Partial Replacement of Cement with Rice Husk Ash and Phosphogypsum

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Abstract - *Traditional building supplies such as cement, fine aggregate, and coarse aggregate are in short supply due to the enormous increase in construction activity. Partially replacing cement will actually accomplish the rising demand for cement and concrete. The goal of this experiment was to investigate whether using rice husk ash and phosphogypsum as a partial replacement for Portland cement influenced the structural properties of concrete. The compressive strength, flexural strength, split tensile strength, and workability of M25 concrete containing rice husk ash and phosphogypsum partially substituted with cement are experimentally evaluated in this study. In all three mix ratios, rice husk ash replaces cement at a constant proportion of 4%, while phosphogypsum replaces cement at 5%, 7.5% and 10%. The concrete's strength qualities are tested after 28 days of curing. An ideal ratio was determined among these three ratios that delivers the maximum gain in strength metrics. As a result, agricultural waste and phosphate industry waste are utilized in a sustainable manner in construction.*

Key Words: Rice Husk Ash, Compressive strength, Compressive Strength, Split tensile Strength, Workability

1.INTRODUCTION

1.1 General

The developing infrastructure sector led to scarcity of cement because of which the cost of cement increased incrementally. This is an experimental study to investigate the strength properties of M25 concrete when the cement is replaced with rice husk ash and phosphogypsum. Rice Husk Ash is a by-product of the agricultural sector that contains significant levels of silicon dioxide and is created by burning rice husk. Phosphogypsum is also a waste product from the phosphate industry and the agriculture industry. The percentage replaced by Rice Husk Ash is held at 4% while percentage replaced by phosphogypsum vary from 5%, 7.5% and 10%. The replacement percentage of RHA is kept constant because the maximum strength obtained while replacing is not much high as compared to strength obtained in replacing phosphogypsum. Also, the variation the strength while increasing the percentage of replacement of RHA is very low. Various tests are conducted on the hardened partially replaced concrete specimens to obtain compressive strength, flexural strength and split tensile strength after 28 days of curing. The results are compared with strength characteristics of standard M25 concrete.

1.2 Objectives

- To enhance compressive strength, workability, flexural strength and split tensile strength by partially replacing cement with rice husk ash and phosphogypsum in various ratios.
- To check whether the partially replaced concrete could be used for construction.
- To provide economical construction material.
- Safeguard the environment by utilizing agro-waste properly.

1.3 Scope

- Cement consumption can be minimised during construction, and hence construction costs can be decreased
- The combined action of RHA and Phosphogypsum increases structural strength while decreasing water permeability, increasing the structure's durability.
- Waste management is aided by the sustainable use of agricultural and industrial waste.

2. MATERIAL SPECIFICATION

2.1 Phosphogypsum

The fertilizer industry produces phosphogypsum (PG), which is a by-product. $CaSO_4H_2O$ the major component, however it also contains impurities such as P_2O_5 , F, and organic compounds. The amount of PG produced is significant: around 5 tonnes of PG are created for every tonne of phosphoric acid. The disposal of phosphogypsum in open yards or phosphogypsum stack yards may constitute a threat to the environment. In agriculture, it is used as a soil conditioner (for alkaline soil) and as a fertiliser. Controlling the settling time of cement (as a retardant) in cement manufacturing process.

Fig-1: Phosphogypsum

2.2 Rice Husk Ash

RHA is a residue of rice husk incineration. During the incineration of rice husk, the majority of the evaporable components are lost slowly, and the silicates are the main leftovers. The chemical composition of RHA is heavily influenced by combustion circumstances, and silica must be kept in an amorphous state by controlling the burning temperature. 90% amorphous silica, 5% carbon, and 2% K_2O make up the average composition of well-burned RHA. Such ashes will need to be ground to a very small particle size in order to create pozzolanic activity, which is likely to render their usage financially unviable. RHA has a specific gravity of 2.11 to 2.27, is very porous, light in weight, and greyish-black in colour, and has a high surface area. RHA can be used as a partial substitute for cement. It can be used as a filler, an addition, abrasive agent. Oil ad sorbent, sweeping component used in the building industry as a suspending agent for porcelain enamel.

