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STUDY ON STRENGTH CHARACTERISTICS OF SUPPLEMENTARY CEMENTITIOUS MATERIAL BASED CONCRETE

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Abstract : *The research was experimentally carried out to investigate the effects of introducing Rice Husk Ash (RHA) or metakaolin in a partial replacement of Ordinary Portland Cement (OPC) on the structural properties to calculate the Strength. Ordinary Portland cement of grades M30 and M60 was replaced by weight of 0%,5%,10%,15%, 20% and 25%. On fresh concrete compacting factor test was carried out and on hardened concrete cube of 150mm. Compressive strength test was carried out after 28 days of curing. This project may show that the compacting factor decreases as the percentage replacement of Ordinary Portland Cement with RHA or Metakaolin increases, which indicates less workable concrete. The compressive strength of hardened concrete decreases with increasing Ordinary Portland Cement with RHA or Metakaolin. This research has proved that RHA or Metakaolin concrete can be used as a Structural Concrete at suitable replacement percentages This study therefore is an investigation of the performances of the concrete made of partially replacing.*

Key words: ***Rice Husk Ash, Cement, Concrete, Compressive strength, Flexural strength, Split tensile strength.***

1.INTRODUCTION

Rice Husk is an agricultural residue widely available in major rice producing countries. The Husk surrounds the paddy grain.During milling process of paddy grain about 78% of weight is obtained as rice, broken rice remaining 22% of the weight of the paddy is obtained as husk.

Generally the Rice Husk Ash is used while burning the the raw clay bricks in brick kilns. Rice Husk Ash is obtained from burning of Rice Husk, which is by-product of rice milling .It is estimated that 1000 kg of rice grain produce 200 kg of Rice Husk ; after Rice Husk is burnt , about 20% of the Rice Husk or 40 kg would become RHA . Rice Husk Ash contains as much as 80-85% silica which is highly reactive, depending upon the temperature of incineration.

2.RICE HUSK ASH

RHA was burnt for approximately 72 hours in air in an uncontrolled burning process. The temperature was in the range of 400^0 - 600^0C. The ash collected was seived through BS standard seive size 75 micron and its colour gray.

Table 1. Chemical Properties of Rice Husk Ash

S.No	Particulars	Properties
1	Silicon Dioxide	86.94 %
2	Aluminium Oxide	0.2 %
3	Iron Oxide	0.1 %
4	Calcium Oxide	0.3 - 2.2 %
5	Magnesium Oxide	0.2 - 0.6 %
6	Sodium Oxide	0.1 - 0.8 %
7	Potassium Oxide	2.15 - 2.30 %
8	Ignition Loss	3.15 - 4.4 %

S. No	Particulars	Properties
1	Colour	Grey
2	Shape Texture	Irregular
3	Mineralogy	Non - Crystalline
4	Particle Size	< 45 microns
5	Odour	Odourless
6	Specific Gravity	2.3

Table 2. Physical Properties of Rice Husk Ash

3. MATERIALS USED

3.1 Water :

Generally, water that is suitable for drinking is satisfactory for use in concrete.In the present experimental programme, potable, fresh, colourless and clean municipal tap water is used for casting.PH of water should be 6 to 8 as much as possible.

3.2 Cement :

Ordinary Portland cement of 53 grade from a single batch was used for the entire work and care has been taken that it has to been stored in airtight containers to prevent it from being affected by the atmospheric and monsoon moisture and humidity. The cement procured was tested for physical requirements in accordance with **IS: 12269-1987** and for chemical requirements in accordance with **IS: 4032-1977**.

Table 3. Properties of cement

S.No	Properties	Values
1	Fineness	7 %
2	Normal Consistency	33 mm
3	Specific Gravity	3.11

3.3.1 Fine Aggregates :

The river sand, passing through 4.75 mm sieve and retained on 600 µm sieve, conforming to Zone II as per **IS 383-1970** was used as fine aggregate in the present study. The sand is free from clay, silt and organic impurities. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk modulus in accordance with **IS:2386-1963.**

S.No	Properties	Values
1	Specific Gravity	2.68
2	Bulk density gm/cc	1.542
3	Fineness Modulus	2.74
4	Zone	II

Table 4: Properties of Fine Aggregates

3.3.2 Coarse Aggregate :

Throughout the investigations, crushed coarse aggregates of 20mm procured from the local crushing plants were used. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density etc. in accordance with **IS:2386-1963 and IS:383-1970**.

