Strength and Permeability Properties of concrete using fly Ash, rice husk Ash, and Ground Granulated Blast Furnace Slag

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Abstract: cement industry may be one amongst the key sources of environmental pollution so the reduction of cement demand should be improved. Fly ash(FA), Rice husk ash(RHA) and Ground granulated blast furnace slag (GGBS) are the by-products of industries and it ought to be reused to scale back the waste pollution. Therefore the present study is directed towards developing a better understanding on the combined performance of FA,RHA and GGBS on the strength properties of Ternary concrete over an Ordinary concrete. This work primarily deals with the strength characteristics such as Compressive, Split Tensile and Flexural Strength. Total 5 Different concrete mixtures were cast and tested with different cement replacement levels (5%, 10%,15%,20%,25%) of combination of three byproducts .Compressive ,Split Tensile and Flexural Strength of Ternary Blended Concrete At the ages of 7, 28, 60 and 90 days for various combinations FA,RHA, and GGBS..All Mixes were studied at water cement ratio of 0.50 and 0.40. The cement has been replaced by rice husk ash, accordingly in the range of 0%, 5 %, 10 %, 15 %, and 20 % by weight. Concrete mixture of M 30 and M40with 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, 56, 90 days for compressive strengths in normal water and in MgSO4 solution of 1% and 5%. Also the durability aspect for rice husk ash concrete for sulphate attack was tested. Similarly the above tests were also performed for FA and SCBA The experimental results shows that, the strength properties of ternary blended concrete increase with increase in cement replacement levels of FA,RHA, and GGBS.. (20%),the addition of FA,RHA, and GGBS does not improve the strength properties of compressive, Split Tensile and Flexural, durability tests are also performed.

Key words: Fly Ash, Rice Husk Ash, GGBS, Concrete, M30 grade concrete M40 grade concrete, cubes, cylinders, MgSO4, durability.

I.INTRODUCTION

These days researchers are studying different agro-based waste materials. The major quantities of waste generated from agricultural sources include sugarcane bagasse, rice husk, and coconut husk. Reusing such waste as a sustainable construction material seems to be a suitable solution for the problem of land filling and the high cost of building materials (Rabi et al 2009). These days, agricultural solid waste materials are being reused in manufacturing blended mortars and concrete for better performance and price. The use of waste materials in concrete has been a continuous procedure in different industries. These waste agricultural materials are used to heighten the mechanical properties of a building material while they are not useful in agriculture fields. Rice husk ash (RHA), sugarcane bagasse ash (SCBA), sawdust and cork granules have been used as pozzolanic materials for reactivity in concrete. They are added to concrete to partially replace cement in concrete mixtures so that the concrete will have sufficient engineering physical and chemical properties. RHA has been used as a suitable raw material to make hydraulic cement and as a good corrective admixture to reduce expansion that occurs as a result of an alkali-silicate reaction, and also to reduce the temperature in high-strength concrete SCBA is a valuable cement-replacing material for cement and concrete production because of its high content of silicon and aluminium oxides. Also, the effect of elevated temperature on strength of normal and high strength concrete with and without different ashes is investigated by different researchers.

FLY ASH

Fly ash is a fine powder which is a byproduct from burning pulverized coal in electric generation power plants. Fly ash is a pozzolana, a substance containing aluminous and siliceous material that forms cement in the presence of water. When mixed with lime and water it forms a compound similar to Portland cement. The fly ash produced by coal-fired power plants provide an excellent prime material used in blended cement, mosaic tiles, and hollow blocks among others. Fly ash can be an expensive replacement for Portland cement in concrete although using it improves strength, segregation, and ease of pumping concrete. The rate of substitution typically specified is 1 to 1 ½ pounds of fly ash to 1 pound of cement. Nonetheless, the amount of fine aggregate should be reduced to accommodate fly ash additional volume.

RICE HUSK ASH

Rice husk is an agricultural residue which accounts for 20% of the 649.7 million tons of rice produced annually worldwide[1]. 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[2]. 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

GROUND GRANULATED BLAST FURNACE SLAG

Ground Granulated Blast furnace Slag (GGBS) is a byproduct from the blast furnaces used to make iron. These operate at a temperature of about 1500 degrees centigrade and are fed with a carefully controlled mixture of iron ore, coke and limestone. The iron ore is reduced to iron and the remaining materials from a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid. and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching optimizes the cementations properties and produces granules similar to coarse sand. This „granulated" slag is then dried and ground to a fine powder. Although normally designated as "GGBS" in the UK, it can also be referred to as "GGBS" or "Slag cement" Concrete is basically a mix of fine aggregate, coarse aggregate and cement. The main problem is the original conventional materials are depleting and we are in hunt for alternate building materials which lands us here on the purpose of GGBS. Being a by product and waste using it effectively up to some extent serves as a step for a greener environment and at the same time keeping in mind that the strength of the concrete doesn't degrade by the usage GGBS.

