EXPERIMENTAL STUDY WITH PARTIAL REPLACEMENT OF CEMENT BY RICE HUSK ASH AND BAGASSE ASH

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ABSTRACT

The utilization of waste materials in concrete manufacture provides a satisfactory solution to some of environmental concerns and problems associated with waste management. Agro waste such as rice husk ash and bagasse ash are used as pozzolanic material for development of blended cement. The rice husk ash and bagasse ash are rich in amorphous silica. Rice husk ash is used as insecticides, pesticides and as a flue gas desulphurization agent. Bagasse ash are used as a fertilizer and used to produce ceramic material. Both rice husk ash and bagasse ash reduces the permeability, shrinkage, heat of hydration. It increases the compressive strength, flexural Strength, and durability. The properties of concrete with partial replacement of cement by rice husk ash and bagasse ash for about 30% were investigated which includes its compressive strength, split tensile, flexural strength, durability property test namely acid attack. Among the various percentage replacement of cement by rice husk ash and bagasse ash, the strength test result shows that the optimum percentage replacement was about 70 : 20 : 10 (Cement : RHA : BA) which gives the optimum proportion of 30% replacement of cement with rice husk ash and bagasse ash to produce high performance concrete and contribute to sustainable construction. This optimum proportion also gives better durability properties when compared to control cement concrete.

KEYWORDS: Rice husk ash, Bagasse ash, Workability, Compressive strength.

1.INTRODUCTION

Concrete is the most widely used man made construction material. It is obtained by mixing cement, water, aggregate and admixtures in required proportions. The mixer when placed in forms and allowed to cure becomes hard like stones. The strength, durability and other characteristics of concrete depends the properties of concrete ingredients, on the proportions of mix, the methods of compaction and other controls during placing and curing. Concrete is being extensively used in most of the construction activities. The usage of steel is far less than the concrete. Concrete has the advantage of easy handling and transportation. It can endure very high temperatures from fire for a long time without loss of structural integrity and performs well during both natural, manmade disasters and even under the impact of flying debris. With major development in the concrete industry, the waste materials utilization in the manufacturing of concrete, being used as replacement material for ingredients is being practiced extensively all over the world. Some of the composite materials are used to replace the cement such as fly ash, rice husk ash, bagasse ash, slag, fibers, grit, dregs etc. The studies for using the waste materials as partial replacement of cement have started in many areas. The rice husk ash and bagasse ash can be a potential replacement material when compared to other natural wastes. Rice husk ash and bagasse ash contains more amount of amorphous silica so it will not affect the strength of concrete by replacement. The rice husk ash and Bagasse ash will increase the properties of concrete such as workability, durability with low creep, low shrinkage, and low heat of hydration, low carbon content, low bleeding, and segregation.

2.OBJECTIVE

i) To determine the strength and durability properties of concrete with various percentage replacement of cement by the combination of rice husk ash and bagasse ash for about 30%.

ii) To determine the optimum percentage

replacement of rice husk ash and bagasse ash as a partial replacement of cement.
iii) To study the compressive, spilt tensile and flexural strength of concrete at 7 and 14 days.

3. SCOPE

The present work is to carry out a detailed analysis of the following sub-systems for the prescribed conditions.
i) Concrete mix design for M30 grade of concrete.
ii) Casting of concrete specimens of M30 grade of concrete with different percentage of RHA and BA.
iii) Testing of specimens at various ages.
iv) Plotting graphs and comparing the strength and durability of concrete specimens at different percentage of RHA and BA.

4.REPLACEMENT MATERIALS IN CEMENT

i)RICE HUSK ASH

Rice husk is an agricultural residue available all parts of the world which is obtained from which is burned under controlled temperature of about 700 °C. After the burning process the carbon content is burnt off and the ash is obtained which contains around 85% - 90% amorphous silica. The pozzolana has high reactivity with no significant amount of crystalline material. Rice husk contains 75% of organic fickle matter. The other 25% is converted into ash during the firing process. The rice husk is a green supplementary material that has applications in small to large scale. Since it can be easily collected and cheap, some amount of rice husk has always been used as an energy source for small applications.

ii) BAGASSE ASH

Bagasse is one of an agricultural waste from sugar manufacturing. When juice is extracted from the cane sugar, the solid waste material is known as bagasse. Sugarcane bagasse is partly used at the sugar mill as fuel for power generation. Furthermore, the sugarcane bagasse is burned under temperature and atmosphere; it gives ash having amorphous silica.

5. METHODOLOGY

- Tested the material properties as per IS code procedures.
- Mix design for concrete proportion was arrived at as per IS- 10262- 1982.
- The properties of fresh concrete were determined as per IS- 1199- 1959.
- The concrete specimens were casted and cured as per IS procedures.
- Tests were conducted on hardened concrete to determine various strength parameters.
- Various durability tests were conducted as per standard codes.
- Finally results were compared with conventional concrete and partial replacement concrete mixed with RHA, BA and other materials and conclusions were arrived at.

