Comparative Study of Rice Husk Ash, Metakaolin & Standard Concrete

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Abstract— This paper summarizes the comparison between properties of Rice Husk Ash (RHA) and Metakaolin when used as partial replacement for Ordinary Portland Cement (OPC) in concrete. OPC was replaced with these mineral admixtures at 5%, 10% and 15% by weight. 0% replacement served as the control. Compressive Strength test was carried out on hardened 150mm concrete cubes after at 1, 3, 7, 28, 45 & 56 days curing in water. Compression strength test confirms its suitability as a partial replacement mineral admixture.

Index Terms —Cement, Compressive strength, Metakaolin, Rice Husk Ash (RHA)

I. INTRODUCTION

In present era the development of a nation is symbolized by presence of its infrastructure, there is a huge demand for sustainable development of infrastructure in developing as well as in developed countries. Concrete being the most versatile and used construction material on earth facing the scarcities of its prime constituent i.e. cement. Use of cement as a binding material not only imposes limitation on compressive strength of concrete but also leads to excessive heat of hydration, increases potential chloride attacks, adds to cost, reduces durability of concrete and structure as a whole.

Use of Mineral admixtures has been practiced recently in order to overcome these effects. In this paper we summarize two such admixtures namely RHA and Metakaolin.

Rice milling generates a byproduct known as husk. This surrounds the paddy grain. During milling of paddy about 78% of weight is received as rice, broken rice and bran .Rest 22% of the weight of paddy is received as husk. RHA is produced by burning rice husk between 600 and 700°C temperatures for 2 hours. It contains 90-95% SiO_2, 1-3% K_2O and < 5% unburnt carbon. Rice Husk Ash (RHA) has been reported to be a good pozzolan by numerous researchers. During mass concrete, as compared to OPC concrete, RHA is very effective in reducing the temperature of mass concrete.

Table 1: Physical and Chemical properties of RHA

PROPERTIES	SPECIFICATION
Appearance	Grey Black
Bulk Density (gm/cc)	0.58
Moisture at 105^{o}C	1.87%
Loss On Ignition	< 6.0%
Residue on 350µ mesh	< 0.5%
SiO_2+Al_2O_3+Fe_2O_3	min. 90%

Metakaolin is a semi-natural product which is obtained by calcinations of kaolin clay at a temperature between 500^{0}C to 800^{0}C. Metakaolin is produced under controlled conditions to refine its color, remove inert impurities and produce particle size to high degree of purity and pozzolanic reactivity. Incorporating Metakaolin in concrete add to various properties of concrete. In fresh state of concrete, it eliminates or minimizes the bleeding, reduces segregation. The resistance to chloride ion penetration, fire and water permeability also becomes better. Due to improved microscopic structure concrete becomes durable.

Table 2: Physical and Chemical properties of Metakaolin

PROPERTIES	SPECIFICATION
Appearance	Off White to Buff
Bulk Density (gm/cc)	0.35-0.50
Moisture at 105^{o}C	< 0.5%
Loss On Ignition	< 2.0%
Residue on 350µ mesh	< 0.5%
SiO_2+Al_2O_3+Fe_2O_3	min. 90%

II. MATERIALS AND METHODS

- Materials

1. Cement- Ambuja OPC 53 grade of cement was used.

2. Flyash- Ashtech (India) Flyash was used.

3. Metakolin- 20 micron

4. RHA- RHA was obtained from Orissa, India.

5. Coarse Aggregate (10mm & 20mm)-Turbe (Quarry), Navi-Mumbai, India.

6. Fine Aggregate (crushed sand -VSI) - Turbe (Quarry), Navi-Mumbai, India.

7. Water-Bore well water used. The water used was clean and free from any visible impurities. With conformation to IS 456-2000 requirements.

8. Admixture- Super plasticizer Sikament 5204NS (to increase workability)

III. METHODOLOGY

- Mix Design

Department of Environment (DOE) Method is used to design the M40 concrete.

Four trials as 0%, 5%, 10% and 15% replacement of metakaolin and RHA with binder are designed. The design mix includes 130Kg of fly ash as a constant ingredient in all the mixes.

The proportions for trial mixes are presented in the tables below.

Table 3: Mix Design for M40 (Standard Concrete)

M40	**1 CUM (kg)**	**0.05 CUM (kg)**
Cement	400	20
Flyash	130	6.5
C/Sand	453.72	22.69
C.A 1	504.86	25.24
C.A 2	757.28	37.86
Water	180	9
Admixture	5.3	0.265

Table 4: 5% Replacement of OPC with RHA/ Metakaolin

M40	**1 CUM (kg)**	**0.05 CUM (kg)**
Cement	393.5	19.675
Flyash	130	6.5
RHA/Metakaolin	6.5	0.325
C/Sand	644	32.2
C.A 1	440	22
C.A 2	640	32
Water	182.4	9.12
Admixture	5.3	0.265

Table 5: 10% Replacement of OPC with RHA/ Metakaolin

M40	**1 CUM (kg)**	**0.05 CUM (kg)**
Cement	387	19.35
Flyash	130	6.5
RHA/Metakaolin	13	0.650
C/Sand	644	32.2
C.A 1	440	22
C.A 2	640	32
Water	182.4	9.12
Admixture	5.3	0.265

Table 6: 15% Replacement of OPC with RHA/ Metakaolin

M40	**1 CUM (kg)**	**0.05 CUM (kg)**
Cement	380.5	19.025
Flyash	130	6.5
RHA/ Metakaolin	19.5	0.975
C/Sand	644	32.2
C.A 1	440	22
C.A 2	640	32
Water	182.4	9.12
Admixture	5.3	0.265

- Test Cubes

Specimen cubes of size 150mm X 150mm X 150mm were casted for compression test under controlled environment.