OBJECTIVE OF THE STUDY

Depending on the suitability of Bagasse ash, it can be used as resource material in the following applications:

- Silica source as it contains high amount of silica in it.
- Brick production as BA used as additive in making bricks that have high compressive strength and low water absorption bricks.
- Farm fertilizer as it contains traces of potassium and phosphorus compounds etc.
- To compare the tests results of fly ash, rice husk ash, and sugarcane Bagasse ash with the normal concrete.
- To find the optimum usage of the percentage replacement of the fly ash , rice husk ash, baggage ash to the concrete.

SCOPE OF THE STUDY

The primary aim of experimental work is to study the properties of sugar cane bagasse ash. Preparation of mix design Replacement of cement with SCBA as different proportions with cement.

- Effect of a GGBS on workability.
- Effect of fly ash and rice husk ash on the strength of the concrete.
- Effect on compressive strength of concrete.
- Effect on split tensile strength of concrete.
- To determine the optimum dosage of the GGBS, Fly ash, Rice husk ash to be added to the concrete mix.
- Comparison of result of different tests with varying proportion of FA, RHA and GGBS.

II.LITERATURE REVIEW

Sagar Dhengare [1], Sourabh Amrodiya[2] and Mohanish Shelote[3] et all,. In developing countries, accumulation of unmanaged agricultural waste has resulted in an increased environmental concern. Recycling of such agricultural wastes is the viable solution not only to pollution problem, but also the problem of land filling. In view of utilization of agricultural waste in concrete and mortar, the present paper reviews, utilization of sugarcane Bagasse ash (SCBA) in different compositions that were added to the raw material at different levels to develop sustainable concrete and mortar. Various physic-mechanical properties of the concrete and mortar incorporating sugarcane Bagasse ash are reviewed and recommendations are suggested as the outcome of the study. The study in turn is useful for various resource SCBA material to develop sustainable construction material.

Mangesh V Madurwar, Sachin A Mandavgane, Ph.D. et al (2014) SBA-QD-L bricks are up to40%

lighter than the conventional locally available bricks and hence support in lightweight construction projects with larger design loads. Observations during the tests showed that SBA-QD-L brick composition with SBA (50% by weight), quarry dust (30% by weight), and lime (20% by weight) exhibits the water absorption of 19.70% (less than 20%) and the compressive strength of 6.59 MPa, which is almost double the conventional commercially available clay bricks (3.5 MPa) and satisfies the requirements in IS: 2185 (Part-I) (BIS 1979) and SP: 21 (BIS 1983) for a building material.

Cbatveera, P. NtmJtyonglkul. et al (1994) This research is conducted to develop new kinds of pozzolana from other agricultural wastes apart from rice husk and rice straw. The study investigated the use of coconut husk, Corn cob and peanut shell ash as pozzolana. The properties of CHA, CCA and PSA namely specific gravity, fineness, chemical composition and the strength activity index with Portland cement were determined. For properties of paste, only ordinary Portland cement and 30% PSA were investigated for normal consistency and initial and final setting time. CCA mortars have lower compressive strength than the controlled mortar (0% CCA) while PSA mortars showed higher compressive strength than the controlled mortar (0% PSA).Among the four mortars tested for chemical attack, PSA mortars showed higher resistance against sulphate attach and RHA against acidic attack.

III.METHODOLOGY

CEMENT

Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete which is a combination of cement and an aggregate to form a strong building material.

OPC 53 GRADE CEMENT

COARSE AGGREGATE

Crushed stone aggregate of 20mm size is brought from nearby quarry. Aggregates of size more than 20mm size are separated by sieving. Tests are carried in order to find out the

- Specific gravity = 2.98
- Fineness modulus = 7.5

Coarse aggregate

FINE AGGREGATE:

Locally available fresh sand, free from organic matter is used. The result of sieve analysis confirms it to Zone-II (according to IS: 383-1970).The tests conducted and results plotted below.

