Partial Replacement of Cement with Rice Husk Ash

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Abstract- **The research has shown that every one ton of cement produce releases half ton of carbon dioxide, so there is an instantaneous need to manage the usage of cement. On the hand materials wastes such as Rice husk Ash (RHA) is difficult to dispose. The Rice husk Ash imparts high early strength to concrete and also condense the permeability of concrete. Therefore the use of Rice husk Ash in concrete not only reduces the ecological pollution but also enhances the properties of concrete and also reduces the cost. This project mainly deals with the replacement of cement with Rice husk Ash. The concrete mix designed by varying the proportions of Rice husk Ash for 0%, 5%, 10%, 20%, 30% the cubes are been casted and cured in normal water for ages of 3, 7 and 28, the properties like slump cone test and compaction factor test for fresh concrete and compressive strength and split tensile strength for hardened concrete are verified and results are analysed.**

1. INTRODUCTION

1.1 The GENERAL

Energy plays a crucial role in growth of developing countries like India. In the context of low availability of non-renewable energy resources coupled with the requirements of large quantities of energy for Building Materials like cement, the importance of using industrial waste cannot be underestimated.

During manufacturing of 1 tones of Ordinary Portland Cement (OPC) we need about 1…1⅓ t of earth resources like limestone, etc. Further during manufacturing of 1 t of Ordinary Portland Cement an equal amount of carbon di-oxide are released into the atmosphere. The carbon-di-oxide emissions act as a silent Killer in the environment under various forms. In this Backdrop, the search for cheaper substitute to OPC is a needful one.

1.2 CEMENT

In the most general sense of the word, cement is a binder, a substance that sets and hardens independently, and can bind other materials together. The word "cement" traces to the Romans, who used the term opus caementicium to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder. The volcanic ash and pulverized brick additives that were added to the burnt lime to obtain a hydraulic binder were later referred to as cementum, cimentum, cäment, and cement.

Cement used in construction is characterized as hydraulic or non-hydraulic. Hydraulic cements (e.g., Portland cement) harden because of hydration, chemical reactions that occur independently of the mixture's water content; they can harden even underwater or when constantly exposed to wet weather. The chemical reaction that results when the anhydrous cement powder is mixed with water produces hydrates that are not water-soluble. Non-hydraulic cements (e.g. gypsum plaster) must be kept dry in order to retain their strength.

1.3 WHY REPLACEMENT???

The topic replacement of cement with waste materials is the one thought that took life from reading the startling things about decaying of environment because of cement. Here are the current issues globally which are threatening the environment! Being civil engineers it's our nominal duty to take care of mother earth.

The problem with Portland cement:-

a) Cement production is the third ranking producer of CO˙ in the world after transport and energy generation.
b) Cement production is responsible for 7-10% of the world's total CO˙ emission and 2% of that produced in the UK (according to the BCA).
c) For every ton of cement produced, approx. 1 ton of CO˙ is produced from chemical reaction and the burning of fossil fuel.
d) The UK produces around 12,000,000 tonnes of cement per annum Cement production is increasing worldwide by approx. 5% per annum.

1.4 SOLID WASTE FROM PADDY INDUSTRY:-

RICE HUSK ASH PROPERTIES:-

RHA has the potential as a cheap cementing material since rice husks are essentially waste material having high silica (SiO2) content, highly porous morphology, lightweight, angular and have a very high external surface area. Its absorbent and insulating properties are useful to many industrial applications, and the ash has been the subject of many research studies. It is estimated that the annual production of paddy rice husk globally was 600 million tons in and with a husk to paddy ratio of 20%, and ash to husk ratio of 18%, therefore the total global ash production could be as high as 21.6 million tones per year and this figure is expected to increase. Consequently, the tremendous amount of cost could be saved by partially replacing OPC with RHA. Rice Husk Ash behaves like cement because of silica and magnesium properties. This silica and magnesium improve the setting of the concrete.

