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Durability Studies on Concrete and Comparison with Partial Replacement of Cement with Rice Husk Ash and Sugarcane Bagasse Ash in Concrete

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ABSTRACT
This research work describes the feasibility of using the Rice Husk Ash (RHA) and Sugarcane Bagasse Ash (SCBA) waste in concrete production as a partial replacement of cement. This present work deals with the effect on strength and mechanical properties of concrete using RHA and SCBA instead of cement. The cement has been replaced by rice husk ash, accordingly in the range of 0%, 5%, 10%, 15%, and 20% by weight. Concrete mixtures with RHA, were produced, tested and compared in terms of compressive strengths with the Conventional concrete. These tests were carried out to evaluate the mechanical properties for the test results of 7, 28, 60, 90 days for compressive strengths in normal water and in MgSO4 solution of 1%, 3% and 5%. Also the durability aspect for rice husk ash concrete for sulphate attack was tested. Similarly the above tests were also performed for SCBA. The result indicates that the RHA and SCBA improve concrete durability. Finally the test results for RHA and SCBA were compared. Key words: Rice Husk Ash, Sugarcane Bagasse Ash, Concrete, M35 grade concrete, cubes, cylinders, MgSO4, durability.
Keywords – M35 grade concrete, MgSO4 Solution, Rice Husk Ash, Sugarcane Bagasse Ash and UTM

I. INTRODUCTION

The challenge for the civil engineering community in the near future will be to realize projects in harmony with the concept of sustainable development, and this involves the use of high-performance materials and products manufactured at reasonable cost with the lowest possible environmental impact. Concrete is the most widely used construction material worldwide. However, the production of Portland cement, an essential constituent of concrete, releases large amounts of CO_2 which is a major contributor to the greenhouse effect and the global warming of the planet. Moreover the developed countries are considering very severe regulations and limitations on CO_2 emissions. In this scenario, the use of supplementary cementing materials (SCMs), such fly ash, slag, silica fume, and rice husk ash and sugar cane bagasse ash as a replacement for Portland cement in

Concrete presents one viable solution with multiple benefits for the sustainable development of the concrete industry.

The most commonly available SCM worldwide is sugar cane bagasse ash, a by-product from the combustion of sugar cane fibers. Sugar cane bagasse ash, if not utilized has to be disposed of in landfills, ponds or rejected in river systems, which may present serious environmental concerns since it is produced in large volumes. Instead of considering it as a "Waste" product, research and development has shown that sugar cane bagasse ash actually represents a highly valuable concrete material. In order to considerably increase the utilization of sugar cane bagasse ash as replacement for cement, such concrete must meet engineering performance requirements that the comparable to those for conventional Portland cement concrete and be cost effective.

Rice husk which is an agricultural by–product is abundantly available all over the world. Most of the rice husk, which is obtained by milling paddy, is going as waste materials even though some quantity is used as bedding material, fuel in boilers, brick kilns etc., the husk and its ash, which not only occupy large areas causing space problems, but also cause environmental pollution.

The present study was carried out on SCBA and RHA obtained by controlled combustion of sugarcane bagasse, which was procured from the Andhra Pradesh province in India. Sugarcane production in India is over 300 million tons/year leaving about 10 million tons as unutilized and, hence, wastes material. This project analyzes the effect of SCBA and RHA in concrete by partial replacement of cement at the ratio of 0%, 5%, 10%, 15% and 20% by weight. The experimental study examines there compressive strength, split tensile strength, flexural strength. The main ingredient consists of Portland cement, SCBA/RHA, river sand, coarse aggregate and water. After mixing, concrete specimens were casted and subsequently all test specimens were cured in water and in $MgSO_4$ solution of 1%, 3% and 5% for 7 days, 28 days, 60 days and 90 days respectively. Also the durability aspect for rice husk ash and sugarcane bagasse ash concrete for sulphate attack was tested. Similarly the above tests were also performed for SCBA/RHA. The result indicates that the RHA and SCBA improve concrete durability. Finally the test results for RHA and SCBA were compared.