- Specific gravity = 2.3
- Fineness modulus = 3.06

Fine aggregates

Super plastizers (perma super plast 220)

Perma Plast Super- 220 is a high range, low dosage, super plasticising admixture for slump retention. It is a product based on refined naphthalene formaldehyde and ligno sulfonate blends. To produce self-compacting flowing concrete. To produce high early strength concrete for delayed slump retention and for long overhauls. Ideally suited for commercial RMC plants and concrete made with crushed sand.For the production of high workability concrete where heavily congested reinforcement exist or poor access is available. To produce flowing self Compacting concrete which requires minimal labour to place. For the production of high strength, high workability concrete. Particularly beneficial in hot climatic conditions and in ready mix concrete. It is based on naphthalene formaldehyde blends.

MIX DESIGN

Final trial mix for M30 grade concrete is 1:1.64:2.55 at w/c of 0.45

GRADE OF CONCRETE	CEMENT KGS	Granulated ground blast furncace slag (GGBS)	Fly Ash	Rice husk Ash	Fine aggregates	coarse aggregates	water content	Admixture
M30	183.82	7.32	7.32	7.32	502	780	88	4
Addition of extra 10%	202.20	8.052	8.052	8.052	552.2	858	96.8	4.818

Final trial mix for M40 grade concrete is 1:2.29:3.56 at w/c of 0.40

GRADE OF CONCRETE	CEMENT KGS	Granulated ground blast furnace slag (GGBS)	Fly Ash	Rice husk Ash	Fine aggregates	coarse aggregates	water content	Admixture
M40	194	7.32 Kgs	7.32 kgs	7.32 kgs	502	780	87.2	4.38
Addition of extra 10%	213.4	8.05	8.05	8.05	552.2	858	8.72	0.44

IV.RESULTS

MATERIAL PROPERTIES

Test results on the cement

Sl.no	Test	Results	IS code used	Acceptable limit
1	Specific gravity of cement	3.10	IS:2386:1963	3 to 3.2
2	Standard consistency of cement	6mm at 32% w/c	IS:4031:1996	w/c ratio 28%-35%
3	Initial and final setting time	45 mins and 10 hours	IS:4031:1988	Minimum 30mins and should not more than 10 hours
4	Fineness of cement	4.00%	IS:4031:1988	<10%

Test results on coarse aggregates

Sl.no	Test	Results	Is code used	Acceptable limit
1	Fineness modulus	6.8	IS:2386:1963	6.0 to 8.0mm
2	Specific gravity	2.95	IS:2386:1963	2 to 3.1mm
3	Porosity	46.83%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.8855	IS:2386:1963	Any value
5	Bulk density	1.50g/cc	IS:2386:1963	-
6	Aggregate impact value	35.5	IS:2386:1963	Less than 45%
7	Aggregate crushing value	27.5%	IS:2386:1963	Less than 45%

Test results on the fine aggregates

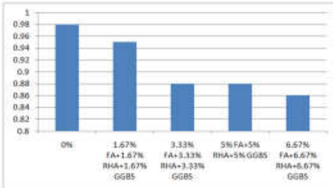
Sl.no	Test	Result	Is code used	Acceptable limits
1	Fineness modulus	4.5	IS:2386:1963	Not more than 3.2 mm
2	Specific gravity	2.43	IS:2386:1963	2.0 to 3.1
3	Porosity	36.6%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.577	IS:2386:1963	Any value
5	Bulk density	1.5424	IS:2386:1963	-
6	Bulking of sand	4.0%	IS:2386:1963	Less than 10%

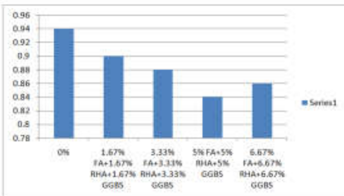
slump values for concrete

S.NO	% Replacement	Slump for M30grade	Slump for M40 grade
1	0%	55	52
2	1.67% FA+1.67% RHA+1.67% GGBS	67	68
3	3.33% FA+3.33% RHA+3.33% GGBS	72	79
4	5% FA+5% RHA+5% GGBS	78	80
5	6.67% FA+6.67% RHA+6.67% GGBS	85	92

Compaction factor Test

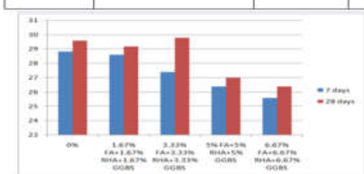
S.NO	% Replacement	Compaction factor for M30 grade concrete	Compaction factor for M40 grade concrete
1	0%	0.98	0.94
2	1.67% FA+1.67% RHA+1.67% GGBS	0.95	0.9
3	3.33% FA+3.33% RHA+3.33% GGBS	0.88	0.88
4	5% FA+5% RHA+5% GGBS	0.88	0.84
5	6.67% FA+6.67% RHA+6.67% GGBS	0.86	0.86

