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Development of High Strength Concrete using Rice Husk Ash and Slag

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***Abstract*— At Present so many countries are facing problems due to pushing up the cost of construction materials Already fly-ash has been used as partial substitution for ordinary Portland cement. But one of the agro-based wastes is rice-husk. Some progress has been made to convert this rice-husk to ash; rice-husk ash contains 85-95% silica when open burnt and ground to a fineness of 16000Sq-cm/gm. Some investigations were reported on using rice-husk ash concretes and were shown to be good when comparable with concretes with no replacements.**

The present study was carried out on the development of high strength concrete (HSC) using rice husk ash and Ground Granulated Blast Furnace Slag (ggbs) which was procured. The cement has been replaced by rice husk ash, ggbs accordingly in the range of 0%, 5%, 10%, 15%, 20%, 25% & 30% by weight of cement for mix respectively.. Concrete specimens were prepared, tested and compared in terms of compressive strengths with the Conventional concrete. These tests were carried out to evaluate the compressive strength properties for the test results of 28, 56, 90 days.

Key Words: High strength concrete (HSC), Ground Granulated Blast Furnace Slag (ggbs), Rice Husk etc…

1. INTRODUCTION

Concrete is the common construction material using, because of its combined mechanical, durable, workability properties with relative low cost. However, production of cement leads to emission of greenhouse gases like CO_2, which is responsible for about 5% of global anthropogenic CO_2 emissions in the world. Even though the planet warming is an issue that may be regarded from a global perspective, the use of pozzolans as cement replacement is a problem that would have local solutions since transport is one of the main cost components for cementitious materials.

Rice Husk ash is an important by-product produced during the de-husking operation of paddy rice. Since they are bulky, the husks present an enormous disposal problem for centralized rice mills. Rice husk converted ash, is found to have desirable properties to be used as replacement to cement. Each ton of paddy rice produces about 200kgs of husk, which on combustion yields approximately 40kgs of fly ash and releases 3,800 kcal/kg of heat energy.

The application of rice husk ash in concrete production brings positive effects of the environment; hence it reduces the problems associated to their disposal. Regarding their use as cement additive, mineral admixtures affect the performances of paste, mortar and concrete owing to both physical and chemical effects. Therefore it is possible to use rice husk ash as cement additive and replacement material to improve quality and reduce cost of pozzolonic construction material.

2. LITERATURE REVIEW

Abdullahi et al., [1] investigated on the compressive strength of some commercial sandcrete blocks. Rice Husk Ash (RHA) was prepared from burning firewood. They conducted physical test of the freshly prepared mix. 150mm×450mm hollow sandcrete blocks were cast cured and crushed for 1, 3, 7, 14, 21, and 28 days at 0, 10, 20, 30, 40 and 50 percent replacement levels. They concluded the results of test and indicated compressive strength of the OPC/RHA sandcrete blocks increases with age at curing and decreases as the percentage of RHA content increases. They concluded that setting times of OPC/RHA paste increases as the ash content increases.

Giddi et al., [2] have stated that every year approximately 20 million tones of paddy is produced in India. This gives around 24 million tons of rice husk and 4.4 million tons of Rice Husk Ash every year. Use of rice husk ash or rice husk in land filling is also an environmentally hazardous way of disposing waste. In his paper he discussed a preliminary analysis of the numerous reported uses of rice husk. He concluded that the use of rice husk for electricity generation in efficient manner is likely to transform this agricultural by product or waste into a valuable fuel for industries and thus might help in boosting the farm economy and rural development. India being the second largest rice producer in the world, systematic approach to this material can give birth to a new industrial sector of rice husk ash in India.

Hilmi Bin Mahmud et al., [3] investigated on the properties of rice husk ash (RHA). The effect of grinding on the particle size and the surface area was first investigated and the effect of RHA average particle size and percentage on concrete workability, fresh density, super plasticizer (SP) content and the compressive strength were also investigated. Although grinding RHA would reduce its average particle size (APS), it was not the main factor controlling the surface area and it is thus resulted from RHA's multilayered, angular and micro porous surface. He concluded that incorporation of RHA in concrete increased water demand. RHA concrete gave excellent improvement in strength for 10% replacement (30.8% increment compared to the control mix), and up to 20% of cement could be valuably replaced with RHA without adversely affecting the strength. Increasing RHA fineness enhanced the strength of blended concrete compared to coarser RHA and control OPC mixtures. He also stated that the dosage of super plasticizer had to be increased along with RHA fineness and content to maintain the desired workability.