II. OBJECTIVE OF THE WORK

In this project objective is to study the influence of partial replacement of cement with Rice Husk Ash and sugarcane bagasse ash in concrete subjected to different curing environments. Experimental investigation on sulphate resistance of concrete in $MgSO_4$ solution. The variable factors considered in this study were concrete grade of M35 & curing periods of 7days, 28 days, 60 and 90 days of the concrete specimens. The parameter investigated was the time in days to cause strength deterioration factor of fully immersed concrete specimens in fresh water & in 1%, 3% &5%$MgSO_4$ solution. Rice Husk Ash and sugarcane bagasse ash has been chemically & physically characterized & partially replaced in the ratio of 0%, 5%, 10%, 15%, and 20%. Fresh concrete tests like compaction factor test and hardened concrete tests like compressive strength at the age of 7days, 28 days, 60 and 90 days was obtained. The compressive strength test results of RHA and SCBA for 7,28,60,90 days are compared.

III. MATERIALS AND PROPERTIES

The materials used in research are:

1. Portland cement (53 grade)
2. Fine aggregate (4.75 mm down)
3. Coarse aggregate (20 mm down)
4. Rice Husk Ash
5. Sugarcane Bagasse Ash
6. Water
7. Admixtures

i. Cement

Ordinary Portland cement is by far the most important type of cement. The manufacture of cement is decreasing all over the world in view of the popularity of blended cement on account of lower energy consumption, environmental pollution, economic and other technical reasons. In advanced western countries the use of cement has come down to about 40% of the total cement production. The cement procured was tested for physical requirements in accordance with IS: 12269-1987 and for chemical requirements in accordance with IS: 4032-1977.

ii. Fine Aggregate

The sand obtained from river beds or quarries is used as fine aggregate. Fine aggregate are material passing through an IS sieve that is less than 4.75mm. According to IS 383:1970 the fine aggregate is being classified in to four different zone, that is Zone-I, Zone-II, Zone-III, Zone-IV. Locally available river sand in dry condition was used for the preparation of specimens. The sand is tested for various properties like specific gravity, bulk density etc., and in accordance with IS 2386-1963.

iii. 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 physical properties of coarse aggregate like specific gravity, Bulk density, impact value, gradation and fineness modulus are tested in accordance with IS: 2386. The maximum size of coarse aggregates used is 20 mm. The materials are of uniform colour and have good angularity and it will be free from dust and organic matter etc.

iv. Rice Husk Ash

The husk 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. This husk is used as fuel in the rice mills to generate steam for the parboiling process.

v. Sugarcane Bagasse Ash

Sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicelluloses of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide (sio2). In spite of being a material of hard degradation and that presents few nutrients, the ash is used on the farms as a fertilizer in the sugarcane harvests. In this sugarcane bagasse ash is collected from agricultural fields.

vi. Water

The locally available potable water accepted for local construction is used in the experimental investigation after testing. The water used is potable water collected from laboratory tap. The pH value should not be less than 6.

vii. Magnesium Sulphate ($Mgso_4$) Properties

The magnesium Sulphate is obtained from locally and is manufactured in Molychem, Mumbai with minimum assay of 99.8%.

Table 1: Analysis of Water (Limitations As Per IS: 456-2000)

S. No.	Impurity	Max. Limit	Results
1	PH Value	6 to 8.5	7.4
2	Suspended matter mg/lit	2000	350
3	Organic matter mg/lit	200	25
4	Inorganic matter mg/lit	3000	200
5	Sulphate (SO_4) mg/lit	500	25
6	Chlorides (Cl) mg/lit	2000 for P.C.C. 1000 for R.C.C.	60

Table 2: Properties of $MgSO_4$

S. No.	Chemical	Volume (%)
1	pH (5% water)	6.3
2	Free Alkali sol. (as NaOH)	0.008
3	Free Acid (as H_2SO_4)	0.01
4	Chlorides	0.02
5	Heavy metals (Pb)	0.0005
6	Arsenic	0.0002
7	Iron (Fe)	0.01
8	Selenium (Se)	0.001
9	Loss of Drying (at 450°c)	50.4

Table 3: Physical Properties of RHA

S. No.	Characteristic	Test Results %
1	**(SiO_2)+Al_2O_3, Fe_2C_3 % by mass**	**85.0**
2	SiO_2% by mass	60.20
3	MgO % by mass	2.48
4	Total sulfur as SO3 % by mass	0.10
5	Available alkali as sodium oxide (Na20) % by mass	4.32
6	Loss of ignition % by mass	5.10

Table 4: Chemical Properties of RHA (Source)

S. No.	Property	Test Results
1	Density	96 kg/m^3
2	Physical state	Solid non-Hazardous
3	Appearance	Very fine powder
4	Particle size	25 microns – mean
5	Color	Gray
6	Specific gravity	2.3