NEED FOR RICE HUSK ASH UTILIZATION:-

Rice husk is an agricultural residue which accounts for 20% of the 649.7 million tons
of rice produced annually worldwide1.The produced partially burnt husk from the milling plants when used as a fuel also contributes to pollution and efforts are being made to overcome this environmental issue by utilizing this material as a supplementary cementing material. The chemical composition of rice husk is found to vary from one sample to another due to the differences in the type of paddy, crop year, climate and geographical conditions.

From the preliminary waste named as rice husk ash, due to its low calcium is taken out for our project to replace the Cement utilization in concrete. Due to the cement production green house gases are emitted in the atmosphere. For producing 4 million t of cement, 1 million green house gases are emitted. Also, to reduce the environmental degradation, this ash has been avoided in mass level disposal in land. To eliminate the ozone layer depletion, production of cement becomes reduced. For this, the rice husk ash is used as partial replacement in the concrete as high performance concrete. By utilizing this waste the strength will be increased and also cost reduction in the concrete is achieved.

2. LITERATURE REVIEW

S. D. Nagrale, Dr. Hemant Hajare, Pankaj R. Modak found that RHA can be used as a replacement for concrete (15 to 25%).This paper evaluates how different contents of Rice Husk Ash added to concrete may influence its physical and mechanical properties. Sample Cubes were tested with different percentage of RHA and different w/c ratio, replacing in mass the cement. Properties like Compressive strength, Water absorption and Slump retention were evaluated.

The conclusions made out of this investigation is with the addition of RHA weight density of concrete reduces by 72-75%.Thus, RHA concrete can be effectively used as light weight concrete for the construction of structures where the weight of structure is of supreme importance. The cost of 1 m3 of OPC concrete works out to Rs. 1157 while that of RHA concrete works out to Rs. 959. Thus, the use of RHA in concrete leads to around 8-12% saving in material cost. So, the addition of RHA in concrete helps in making an economical concrete. The Compressive Strength will increase with the addition of RHA. The use of RHA considerably reduces the water absorption of concrete. Thus, concrete containing RHA can be effectively used in places where the concrete can come in contact with water or moisture. RHA has the potential to act as an admixture, which increases the strength, workability & pozzolanic properties of concrete.

Maurice E. Ephraim, Godwin A. Akeke and Joseph O. Ukpata experimentally carried out to investigate the effects of partially replacing Ordinary Portland cement (OPC) with our local additive Rice Husk Ash (RHA) which is known to be super pozzolanic in concrete at optimum replacement percentage which will help to reduce the cost of housing. With this research work, the problem of waste management of this agro-waste will be solved.

The specific gravity of RHA was found to be 1.55, the density of RHA concrete was found to be 2.043, 1.912 and 1.932kg/m3 at 10%, 20% and 25% replacement percentages respectively. RHA concrete was found to be very workable with a slump value of over 100mm. The incorporation of RHA in concrete resulted in increase water demand and enhanced strength. The compressive strength values at 28days were found to be 38.4, 36.5 and 33N/mm2 at the same replacement percentages above. These compressive strength values compared favorably with the controlled concrete strength of 37N/mm2at a mix ratio of 1:1.5:3.

Adding RHA to concrete resulted in increased water demand, increase in workability and enhanced strength compared to the control sample. The compressive strength values at 28days were found to be 38.4, 36.5 and 33N/mm2 compared to the control with 37N/mm2. This results show that an addition of RHA from 5-10% will increase the strength and a further addition up to 15- 25%RHA will have a slight reduction in strength of 15% and a decreasing in strength values is pointed out.

Nguyen Van Tuana, Guang Ye, Klaas van Breugel, Alex L.A. Fraaij, Bui Danh Dai has investigated the study of using rice husk ash to produce ultra high performance concrete.

This study showed the potential of using RHA to produce UHPC.

From this study, some conclusions can be drawn:

a) RHA can be considered as a supplementary cementitious material using for producing UHPC.
b) The addition of RHA does not significantly decrease the compressive Strength of UHPC compared to that of SF, when less than 30% RHA is added.
c) Compared to SF, the fineness of RHA has a favorable effect on compressive strength when cured in the normal condition.The optimum mean RHA particle size for producing UHPC was found to be 5.6 lm. The finer RHA can improve significantly the compressive strength of UHPC. The compressive strength of UHPC using the finest RHA with the mean particle size of 3.6 lm can reach to 180 MPa and 210 MPa at ages of 28 and 91 days.
d) The RHA can increase the total cement replacement percentage up to 40% to produce UHPC.