P.Muthupriya et al., [4] studied the behavior of short columns produced from High Performance Concrete (HPC). In the investigation HPC grade M60 was manufactured with usual ingredients such as cement, fine aggregate, coarse aggregate, water and mineral admixtures such as silica fume and GGBS at various replacement levels and the super plasticizer(1.5% by weight of cement). The water binder ratio adopted was 0.3. Specimens such as cubes, cylinders and prisms were casted and tested for various mixes viz., seven mixes M1 to M7 are casted with 0%,5%, 7.5% and 10% replacement of silica fume to cement and another replacement of GGBS to study the mechanical properties such as compressive strength, split tensile strength and flexural strength at different ages of concrete 3,7,28,56 and 90 days. The result showed that the optimum replacement of silica fume is at 7.5% and GGBS was 10%.

B.B.Patil and P.D.Kumbhar [5] studied the strength and durability properties of High Performance Concrete incorporating High Reactivity Metakaoline. In this investigation HPC grade M60 was manufactured with usual ingredients such as cement, fine aggregate, coarse aggregate, water and mineral admixture Metakaoline at various replacement levels and the super plasticizer (0.73% by weight of cement). The water binder ratio adopted was 0.31. Cube specimens were casted and tested for various mixes viz., 6 mixes were casted with 0%,5%,7.5%,10%,12.5% and 15% replacement of Metakaoline to cement to study the compressive strength of concrete at 28 days. The result showed that the durability & strength of concrete are increased at an optimum replacement of Metakaoline at 7.5%.

3. EXPERIMENTAL INVESTIGATION

In the present experimental investigation rice husk ash & GGBS has been used as partial replacement of cement in concrete mixes. On replacing cement with different weight percentage of rice husk ash & GGBS the compressive strength studied at different ages of concrete cured in water. The details of experimental investigations are as follows

3.1 Materials Used

3.1.1 Cement

Ordinary Portland Cement (OPC) is the basic Portland cement and is best suited for use in general concrete construction. It is of tree types 33 grade, 43 grades, and 53grade. One of the important benefits is the faster rate of development of strength. The cement using in present study is 53 Grade

Table 1: Chemical composition (%) of cement:

S,No.	Composition	Opc-53
1.	Sio_2	21.52
2.	Al_2o_3	6.16
3.	Fe_2o_3	4.60
4.	Cao	63.36
5.	Mgo	0.83
6.	So_3	1.87
7.	IR	1.30
8.	Loss of ignition	1.64

Table 2: PROPERTIES OF CEMENT

S.No	Property	Test Result
1.	Normal consistency	33%
2.	a) Initial setting time	80 minutes
	b) final setting time	180 minutes
3.	Specific Gravity	3.15
4.	Soundness (Le-chatlier Exp.)	1.30mm
5.	Compressive strength of cement(28 days)	53 Mpa
6.	Specific surface area	$320m^2/Kg$

3.1.2 Rice Husk Ash:

Rice Husk Ash (RHA) is an agricultural waste product, and how to dispose of it is a problem to waste mangers. Rice husk contains silica in hydrated amorphous form and cellulose which yields carbon when thermally decomposed. When such a product is further heated at high temperature (> 1400°C), a reaction occurs between silica and carbon resulting in the formation of SiC.

3.1.3 Aggregate:

Aggregate properties greatly influence the behaviour of concrete, since they occupy about 80% of the total volume of concrete. The aggregate are classified as

i. Fine aggregate
ii. Coarse aggregate

The coarse aggregate are granular materials obtained from rocks and crushed stones. They may be also obtained from synthetic material like slag, shale, fly ash and clay for use in light weight concrete. The sand obtained from river beds or quarries is used as fine aggregate.

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Table 3: Properties of Fine Aggregate

S.NO	Property	Test Result
1	Specific Gravity	2.60
2	Bulk density(Kg/m)	1543(loose state) 1750(dry rodded)
3	Fineness Modulus	2.74
4	Zone	2

Table 4: Properties of Coarse Aggregate

S.NO	Property	Test Result
1	Bulk density(kg/m^3)	1468[loose state] 1611[dry ridded]
2	Specific Gravity(G)	2.74
3	Fineness Modulus	7.17

3.1.4 Water:

Clean potable water is used for mixing concrete. Water used for mixing and curing should be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete and steel.