Table 5. Properties of Coarse Aggregate

S.No	Properties	Values
1	Bulking Density (γ) gm/cc	1.610
2	Specific Gravity (G)(20mm)	2.73
3	Fineness Modulus	7.17

4. METHODOLOGY

The main objective of this work is to study the suitability of the rice husk ash as a pozzolanic material for cement replacement in concrete. However it is expected that the use of rice husk ash in concrete improve the strength properties of concrete.

Also it is an attempt made to develop the concrete using rice husk ash as a source material for partial replacement of cement, which satisfies the various structural properties of concrete like compressive strength and Flexural strength and Split tensile strength.

4.1 Methodology adopted for mix design :

Mix design is a process of selecting suitable ingredients for concrete and determining their proportions which would

produce economical concrete. The proportioning of the ingredients of concrete is an important segment of concrete technology as it ensures quality and economy. For obtaining the concrete of desired performance characteristics, the component materials should be selected likewise. Then by considering these components, appropriate mix design is prepared.

4.2 Design of concrete mix :

The compressive strength is said to be the index of quality of concrete. Therefore the design mix should be prepared keeping in view compressive strength of concrete with adequate workability so that the fresh concrete can be properly mixed, placed and compacted. The proportions for the mix were calculated adopting the requirements of water as specified in **IS: 10262-2019.**

The following three steps must be followed for proportioning of concrete mixes.

(i) Selection of suitable ingredients-cement, supplementary cementing materials, aggregates, and water and chemical admixtures (if required).

(ii) Determination of the relative quantities of components to have economical concrete, that has desired rheological properties i.e. strength .

(iii) Careful quality control of every phase of the concrete making process.

In the present study Mix Design (Design value at the age of 28 days) grade concrete is done according to **BIS: 10262-2019.**

5. MECHANICAL PROPERTIES

5.1 Compressive Strength :

Specimens were demoulded after 24 hours of casting. Then they were poured in curing tank for the predefined time. At the age of testing, specimens were taken out of the tank and allowed surface drying for 10-15 minutes. Specimens were tested in Compression Testing Machine (CTM) at the load rate of 5 kn/sec specified as per **IS: 516-1959.** CTM has the capacity of 5000kN. The failure load was then evaluated.

Figure 1. Compressive Testing Machine

5.1 Split Tensile Strength :

Specimens were demoulded after 24 hours of casting. Then they were poured in curing tank for the predefined time. At the age of testing, specimens were taken out of the tank and allowed surface drying for 10-15 minutes. Specimens were tested in Universal testing machine (UTM) at the load rate of 70 kn/min. UTM has the load capacity of 1000kN. The failure load was then evaluated. The formula used is Split tensile strength = $0.5187XP / S^2$

P = Failure load, in N

S = Side of cube, in mm

6. RESULTS AND DISCUSSIONS

In this results and discussion the parameters studied on the control concrete and concrete made with replacement of Rice husk Ash with cement. These parameters are Compressive strength, Flexural strength and Split Tensile Strength.

6.1 Compressive strength for trail tests with out RHA replacement :

6.1.1 : Compressive strength of control concrete for M30 grade @ 28 days:

M30 : Compressive Strength @ 28 days

= 35.5 N/mm^2 (Control Mix)

6.1.2 : Compressive strength of control concrete for M60 grade @ 28 days:

M60 : Compressive Strength @ 28 days

= 70.3 N/mm^2 (Control Mix)

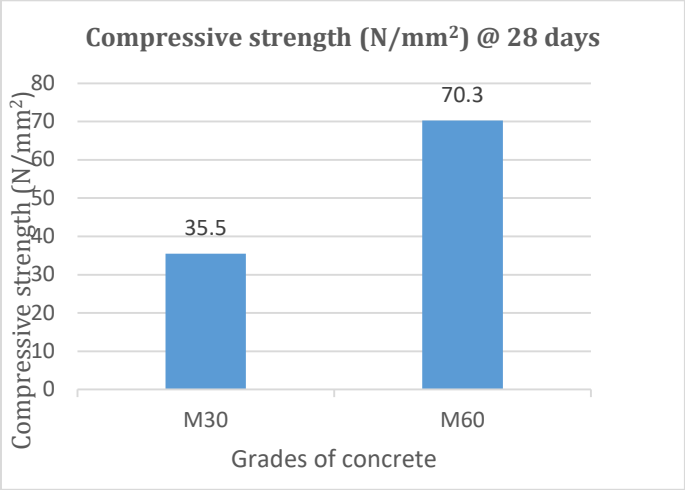


Figure 2. Results of Compressive strength of control concrete for M30 and M60 grade