6. LITERATURE REVIEW

Experimental Study on Bagasse Ash in Concrete- R.Srinivasan (2014)'

The utilization of industrial and agricultural waste produced by industrial processes has been the focus of waste reduction research for economical, environmental, and technical reasons. Sugar-cane bagasse is a fibrous waste-product of the sugar refining industry, along with ethanol vapor. This waste product (Sugar-cane Bagasse ash) is already causing serious environmental pollution, which calls for urgent ways of handling the waste. Bagasse ash mainly contains aluminum ion and silica. In this paper, Bagasse ash has been chemically and physically characterized, and partially replaced in the ratio of 0%, 5%, 15% and 25% by weight of cement in concrete. Fresh concrete tests like compaction factor test and slump cone test were undertaken was well as hardened concrete tests like compressive strength, split tensile strength, flexural strength and modulus of elasticity at the age of seven and 28 days was obtained. The result shows that the strength of concrete increased as percentage of bagasse ash replacement increased.

Partial replacement of cement in concrete sugarcane baggase ash behaviour in HCL solution -K Meeravali , K V G D Balaji , T. Santhosh Kumar(2013)

The durability aspects of concrete especially in aggressive environments have become a severe

problem in modern day construction. Blended cement concrete is one of the best solutions to this durability criterion. The adoption of blended cements has shown a sharp increment in results of compressive strength in standard conditions and in aggressive conditions. Sugarcane bagasse ash (SCBA) is chosen for this study which has been confirmed as a blending material possessing pozzolanic properties which even reduces the cost of construction and environmental pollution caused due to cement manufacture and disposal of SCBA. In this paper cement is replaced by sugarcane bagasse up to 25% in regular intervals of 5%. To analyse the behaviour of SCBA concrete in HCl the casted specimens are cured in 5% HCl solution for 7, 28 and 60 days. The water binder ratio adopted is 0.4. The use of blending materials in concrete reduces the heat of hydration and increases the life of structure. When calcium hydroxide reacts with hydrochloric acid gives out ettringite (and $CaCl_2$) possessing a crystal type of structure which makes the concrete porous and allows the external chloride ions to penetrate into concrete leading in the loss of weight and strength of concrete. In this paper an attempt is made to prove that SCBA helps to restrict this attack of HCl on concrete.

Waste product baggase ash from sugarcane industry can be used as stabilizing material for expansive soils- Amit S. Kharade , Vishal V. Suryavanshi , Bhikaji S. Gujar , Rohankit R. Deshmukh(2012)

Soil is a base of structure, which actually supports the structure from beneath and distributes the load effectively. If the stability of the soil is not adequate then failure of structure occurs in form of settlement, cracks etc. Expansive soil also known as black cotton soil is more responsible for such situations and this is due to presence of montmorillonite mineral in it, which has ability to undergo large swelling and shrinkage. To overcome this, properties of soil must be improved by artificial means known as 'Soil Stabilization'. It is a technique which improvises one or more soil properties by mechanical, cementing and chemical use. Many research has been conducted for stabilization of soil by using cementing, chemical materials e.g. Fly ash, cement, Calcium chloride, Sodium chloride etc. Toady world is facing serious problem of disposal of agricultural waste. Western Maharashtra is popular for production of sugar cane in large quantity. Sugar factories produces waste after extraction of sugar cane in machines that waste when burnt, the resultant ash is known as 'Bagasse Ash'. It is a fibrous material with presence of silica (SiO_2) and can be used to improve the existing properties of black cotton soil. In this study laboratory experiments were conducted on black cotton soil with partial replacement by Bagasse Ash (3%, 6%, 9% and 12%). This paper highlights significant increase in properties of black cotton soil obtained at 6% replacement of Bagasse Ash without any chemical or cementing material.

Effect of Rice Husk Ash (RHA) as Partial Replacement of Cement on Concrete Properties-c.marthong(2012)

Cement is widely noted to be most expensive constituents of concrete. The entire construction industry is in search of a suitable and effective the waste product that would considerably minimize the use of cements and ultimately reduces the construction cost. Rice husk ash (RHA) which has the pozzolanic properties is a way forward.Three grades of ordinary Portland cement (OPC) namely; 33, 43 and 53 as classified by Bureau of Indian Standard (BIS) are commonly used in construction industry. A comparative study on effects of concrete properties when OPC of varying grades was partially replaced by RHA is discussed in this paper. Percentage replacement of OPC with RHA was 0, 10, 20, 30 and 40% respectively. The compressive strength, water absorption, shrinkage and durability of concrete were mainly studied.