Table 5: Analysis of Water (As Per Is: 456-2000)

S.NO	Impurity	Max. Limit	Results
1	PH Value	6 to 8.5	7
2	Suspended matter mg/lit	2000	220
3	Organic matter mg/lit	200	20
4	Inorganic mattermg/lit	3000	150
5	Sulphate(so_4) mg/lit	500	30
6	Chloride(cl)mg/lit	2000 for P.C.C., 1000 For R.C.C	60

3.1.5 Super Plasticizer:

Super plasticizers are otherwise known as high range water reducers, are the chemicals used as admixtures where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle aggregation and to improve the flow characteristics of suspensions such as in concrete applications.

CONPLAST 430 is supplied as a brown solution which instantly disperses in water. It disperses the fine particles in the concrete mix, enabling the water content of the concrete to perform more effectively. The very high levels of water reduction possible allow major increases in strength to be obtained.

3.2 Preparation of Testing Specimens

In this experimental work the concrete specimens were casted. The specimens considered in this study consisted of 150mm x 150 mm x 150 mm cubes. The mix design of concrete was done according to American Concrete Institute ACI: 211-4R and the water cement ratio is 0.3.

Based on the quantities of ingredient of the mix, rice husk ash and ggbs for 0, 5, 10, 15, 20 and 25% were replacement by weight of the cement. The water/cement ratio is same to investigate the effects of replacing cement with fly ash when other parameters are almost kept same.

3.2.1 Mixing:

Initially the coarse aggregates and fine aggregates are weighed. Later required quantities of cement and fly ash are mixed dry to a uniform color. As per the mix design water is measured. All the ingredients are added to the concrete mixture and mixed for the required time period to achieve a homogeneous mix of uniform color. Before casting the specimens, workability of mixes is found by compaction factor test and slump cone test.

Fig.1: Mixing of Ingredients

3.2.2 Casting:

The cast iron moulds are used for casting. They are securely tightened to correct dimensions before casting. Care is taken that there is no gaps left from where there is no possibility of leakage out of slurry. Clean and oiled moulds for each category are then placed on the vibrating table respectively and filled in three layers. Vibrations are stopped as soon as the cement slurry appeared on the top surface of the mould. Excess concrete was removed with trowel and top surface is finished level and smooth as per IS 516-1959.

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Fig.2: Cube Specimens

4. RESULTS

The compression testing machine (Microprocessor based) used for testing the cube specimens is of standard make. Concrete specimens cubes are used to determine the compressive strength of fly ash concrete as per IS 516-1959

Table 6: Compressive strength of cubes replaced with RHA at 28, 60 & 90 days

Sample	% of RHA	Compressive Strength of Cube Specimens		
		28 days	60 days	90 days
M-0	0	65.77	79.11	89.77
M-5	5	64.00	73.33	84.00
M-10	10	57.33	65.77	72.00
M-15	15	52.00	59.11	66.66
M-20	20	45.77	52.88	61.77
M-25	25	42.22	47.11	56.00

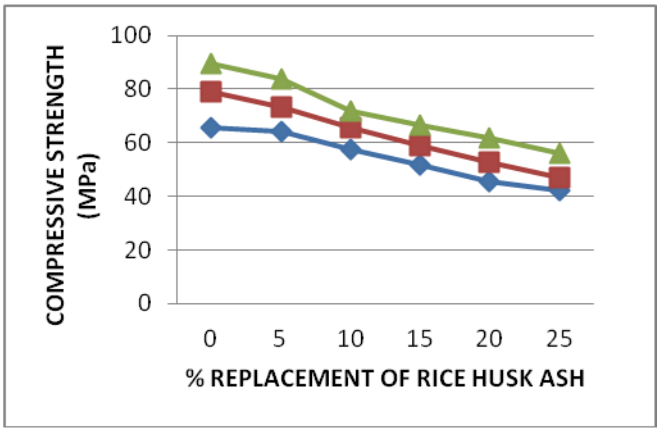

Fig.3: Graph showing variations in compressive strengths replaced with RHA at 28, 60 & 90 days