Table 5: Physical properties of SCBA

S. No.	Characteristic	Test Results %
1	SiO_2 % by mass	93.80
2	Al_2o_3 by mass	0.74
3	Fe_2o_3 by mass	0.30
4	Tio_2 by mass	0.10
5	Cao by mass	0.89
6	Mgo by mass	0.32
7	Na_2o by mass	0.28
8	K_2o by mass	0.12
9	LOI	3.37

Table 6: Physical Properties of Fine and Coarse Aggregate

S. No.	Property	Test Result
1.	Density	575Kg/**m^3**
2.	Specific Gravity	2.2
3.	Mean particle size	0.1-0.2 urn
4.	Min specific surface area	420m^2/ kg
5.	Particle shape	Spherical

Table 7: Chemical properties of SCBA (Source)

S. No.	Properties	Test results	
		Fine Aggregate	Coarse Aggregate
1.	Specific gravity	2.60	2.74
2.	Bulk Density (Kg/m^3) a) loose b) compacted	1600 kg/m^3 1750 kg/m^3	1400 Kg/m^3 1580 Kg/m^3
3.	Fineness Modulus	2.76	7.17

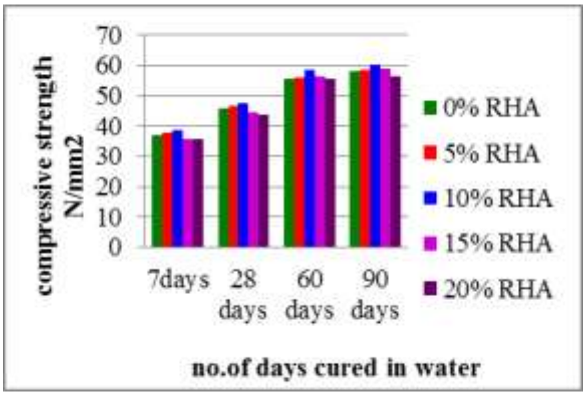
Table 8: Mix Proportions by Weight

Cement (kgs)	Fine aggregate (kgs.)	Coarse aggregate (kgs.)	w/c ratio (lt.)
453.66	527.28	1225.30	186
1	1.16	2.70	0.41

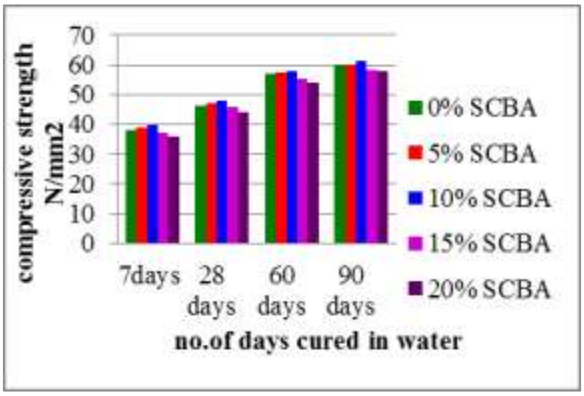
IV. RESULTS

Compressive Strength of Concrete

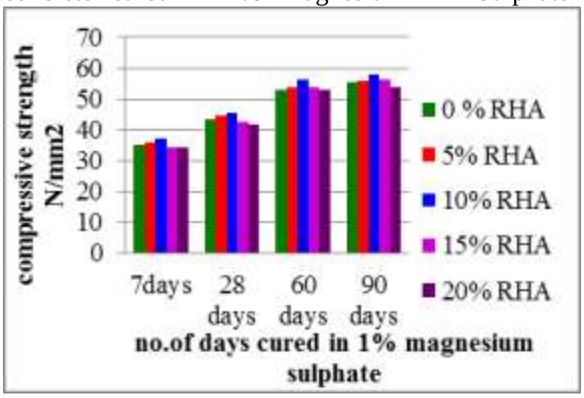
Graph 1: Compressive strength results of RHA concrete cured in normal water