6.2.1 Compressive strength of RHA concrete in M30 @28 days

Table 6 : Compressive strength of RHA concrete in M30 @ 28 days

Mix	RHA Replacement	Compressive strength (N/mm²)
M1	0 %	35.5
M2	5 %	38.3
M3	10 %	41.2
M4	15 %	43.2
M5	20 %	44.6
M6	25 %	39.6

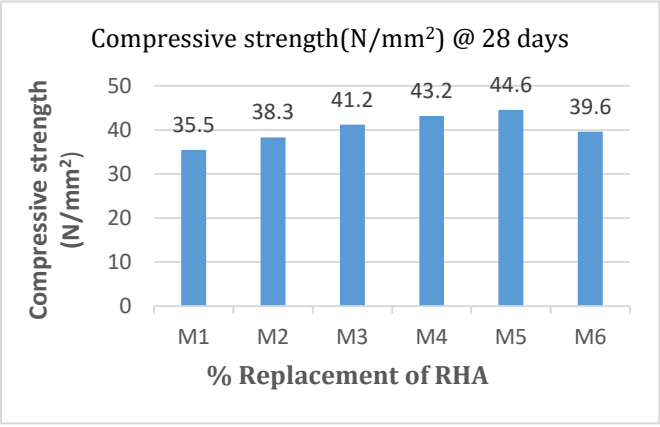


Figure 3. Compressive strength of RHA concrete in M30 @ 28 days

6.2.2 Split tensile strength of RHA concrete in M30 @ 28 days :

Table 7. Split tensile strength of RHA concrete in M30 @ 28 days.

Mix	RHA Replacement	Split tensile strength (N/mm²)
M1	0 %	2.78
M2	5 %	2.90
M3	10 %	3.00
M4	15 %	3.10
M5	20 %	3.17
M6	25 %	2.94

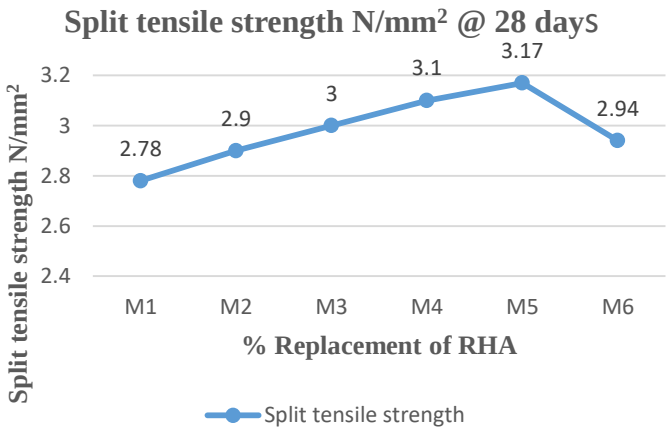


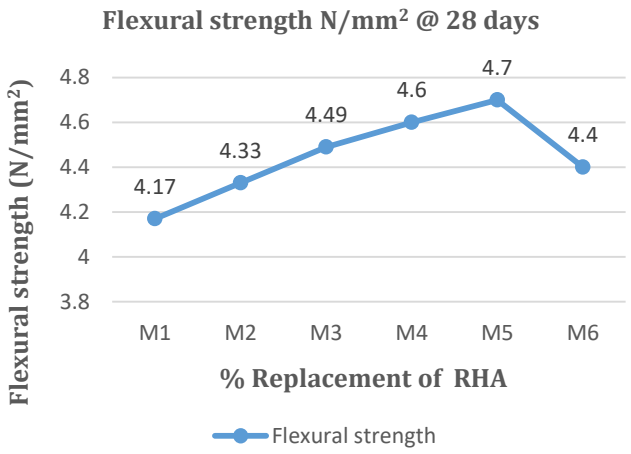
Figure 6.2.2 : Split tensile strength of RHA concrete in M30 @ 28 days

6.2.3 Flexural strength of RHA concrete in M30 @ 28 days :

Table 8. Flexural strength of RHA concrete in M30 @ 28 Days

Mix	RHA Replacement	Flexural strength (N/mm²)
M1	0 %	4.17
M2	5 %	4.33
M3	10 %	4.49
M4	15 %	4.60
M5	20 %	4.70
M6	25 %	4.40