The compressive strengths were decreasing with the increase in the replacement content of Rice Husk Ash Content

Table 7: Compressive strength of cubes replaced with GGBS at 28, 60 & 90 days

Sample	% of GGBS	Compressive Strength of Cube Specimens		
		28 days	60 days	90 days
M-0	0	65.77	79.11	89.77
M-5	5	67.55	83.11	93.33
M-10	10	72.00	88.88	96.00
M-15	15	71.11	84.00	90.66
M-20	20	69.33	79.11	87.11
M-25	25	65.77	73.77	81.77

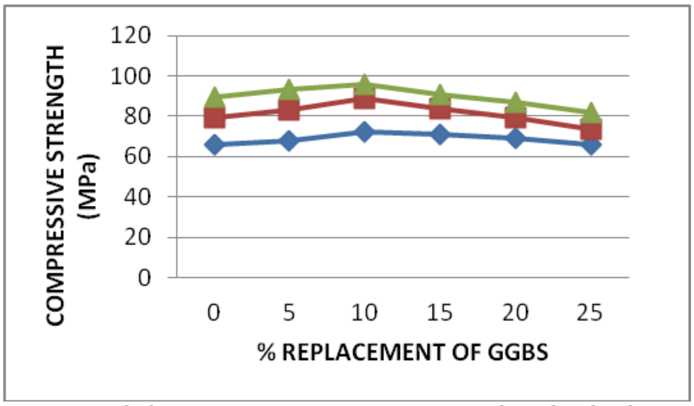

Fig.4: Graph showing variations in compressive strengths replaced with GGBS at 28, 60 & 90 days

Table 8: Compressive strength of cubes when replaced with RHA & GGBS at 28 days

Sample Designation	% of RHA & GGBS	Compressive Strength of Cube Specimens	
		28 days (RHA)	28 days (GGBS)
M-0	0	65.77	65.77
M-5	5	64.00	67.55
M-10	10	57.33	72.00
M-15	15	52.00	71.11
M-20	20	45.77	69.33
M-25	25	42.22	65.77

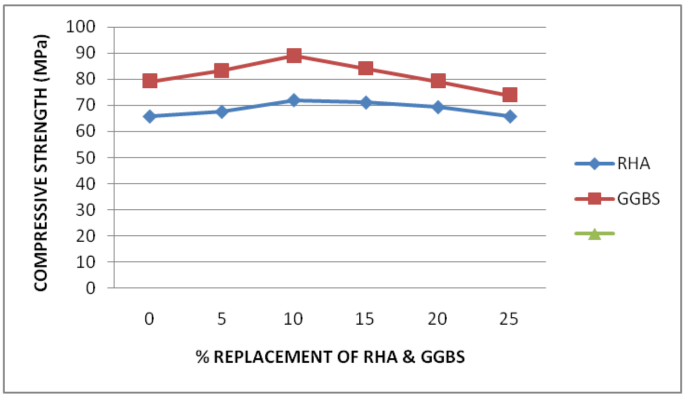

Fig.5: Graph showing variations in compressive strengths with replacement of RHA & GGBS at 28 days

Table 9: Compressive strength of cubes when replaced with RHA & GGBS at 60 days

Sample Designation	% of RHA & GGBS	Compressive Strength of Cube Specimens	
		60 days (RHA)	60 days (GGBS)
M-0	0	79.11	79.11
M-5	5	73.33	83.11
M-10	10	65.77	88.88
M-15	15	59.11	84.00
M-20	20	52.88	79.11
M-25	25	47.11	73.77

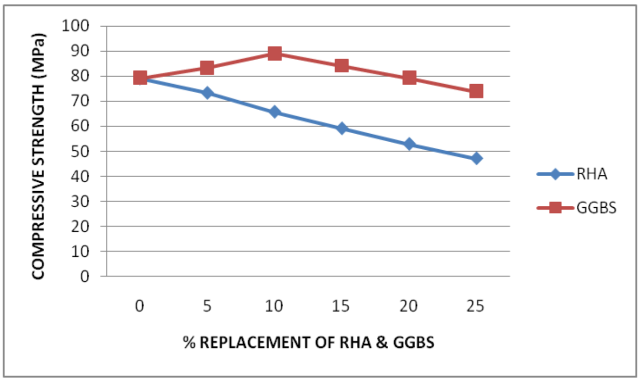

Fig.6: Graph showing variations in compressive strengths with replacement of RHA & GGBS at 60 days