Fig-2: Rice Husk Ash

2.3 Cement

The Pozzolanic Portland Cement of 53 grade is employed in this experiment. Pozzolanic Portland Cement is a subtype of Blended Cement that is made by inter grinding OPC clinker with gypsum and pozzolanic ingredients in predetermined quantities. The specific gravity of the cement is 2.74 which is determined using Le Chatelier Flask test. The initial setting time is determined as 48 minutes.

2.4 Fine aggregate

In this study M-sand is used. M-sand is a kind of sand manufactured by crushing hard stones into small angular particles, then cleansing and finely grading them.

Specific gravity	2.75
Water absorption	2.2%
Fineness modulus	3.34
Bulk density	Compacted-1.6 Kg/L Loose-1.21 Kg/L
Percentage Voids	41.81%

Table-1: Properties of Fine Aggregate

2.5 Coarse Aggregate

The coarse aggregates employed are machine crushed 20mm regular size aggregates. It is free of impurities like dust, clay and biological matter etc.

Specific gravity	2.69
Water absorption	0.6%
Fineness modulus	8.26
Bulk density	Compacted-1.48 Kg/L Loose-1.4 Kg/L
Percentage Voids	44.98%

Table-2: Properties of Coarse Aggregate

2.6 Water

For mixing and curing processes, ordinary tap water is used.

3. METHODOLOGY

3.1 Mix Design

As per IS 10262: 2009, the mix design was done utilising standard concrete mix proportion guide lines. The water cement ratio is taken as 0.44. Table 3 shows the computed mix proportions and material quantities for a one-metre cube of typical M25 concrete mix.

Material	Proportion by weight	Weight/m³
Cement	1	435.45
Fine Aggregate	1.32	576.26
Coarse Aggregate	2.59	1129.06
Water	0.44	191.6

Table-3: Mix Proportions and Weight/m³

3.2 Casting and Curing

Batching, mixing, and casting are all done with caution. The standard size cubes (150 mm x 150 mm x 150 mm) are used to evaluate compressive strength, cylinders (150 mm diameter and 300 mm length) are used to evaluate split tensile strength, and beams (100 mm x 100 mm x 500 mm) are used to assess flexural strength. Oil was applied to all of the inside surfaces and base plates of the moulds to allow for simple removal of the form and a smooth finish. The percentage replacement of Rice Husk Ash is kept constant at 4% while percentage replacement of phosphogypsum vary from 5%, 7.5% and 10%. Ingredients are weighed and thoroughly mixed. Water is carefully added to ensure that no water is lost during the mixing process. All mixes are subjected to a slump test to verify their workability. The moulds are filled with a variety of concrete mixes including varying percentages of RHA and phosphogypsum. The tamping rod was used to provide vibration. The specimen's top surface has been levelled and finished. The specimens are demoulded after 24 hours and moved to a curing tank where they will cure for 28 days.

Fig-3: Materials piled up for mixing

Fig-4: Concrete cubes

3.3 Testing of Hardened Concrete

All concrete specimens are tested after 28 days of curing. All the cubes and cylinder are tested in compressive testing machine and beams are tested in flexural testing machine. The failure load of the three specimens of each category were noted and their average value is reported.

Fig-5: Cylinder kept for testing in CTM

Fig-6: Cylinder after testing

4. RESULTS AND DISCUSSION

4.1 Workability

The slump value of all mixes including standard M25 mix is shown in table 4. The highest workable mix is one containing 4% RHA and 5% phosphogypsum with a slump value of 41mm.