Figure 5. Flexural strength of RHA concrete in M30 @ 28 days



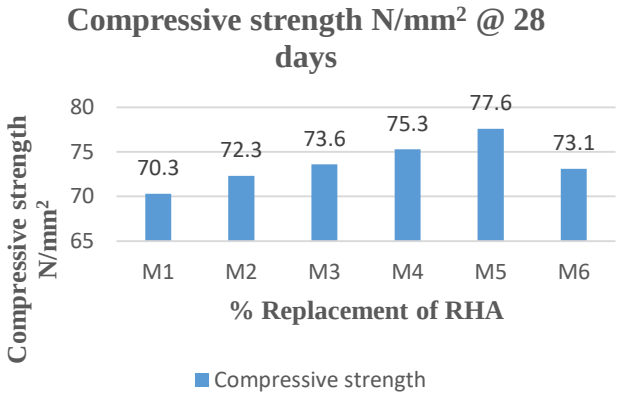
6.3 M60 grade concrete with replacement of cement by Rice Husk Ash (RHA) :

6.3.1 Compressive strength of RHA concrete in M60 @ 28 days :

Table 9 : Compressive strength of RHA concrete in M60 @28 days

Mix	RHA Replacement	Compressive strength (N/mm²)
M1	0 %	70.3
M2	5 %	72.3
M3	10 %	73.6
M4	15 %	75.3
M5	20 %	77.6
M6	25 %	73.1

Figure 6. Compressive strength of RHA concrete in M60 @ 28 days

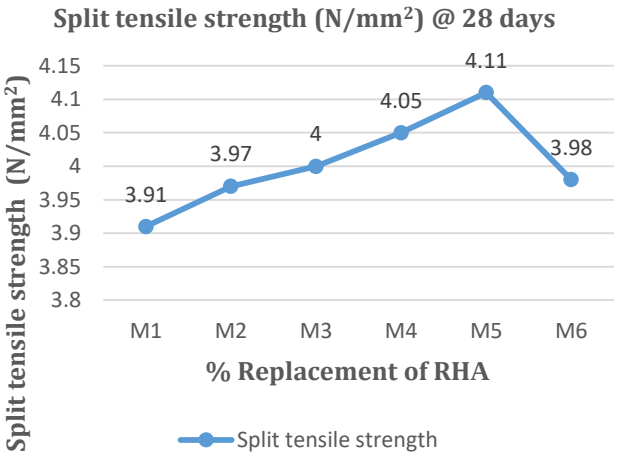


6.3.2 Split tensile strength of RHA concrete in M60 @ 28 days :

Table 10. Split tensile strength of RHA concrete in M60 @ 28 days

Mix	RHA Replacement	Split tensile strength (N/mm²)
M1	0 %	3.91
M2	5 %	3.97
M3	10 %	4.00
M4	15 %	4.05
M5	20 %	4.11
M6	25 %	3.98

Figure 7. Split tensile strength of RHA concrete in M60 @ 28 days

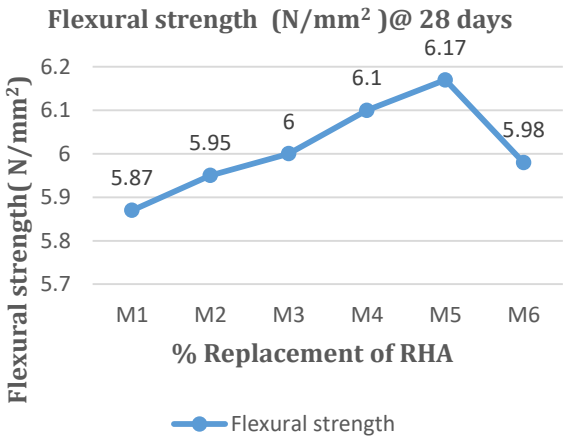


6.3.3 Flexural strength of RHA concrete in M60 @ 28 days :

Table 11. Flexural strength of RHA concrete in M60 @ 28 days.

Mix	RHA Replacement	Flexural strength (N/mm²)
M1	0 %	5.87
M2	5 %	5.95
M3	10 %	6.00
M4	15 %	6.10
M5	20 %	6.17
M6	25 %	5.98

Figure8. Flexural strength of RHA concrete in M30 @ 28 days



7. CONCLUSIONS

After doing this project following conclusions are made :

1) There was a significant improvement in compressive strength with rice husk ash content of 20% for different grades namely M30 and M60 grades and at age of 28 days. The increase in compressive strength was the order of 7.3% to 20% for M30 grade and 2.7% to 9.40% for M60 at 28 days.

2) Flexure strength of RHA concrete in M30 grade there increase in the order of 3.69% to 11.27% for different grades and at the age of 28 days

3) Flexural strength of RHA concrete in M60 grade there increase in the order of 1.344% to 4.862% for different grades and at the age of 28 days.

4) The split tensile strength of RHA - OPC concrete decreases as the percentage replacement of OPC with RHA increases. There was enormous reduction in split tensile strength as the percentage of rice husk ash increased in strength decreased enormously at 25% for both the grades and at the age of 28 days.

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