Table 10: Compressive strength of cubes when replaced with RHA & GGBS at 90 days

Sample Designation	% of RHA & GGBS	Compressive Strength of Cube Specimens	
		90 days (RHA)	90 days (GGBS)
M-0	0	89.77	89.77
M-5	5	84.00	93.33
M-10	10	72.00	96.00
M-15	15	66.66	90.66
M-20	20	61.77	87.11
M-25	25	56.00	81.77

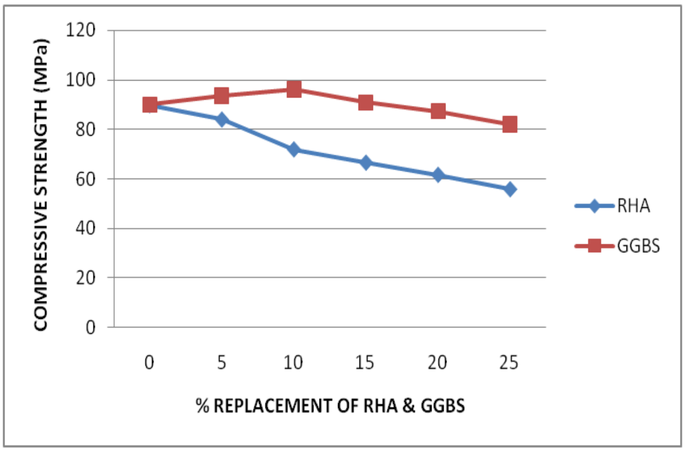

Fig.7 Graph showing variations in compressive strengths with replacement of RHA & GGBS at 90 days

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5. CONCLUSIONS

The following are the conclusions drawn from various experimental results reported from this work:

- RHA can be successfully used as a mineral admixture for replacement of cement. But the compressive strength values were found to be slightly lesser when compared with the control mix concrete.
- The trial mix M-5 i.e 5% replacement of RHA along with super-plasticizer gave the compressive strength up to 64 MPa, which is more than that of designed M60 grade compressive strength.
- The other trail mixes M-10,M-15,M-20,M-25 i.e replacement levels of RHA viz., 10%,15%,20% & 25%, the compressive strength values were found to be decreasing with the increase in the percentage replacement of the mineral admixture which were tested after 28 days of curing.
- The percentage decrease in compressive strength when compared with control mix for the replacement of RHA were 2.69%, 12.8%,20.9%,30.4%,35.8% respectively for the trail mixes M-5,M-10,M-15,M-20,M-25 after 28 days of curing.
- Mixing of GGBS to concrete significantly affected the strength parameters of concrete.
- The optimum replacement of GGBS was found to be 10% replacement and the compressive strength was found to be 72 MPa when compared with control mix and other trial mixes of RHA & GGBS.
- The increase compressive strength when compared with control mix for the replacement of GGBS were 2.7%, 9.4%,8.1%, 5.4%, 0% respectively for the trail mixes M-5,M-10,M-15,M-20,M-25 after 28 days of curing.
- The percentage decrease in compressive strength when compared with control mix for the replacement of RHA were 7.30%, 16.86%,25.28%,33.15%,40.4% respectively for the trail mixes M-5,M-10,M-15,M-20,M-25 after 60 days of curing.
- The percentage decrease in compressive strength when compared with control mix for the replacement of RHA were 6.4%, 19.70%,25.7%,31.10%,37% respectively for the trail mixes M-5,M-10,M-15,M-20,M-25 after 90 days of curing.
- The percentage increase in compressive strength when compared with control mix for the replacement of GGBS were 5.60%, 10.9%,5.8%,0% respectively for the trail mixes M-5,M-10,M-15,M-20, and a decrease in M-25 with a percentage of 6.7% after 60 days of curing.
- The percentage increase in compressive strength when compared with control mix for the replacement of GGBS were 3.8%, 6.4%,0.9%,respectively for the trail mixes M-5,M-10,M-15 and decrease in strength for M-20 &M-25 with a percentages of 2.9%,8.9% after 90 days of curing.

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