3. EXPERIMENTAL INVESTIGATION

The materials used in this investigation include:-

1) Cement
2) Fine Aggregate
3) Coarse Aggregate
4) Rice husk Ash

3.1. Testing For Physical Properties of Cement

S.No.	Type Of Test	Result
1	Fineness	2.6%
2	Standard consistency	26%
3	Specific gravity	3.11
4	Initial setting time (min)	50 minutes
5	Final setting time (min)	290 minutes

4.2. Testing For Physical Properties of fine Aggregates

S.No.	Type Of Test	Result
1	Moisture content	2.04
2	Fineness Modulus	2.66% (Zone-II)
3	Specific gravity	2.673
4	% of Water Absorption	2.8%
5	Bulking factor	2.23
6	Silt content	2.73%

4.3. Testing For Physical Properties of RHA

S.No.	Type Of Test	Result
1	Fineness Modulus	0%
2	Specific gravity	3.02

4.4. Testing For Physical Properties of coarse Aggregates

S.No.	Type Of Test	Result
1	Water Absorption	1.63
3	Specific gravity	2.67

4.5 MIX DESIGN FOR M30 GRADE:

The concrete mix design has been done as per IS method

- Details of materials
- Grade of concrete – M30
- Type of cement – OPC 53 grade
- Maximum nominal size of Coarse aggregate – 20mm
- Exposure condition – Severe
- Degree of Supervision – good
- Type of aggregate – Angular aggregate

Assuming state of surface to be SSD (Surface Saturated Dry state)

- Test data of materials
- Specific gravity of OPC- 3.11
- Specific gravity of Natural Sand – 2.673
- Specific gravity of ROBO sand – 2.67
- Specific gravity of Coarse aggregate - 2.66
- Sieve analysis
- Sand – Conforming to zone-II of IS 383-1970
- Aggregate 20 mm nominal size

5. EXPERIMENTAL WORK

5.1. FRESH CONCRETE

5.1.1. Slump cone test:

This test is used extensively in site all over the world. The slump test does not measure the workability of concrete, but the test is very useful in detecting variations in the uniformity of a mix of given nominal proportions.

The slump test is done as prescribed by IS: 516.
The apparatus for conducting the slump test essential consists of a metallic mould in the form of a cone having the internal dimensions as under
Bottom diameter : 200 mm
Top diameter : 100 mm
5.1.2. Compaction factor test:
There is no generally accepted method of directly measuring the amount of work necessary to achieve full compaction, which is a definition of workability. Probably the best test yet available uses the inverse approach: the degree of compaction achieved by a standard amount of work is determined. The work applied includes perforce the work done against the surface friction but this is reduced to a minimum, although probably the actual friction varies with the workability of the mix.
5.2 Hardened properties of concrete:
5.2.1 Compression test:
Compression test was conducted on 150mm×150mm×150mm cubes. Concrete specimens were removed from curing tank and cleaned. In the testing machine, the cube is placed with the cast faces at right angles to that of compressive faces, then load is applied at a constant rate of 1.4 kg/cm^2/minute up to failure and the ultimate load is noted. The load is increased until the specimen fails and the maximum load is recorded. The compression tests were carried out at 7 days, 28 days and 90 days. For strength computation, the average load of three specimens is considered for each mix. The average of three specimens was reported as the cube compressive of strength.
5.2.2 Split tensile strength test:
The cylinder specimen is of the size 150 mm diameters and 300mm length. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of compression testing machine and the load is applied until failure of cylinder, along its longitudinal direction. The cylinder specimens are tested at 7 days, 28 days and 90 days. The average of three specimens was reported as the split tensile strength.

