 3Ca_2+ + Al_2O_3 \cdot 3H_2O + 3CaSO_4 + 32H_2O$

Sulphate ions penetrated into concrete in general react with calcium hydroxide of cement matrix to form gypsum, which softens the inner concrete structure and decreases the concrete properties. The gypsum in cement softens concrete and decomposes hydration products and thus the weight and strength of the concrete specimens are reduced. It is observed that, the degree of deterioration is dependent on binder and it is attributed to different hydration products and the rate of hydration. The higher calcium hydroxide implies that higher probability of formation of gypsum in the cement matrix. In this investigation rice husk is acts like a fibre in the concrete matrix. Mechanical properties like compressive strength and split tensile strength of concrete is more in concrete cured HCl solution compared to concrete cured in sulphuric acid.

Table 7 –Durability of concrete with optimized RHA and optimized metakoline

Replacement of RHA	Compressive Strength (MPa)	
	HCl	H_2SO_4
0	67.6	66.8
5	69.3	68.8
10	76.4	75.6
15	71.7	71.4
20	70.6	70.6

Table 8- Percentage reduction in compressive strength of concrete due acid attacks with RHA and optimized metakoline

Replacement of RHA	Percentage reduction in compressive Strength	
	HCl	H_2SO_4
	28 Days	28 Days
0	8.15	9.24
5	8.45	9.11
10	7.28	8.25
15	8.43	8.81
20	8.55	8.55

6.0 CONCLUSIONS

- The workability of high strength concrete is marginally effected with the addition of metakoline and RHA.

Metakoline and RHA replacement to cement has increased the mechanical properties of concrete in both phases of investigation.

- Upto 15% replacement of metakoline the strength properties have increased but later with the increase in replacement decrement is observed. Similarly, upto 10% replacement of RHA the strength properties have increased but later with the increase in replacement decrement is observed. Thus, 15% and 10% are optimum replacement dosages of metakoline and RHA in strength characteristic point of view.
- Sorptitiviy of concrete with metakoline and RHA is significantly because of more homogenous mix of concrete is obtained by supplementary materials.
- The percentage loss of weight due to acid and alkaline attack has decreased with the increase in replacement upto 20% RHA. Certainly, considering workability, mechanical properties and durability 10% RHA replacement to cement will be optimum usage.

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