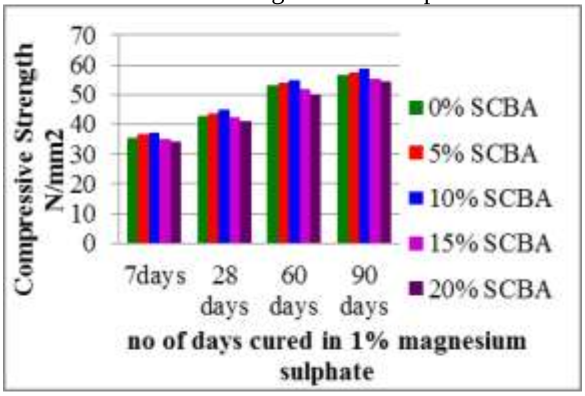
Graph 2: Compressive strength results of SCBA concrete cured in normal water



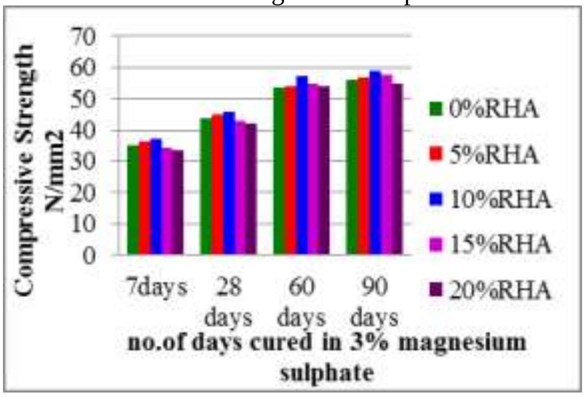
Graph 3: Compressive strength results of RHA concrete cured in 1% Magnesium Sulphate



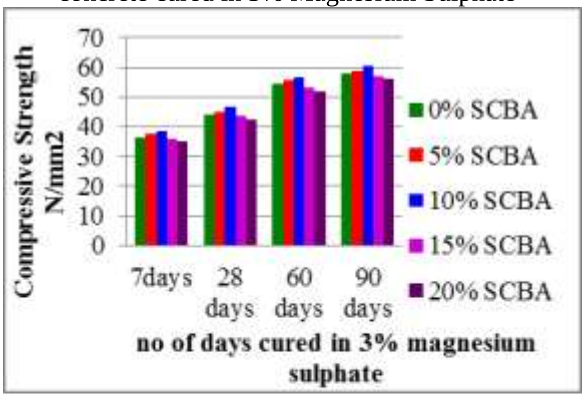
Graph 4: Compressive strength results of SCBA concrete cured in 1% Magnesium Sulphate



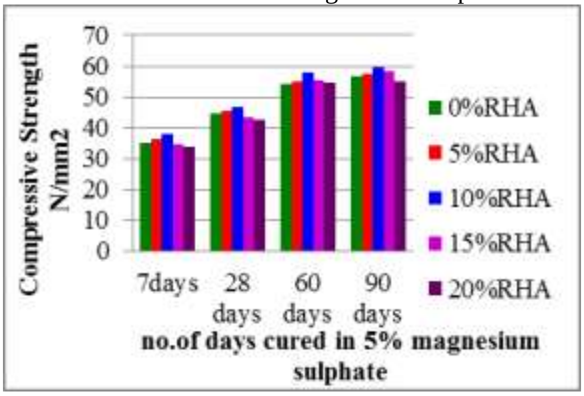
Graph 5: Compressive strength results of RHA concrete cured in 3% Magnesium Sulphate



Graph 6: Compressive strength results of SCBA concrete cured in 3% Magnesium Sulphate



Graph 7: Compressive strength results of RHA concrete cured in 5% Magnesium Sulphate



Graph 8: Compressive strength results of SCBA concrete cured in 5% Magnesium Sulphate

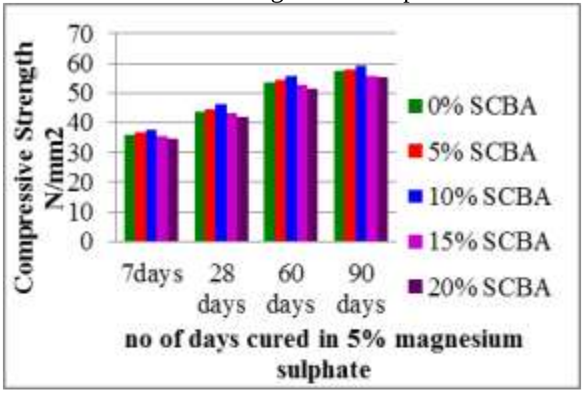


Table 9: Compressive Strength results for cubes cured in water

Sample Designation	% of RHA	7 days	28 days	60 days	90 days
W-0	0	36.89	45.83	55.69	57.98
W-05	5	37.72	46.75	56.16	58.69
W-10	10	38.79	47.69	58.63	60.23
W-15	15	35.86	44.78	56.43	59.16
W-20	20	35.78	43.79	55.57	56.23