Percentage RHA	Percentage PG	Slump value (mm)
0	0	25
4	5	41
4	7.5	35
4	10	30

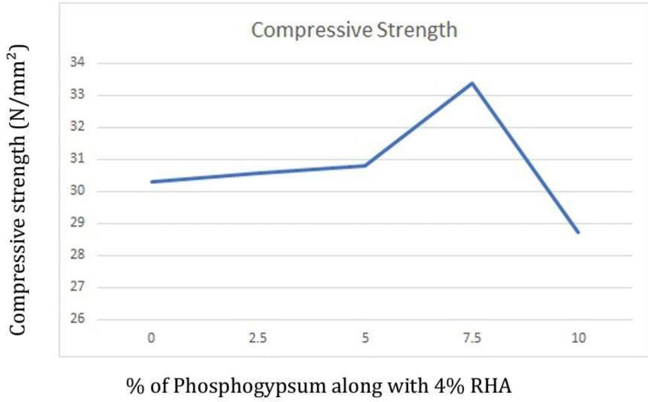
Table-4: Workability results

4.2 Compressive Strength

The compressive strength of all replaced concrete and the standard M25 concrete is shown in table 5. The highest compressive strength obtained is 33.40 N/mm² in the mix containing 4% RHA and 7.5% Phosphogypsum.

Percentage RHA	Percentage PG	Compressive strength (N/mm²)
0	0	30.29
4	5	30.81
4	7.5	33.40
4	10	28.73

Table-5: Compressive strength results



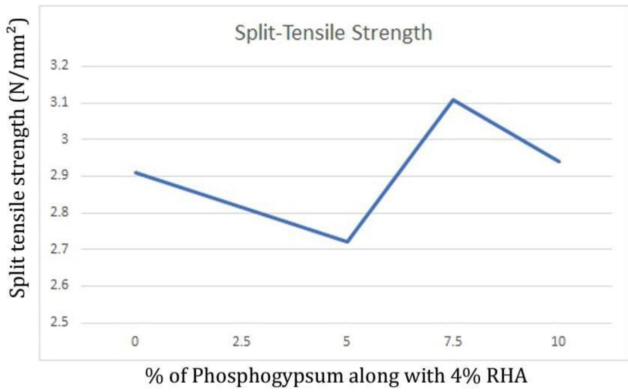
Graph-1: Compressive Strength

4.3 Split Tensile Strength

The split tensile strength of all replaced concrete and the standard M25 concrete is shown in table 6. The highest split tensile obtained is 3.11 N/mm² in the mix containing 4% RHA and 7.5% Phosphogypsum.

Percentage RHA	Percentage PG	Split Tensile Strength (N/mm²)
0	0	2.91
4	5	2.72
4	7.5	3.11
4	10	2.94

Table-6: Split tensile strength results



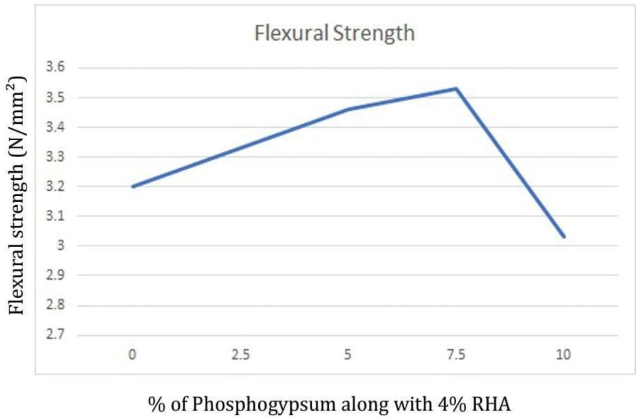
Graph-2: Split Tensile strength

4.4 Flexural Strength

The flexural strength of all replaced concrete and the standard M25 concrete is shown in table 7. The highest flexural strength obtained is 3.53 N/mm² in the mix containing 4% RHA and 7.5% Phosphogypsum.

Percentage RHA	Percentage PG	Flexural Strength (N/mm^2)
0	0	3.20
4	5	3.46
4	7.5	3.53
4	10	3.03

Table-7: Flexural strength results



Graph-3: Flexural Strength

5. CONCLUSION

Cement usage can be minimized by replacing cement with Rice Husk Ash and Phosphogypsum in concrete. Using 4% RHA and 7.5% phosphogypsum, the optimum percentage replacement is achieved which performs maximum strength parameters. The mixture comprising 4% RHA and 5% Phosphogypsum has the highest workability value. Water permeability and cracks in the structure can be minimised as a result of enhanced strength and densification, increasing the building's durability. As a result, phosphate industrial waste (PG) and agro-waste (RHA) are used in a sustainable approach.

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