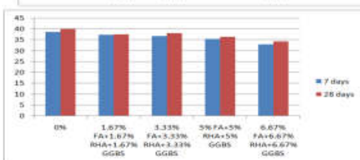




Compressive strength:

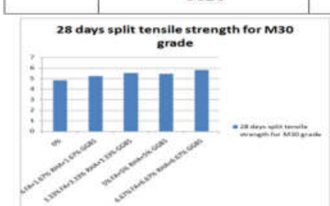
s.no	% Replacement	Compressive strength of concrete			
		M30 grade concrete		M40 grade concrete	
		7 days	28 days	7 days	28 days
1	0%	28.84	29.6	38.6	39.86
2	1.67% FA+1.67% RHA+1.67% GGBS	28.6	29.2	37.24	37.44
3	3.33% FA+3.33% RHA+3.33% GGBS	27.4	29.8	36.6	37.9
4	5% FA+5% RHA+5% GGBS	26.4	27	35.4	36.2
5	6.67% FA+6.67% RHA+6.67% GGBS	25.6	26.4	32.8	34.22

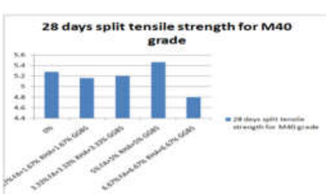




Split tensile strength of concrete

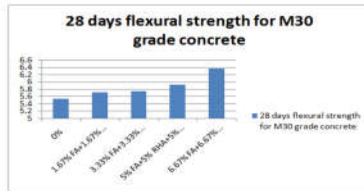
S.no	% Replacement	28 days split tensile strength for M30 grade	28 days split tensile strength for M40 grade
1	0%	4.82	5.28
2	1.67%FA+1.67%RHA+1.67% GGBS	5.21	5.16
3	3.33%FA+3.33%RHA+3.33% GGBS	5.53	5.2
4	5% FA+5% RHA+5% GGBS	5.45	5.46
5	6.67%FA+6.67%RHA+6.67% GGBS	5.8	4.8

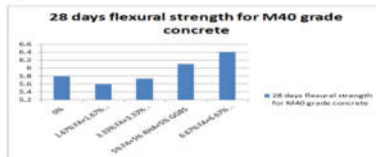




Flexural strength of concrete:

S.no	% Replacement	28 days flexural strength for M30 grade concrete	28 days flexural strength for M40 grade concrete
1	0%	5.54	5.8
2	1.67% FA+1.67% RHA+1.67% GGBS	5.71	5.6
3	3.33% FA+3.33% RHA+3.33% GGBS	5.74	5.74
4	5% FA+5% RHA+5% GGBS	5.92	6.1
5	6.67% FA+6.67% RHA+6.67% GGBS	6.36	6.4

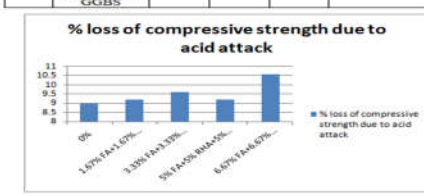




Durability

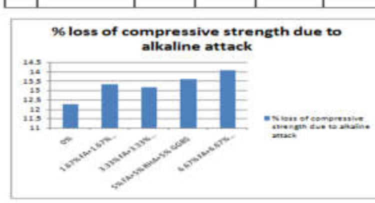
For M30 grade concrete for acid attack

Sl.no	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0%	2261	2242	0.82	29.6	26.95	8.96
2	1.67% FA+1.67% RHA+1.67% GGBS	2340	2318	0.94	29.2	26.51	9.2
3	3.33% FA+3.33% RHA+3.33% GGBS	2351	2323	1.2	29.8	26.94	9.6
4	5% FA+5% RHA+5% GGBS	2234	2202	1.44	27	24.5	9.2
5	6.67% FA+6.67% RHA+6.67% GGBS	2394	2356	1.6	26.4	23.6	10.6



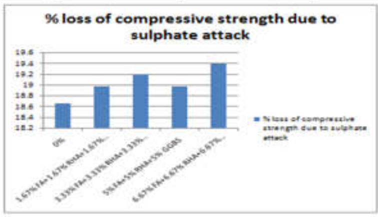
Alkaline attack

Sl. No	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to alkaline attack
1	0%	2266	2259	1.2	29.6	25.98	12.26
2	1.67% FA+1.67% RHA+1.67% GGBS	2340	2306	1.44	29.2	25.3	13.34
3	3.33% FA+3.33% RHA+3.33% GGBS	2280	2244	1.6	29.8	25.86	13.2
4	5% FA+5% RHA+5% GGBS	2310	2268	1.84	27	23.32	13.62
5	6.67% FA+6.67% RHA+6.67% GGBS	2296	2251	1.96	26.4	22.67	14.1