6. TESTS ON CONCRETE

6.1WORKABILITY

6.1.1 SLUMP CONE TEST

6. OBSERVATIONS & CALCULATIONS

Table 6.1 Slump Cone Test

S. No	Materials	% of Replacement	Slump height (mm)
1	Normal concrete		50
2	Rice husk ash	5	30
		10	20
		20	25
		30	20

REPORTING OF RESULTS:
The slump measured should be recorded in mm of subsidence of the specimen during the test. Any slump specimen, whom collapses or shears off laterally, gives incorrect result and if this occurs, the test should be repeated with another sample. If, in the repeat test also, the specimen shears, the slump should be measured and the fact that the specimen sheared, should be recorded.
6.1.2 COMPACTING FACTOR

S.No	Materials		weight of partially compacted concrete(w1) (kg)	Weight of fully compacted concrete (w2) (kg)	Compaction factor = [w1 / w2]
1	Normal concrete		16.95	19.20	0.88
2	Rice Husk Ash	5%	16.89	19.68	0.85
		10 %	16.76	19.54	0.857
		20 %	16.96	19.98	0.848
		30 %	17.00	19.64	0.865

6.2. HARDENED CONCRETE

6.2.1 COMPRESSION TEST

The measured compressive strength of the specimen should be calculated by dividing the maximum load applied to the specimen during the test by the cross - sectional area, Calculated from the mean dimensions of the section and should be expressed to the nearest kg/sq.cm. An average of three values should be taken as the representative of the batch, provided the individual variation is not more than ±15% of the average. Otherwise repeat tests should be done.

Sr. No	Concrete	Compressive Strength (Mpa)		
		3 Days	7 Days	28 Days
1	Normal concrete	24.2	27.5	37.6
2	5% RHA	21.03	25.48	37.37
3	10%RHA	22.28	28.15	37.99
4	20%RHA	21.95	26.38	37.28
5	30%RHA	19.77	26.05	34.25

6.2.2.SPLIT TENSILE STRENGTH TEST

Sl. No	Concrete	Split tensile Strength (Mpa)		
		3 Days	7 Days	28 Days
1	Normal concrete	2.7	2.97	3.2
2	5% RHA	1.79	2.68	3.25
3	10%RHA	1.90	2.68	3.01
4	20%RHA	1.86	2.7	3.91
5	30%RHA	1.57	1.97	3.58

7.CONCLUSION

Rice husk is an abundant waste generated from agriculture product in India. This is a Potential source to produce RHAs for construction applications in India. Low quality RHA can be used as filler for concrete. The acceptable content is 20% to replace for cement with an acceptance of reduction in compressive strength. The optimum replacement of OPC with RHA taken at 28 days strength for Grade 30 and Grade 40 was 30%, while for Grade 50 was 20%. Replacement of OPC with RHA reduced the water permeability of the concrete. Thus, suggested that the presence of RHA in the mix and with concrete of higher grade, the coefficient of permeability reduces, thus improves the durability of concrete. This is due to pore refinement attributed to RHA fineness or a transformation of large permeable pores to a small impermeable pore. The RHA used in this study is efficient as a pozzolanic material; it is rich in amorphous silica (88.32%). The loss on ignition was relatively high (5.81%). Increasing RHA fineness increases its reactivity. The water absorption values of RHA concrete are lower than the OPC control concrete. These results emphasize the beneficial effect of incorporating RHA to increase the durability of concrete, irrespective of their concrete grade. The percentage of water absorption obtained for all the grades are between 3% - 5% which can be considered as average absorption. The resistance to chloride ion penetration of concrete as measured by the charge coulomb was significantly increased with incorporation of RHA. Thus, suggested that the presence of RHA resulted in lower coefficient of permeability, thus improves the durability of concrete. The Specific gravity, uncompact bulk density, and compacted bulk density of rice husk ash were found to be 2.13, 460 Kg/m3 and 530 Kg/m3. For a given mix, the water requirement increases as the rice husk ash content increases The setting times of OPC/RHA paste increases as the ash content increases The density of OPC/RHA is within the range for sand Crete blocks (500 to 2100kg/m3) The compressive strength of the blocks for all mix increases with age at curing and decreases as the RHA content increases Rice husk is available in significant quantities as a waste and can be utilized for making blocks. This will go a long way to reduce the quantity of waste in our environment the optimum replacement level of OPC with RHA is 20%.

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