Table 10: Compressive Strength results for cubes cured in water

Sample Designation	% of SCBA	7 days	28 days	60 days	90 days
W-0	0	38.24	46.19	56.82	59.99
W-05	5	38.95	47.08	57.54	60.18
W-10	10	39.69	48.145	57.86	61.16
W-15	15	37.30	45.61	55.28	58.12
W-20	20	35.76	44.14	54.01	57.81

Table 11: Compressive Strength results for cubes cured in 1% magnesium sulphate solution

Sample Designation	% of RHA	7 days	28 days	60 days	90 days
W-0	0	35.00	43.59	53.02	55.249
W-05	5	36.03	44.57	53.57	56.007
W-10	10	37.12	45.67	56.10	57.76
W-15	15	34.29	42.61	53.74	56.42
W-20	20	34.10	41.72	52.96	53.68

Table 12: Compressive Strength results for cubes cured in 1% magnesium sulphate solution

Sample Designation	% of SCBA	7 days	28 days	60days	90days
W-0	0	35.34	42.68	52.99	56.46
W-05	5	36.62	43.70	53.85	57.37
W-10	10	37.12	44.99	54.68	58.85
W-15	15	34.99	42.55	51.98	55.12
W-20	20	34.38	41.14	50.12	54.4

Table 13: Compressive Strength results for cubes cured in 3% magnesium sulphate solution

Sample Designation	% of RHA	7 days	28 days	60days	90days
W-0	0	35.17	44.60	54.28	56.10
W-05	5	36.54	45.67	54.93	56.97
W-10	10	37.98	46.86	57.89	58.96
W-15	15	34.88	43.58	55.34	57.60
W-20	20	33.68	42.68	54.47	54.70

Table 14: Compressive Strength results for cubes cured in 3% magnesium sulphate solution

Sample Designation	% of SCBA	7 days	28 days	60days	90days
W-0	0	36.24	44.18	54.51	57.81
W-05	5	37.46	45.17	55.68	58.68
W-10	10	38.32	46.64	56.52	60.32
W-15	15	35.86	43.82	53.26	56.83
W-20	20	35.23	42.32	52.04	55.98

Table 15: Compressive Strength results for cubes cured in 5% magnesium sulphate solution

Sample Designation	% of RHA	7 days	28 days	60days	90days
W-0	0	35.09	43.62	53.39	56.74
W-05	5	36.21	44.81	53.90	57.52
W-10	10	37.17	45.87	57.22	59.62
W-15	15	34.32	42.72	54.68	58.17
W-20	20	33.26	41.89	53.78	55.20

Table 16: Compressive Strength results for cubes cured in 5% magnesium sulphate solution

Sample Designation	% of SCBA	7 days	28 days	60days	90days
W-0	0	35.69	43.62	53.72	57.36
W-05	5	36.8	44.6	54.56	57.88
W-10	10	37.52	46.14	55.6	59.16
W-15	15	35.32	43.22	52.64	55.6
W-20	20	34.68	41.88	51.39	55.19

V. CONCLUSION

When the compressive strengths of concrete with 0%, 5%, 10%, 15% and 20% weight replacement of cement with RHA and SCBA cured in Normal Water and in 1%, 3%, 5% MgSO4 solution for 28 days.

The target mean strength has been increased for the partial replacement of up to 10% by weight. Whereas the compressive strengths at 15 and 20 % replacement of RHA and SCBA are lower.

Due to slow Pozzolonic action the rice husk ash (RHA) concrete achieves significant improvement in its mechanical properties at later stages of curing but still it reduces for 15 and 20 % replacement.

Due to slow pozzolanic reaction the Sugar Cane Bagasse Ash (SCBA) concrete achieves significant improvement in its mechanical properties at later ages.

In concretes can be replaced with 20% SCBA without sacrificing strength at later ages.

Both RHA and SCBA concrete is resistant against sulphate attack up to 3%, but further increase up to 5% of $MgSO_4$ the decrease in compressive strengths can be observed.

The workability of RHA concretes have decreased in compared with ordinary concrete. It is inferred that reduction in workability is due to large surface area of RHA and SCBA.

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LIST OF I.S. CODES

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