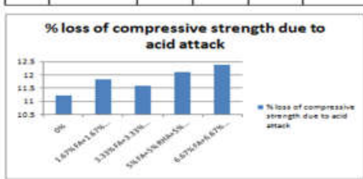
Sulphate attack test

Sl.no	% replacement	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	0%	29.6	24.07	18.66
2	1.67% FA+1.67% RHA+1.67% GGBS	29.2	23.65	18.98
3	3.33% FA+3.33% RHA+3.33% GGBS	29.8	24.07	19.2
4	5% FA+5% RHA+5% GGBS	27	21.87	18.98
5	6.67% FA+6.67% RHA+6.67% GGBS	26.4	21.27	19.4



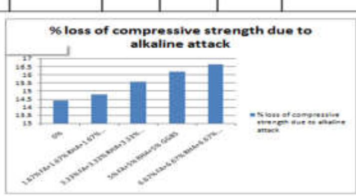
For M40 grade concrete:

Sl.no	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0%	2261	2240	0.93	39.86	35.4	11.24
2	1.67% FA+1.67% RHA+1.67% GGBS	2340	2312	1.2	37.44	33	11.84
3	3.33% FA+3.33% RHA+3.33% GGBS	2351	2318	1.4	37.9	33.5	11.6
4	5% FA+5% RHA+5% GGBS	2234	2194	1.8	36.2	31.81	12.12
5	6.67% FA+6.67% RHA+6.67% GGBS	2394	2341	2.2	34.22	29.98	12.4



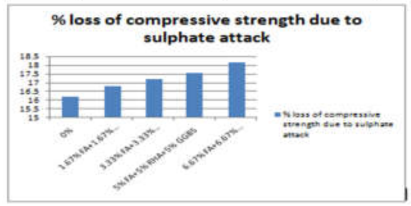
Alkaline attack

Sl. No	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to alkaline attack
1	0%	2351	2320	1.3	39.86	34.12	14.4
2	1.67% FA+1.67% RHA+1.67% GGBS	2340	2302	1.6	37.44	31.9	14.8
3	3.33% FA+3.33% RHA+3.33% GGBS	2260	2228	1.4	37.9	32	15.6
4	5% FA+5% RHA+5% GGBS	2245	2205	1.8	36.2	30.33	16.2
5	6.67% FA+6.67% RHA+6.67% GGBS	2260	2210	2.2	34.22	28.52	16.66



Sulphate attack test

Sl.no	% replacement	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	0%	39.86	33.4	16.22
2	1.67% FA+1.67% RHA+1.67% GGBS	37.44	31.13	16.84
3	3.33% FA+3.33% RHA+3.33% GGBS	37.9	31.37	17.22
4	5% FA+5% RHA+5% GGBS	36.2	29.82	17.6
5	6.67% FA+6.67% RHA+6.67% GGBS	34.22	28	18.2



V.CONCLUSIONS

From the above experimental program the following conclusions were made

1. The material properties of the cement, fine aggregates and coarse aggregates are within the acceptable limits as per IS code recommendations so we will use the materials for research.
2. Slump cone value for the RHA, FA, GGBS concrete increases with increasing in the percentage of RHA, FA, GGBS so the concrete was not workable.
3.Compaction factor value of RHA, FA, GGBS concrete decreases with increase in the percentage of RHA, FA, GGBS
4. The compressive strength of concrete is maximum at 20% replacement of RHA, FA, GGBS and is the optimum value for 7days curing and 28days curing
5. Split tensile strength for the cylindrical specimens is maximum at 40% of replacement of copper slag for 28days curing.
6. The flexural strength of copper slag concrete is also maximum at 20% replacement of copper slag for 28 days of curing.
7. So the replacement of 5% to 20% of RHA, FA, GGBS is generally useful for better strength values in M30 And M40 grade of concrete.

FUTURE RECOMMENDATIONS:

- Using RHA, FA, GGBS with cement checking out whether the minimum strength required for M50 and M60 grades of concrete can be achieved.

- Checking out the feasibility of utilization of HA, FA, GGBS finding the Strength characteristics of Concrete.

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