- Testing of samples

The cubes prepared for testing were cured properly and tested as per compression test procedures in digital Compression testing machine of 3000 KN capacity. Tests are carried out at the age of 1, 3, 7, 28, 45 and 56 days of test cubes. The tests results are reported in table for control, RHA & Metakaolin concrete respectively. Table tables below gives the test results at respective days.

IV. RESULTS AND DISCUSSIONS

Table 7: Compressive Strength at 5% replacement in MPa

No of Days	**Standard**	**With RHA**	**With Metakaolin**
1	8.56	8.1	13.65
3	19.45	18.56	23.45
7	30.65	28.23	35.85
28	43.86	52.36	51.59
45	53.44	61.52	59.42
56	56.78	64.65	61.32

Table 8: Compressive Strength at 10% replacement in MPa

No of Days	**Standard**	**With RHA**	**With Metakaolin**
1	8.56	10.23	16.63
3	19.45	26.32	31.56
7	30.65	34.33	41.87
28	43.86	51.56	56.40
45	53.44	59.32	61.65
56	56.78	68.23	65.54

Table 9: Compressive Strength at 15% replacement in MPa

No of Days	Standard	With RHA	With Metakaolin
1	8.56	9.65	18.25
3	19.45	21.41	29.85
7	30.65	26.34	36.50
28	43.86	49.64	56.45
45	53.44	56.53	58.25
56	56.78	64.12	60.15

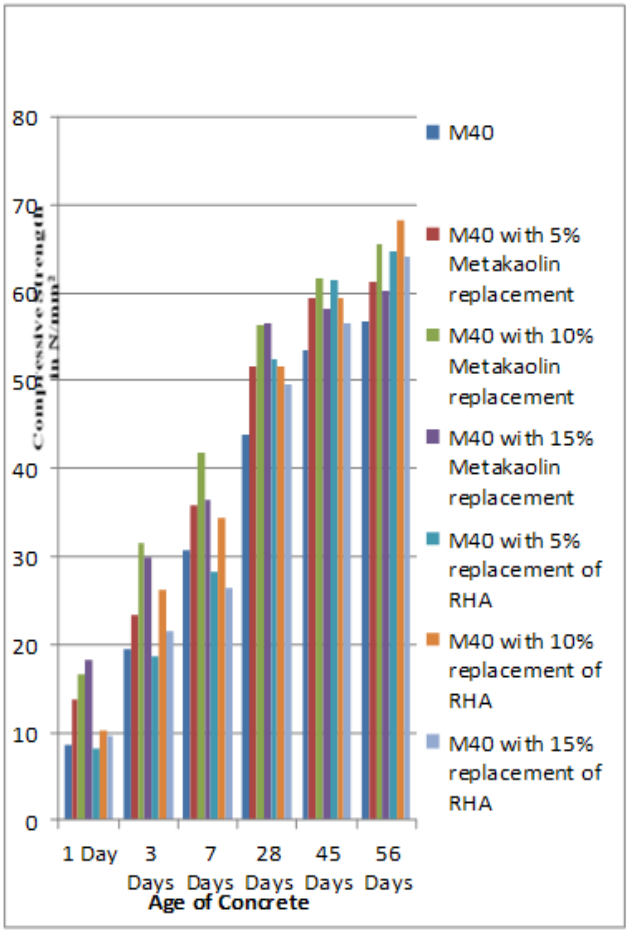

Fig 1: Effect of age on Compressive Strength of Concrete W.R.T Different Replacement of RHA & Metakaolin by the Weight of Cement.

V. CONCLUSION

At all the cement replacement levels of Rice husk ash, the rate of development of compressive strength up to 28 days is slower as compared with that of concrete in which RHA content is zero, while the rate of development of strength gradually increases after 28 days up to 56 days in case of RHA mixed concrete.

The compressive strength of concrete having 10% replacement was found to be more than the other levels of replacements. (I.e. 0%, 5%, & 15%).

For the desired workability and strength, the water content required in case of RHA mixed concrete was more than in normal concrete. This is because RHA is finer than cement & the fact is that RHA particles being finer it has more surface area and hence water required is comparatively more.

Metakaolin replacement accelerates the rate of gain of strength in concrete and is predominant at early age. Metakaolin replacement shows an increase in 28 day strength between 13 to 30 percent with comparison to without replacement mix.

Mixes with 10% and above metakaolin replacements were reported for reduction in workability and makes concrete sticky. Mix with 10% replacement of Metakolin resulted maximum increase in compressive strength.

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