Evaluation of sugarcane baggase ash as a replacement for cement in concrete works -. Department of Civil Engineering, University of Ilorin, Ilorin, Nigeria(2012)

This research evaluates the suitability of SCBA as a partial replacement for cement in concrete productions. Total weight of 34.7kg of sugarcane bagasse (SCB) was obtained and burnt at 7000C. A total of 2.71kg of SCBA was obtained after passing the residual through 45µm sieve, standard size of ordinary portland cement (OPC).It was then used to replace OPC by weight in ratio of 0%, 10%, 20% and 30%. Total of 48 pieces of 100mm concrete cubes mix were prepared. The cubes were tested at 7, 14, 21 and 28days of curing ages for density and compressive strength. The results of chemical test showed that SCBA has pozzolanic properties having met ASTM- 595 (1985) with total sum of silica, alumina and ferric composition of 80.55%. The results showed a decrease in concrete density with increase in % replacement of

SCBA. Average compressive strength of 26.8N/mm2 was obtained for control specimens at 28days (i.e. 0% SCBA) while 22.3,20.1and17.3N/mm^2 compressive strength at 28days were obtained for 10%, 20% and 30% replacement respectively. Pozzolanic activity index (PAI) of 83.2%, 75% and 64.5% were obtained. This showed that only 10% and 20% replacement of cement by weight of SCBA satisfied ASTM-595(1985) specification for PAI. It was concluded that SCBA is a low weight material and 10% replacement of SCBA has the highest PAI. Also, 10% and 20% replacement of SCBA with compressive strengths of 22.3N/mm^2 and 20.1N/mm^2 are recommended for reinforced concrete.

Utilization of bagasse ash in high-strength concrete,Sumrerng Rukzon, Prinya Chindaprasirt, (2011)
This paper presents the use of bagasse ash (BA) as a pozzolanic material for producing high-strength concrete. Portland cement type I (PC) is partially replaced with finely ground bagasse ash. The concrete mixtures, in part, are replaced with 10%, 20% and 30% of BA respectively. In addition, the compressive strength, the porosity, the coefficient of water absorption, the rapid chloride penetration and the chloride diffusion of concretes are determined. The test results indicate that the incorporation of BA up to 30% replacement level increases the resistance to chloride penetration. Besides, the use of 10% of BA produced concretes with good strength and low porosity. Reasonably, the substitution of 30% BA is acceptable for producing high-strength concrete.

Study of Concrete Properties Using Rice Husk Ash and Marble Powder -- Piyush Raikwar , Vandana Tare(2011) This paper presents the study of concrete mix design using rice husk ash and marble powder. The problems of disposal of the RHA & MP are also sort out to some extent. RHA-MP causes increment strength of concrete. The concrete is mixed with RHA in varying percentage of 10-30%, with constant 5% of marble powder, then properties like compressive strength, flexural strength, durability, water absorption are studied. The optimum value of RHA-MP in concrete is 21% and cost analysis of optimum percentage of RHA-MP concrete is also evaluated. The investigation concluded that, When 21 % of cement is replaced by 16% Rice husk ash and 5% Marble Powder, compressive strength and flexural strength of RHA-MP concrete is more than the normal concrete. Water absorption of RHA-MP concrete is decreases for 16% RHA and 5% MP and then increases. Durability is increased for the concrete mix having 20% RHA and 5% MP of RHA-MP concrete.

Rice husk ash – Pozzolanic material for sustainability Kartini.K (2011)
This paper presents an intensive study on RHA was conducted to determine its suitability. From the grade of concrete (Grade 20) studied, it shows that up to 30% replacement of OPC with RHA has the potential to be used as partial cement replacement (PCR), having good compressive strength performance and durability, thus have the potential of using RHA as PCR material and this can contribute to sustainable construction. The use of Superplasticiser in RHA concrete will increase the slump. RHA reduces the permeability, resistance to chloride penetration.

Performance of concrete in presence of supplementary cementitious material, M.A. Hossain, M.H. Rashid, M.M.Rahman and O.U.Laz., (2011)
This paper presents the use of RHA as partial replacement of cement in concrete production. Three different replacement levels namely 0%, 10% and 20% are chosen for the study concern. The curing periods are starting from 7 days, 14 days, 28 days, 90 days and 300 days are considered. The compressive strength of concrete with 10% RHA has been increased significantly and for upto 20% replacement level could be beneficially without adversely affecting the strength. The addition of 10% and 20% RHA with OPC to the concrete, the time required for the equal pH in the anodic and cathodic compartment is more than the control sample which indicated that they have better resistance of water. Permeability of concrete is measured in terms of current passing through it at 14 days curing.

7. MATERIALS USED AND THEIR PROPERTIES

A.Cement

Cement is a binder, a substance that sets and hardens independently, and can bind other materials together. The most important use of cement is the production of mortar and concrete the bonding of natural or artificial aggregates to form a strong building material that is durable in the face of normal environmental effects. Ordinary Portland cement of 53- grade is used. This is used to develop high strength and has low setting time.

It gives much better results and compressive strength in 28 days.

Table 1.Properties of cement

S.no	Physical properties	Values
1.	Specific gravity	3.16
2.	Fineness modulus	2%
3.	Consistency	33%
4.	Initial setting time	36min
5.	Final setting time	210min

B.Fine Aggregate

To increase the density of the resulting mix, the aggregate is frequently used in two or more sizes. The aggregate serves as reinforcement to add strength to the overall composite material. Fine Aggregate may have more impact on the strength of the building than cement. Fine aggregate will consist of natural sand, manufactured sand, or a combination of the two, and will be composed of clean, hard, durable particles.

Table 2.Properties of fine aggregate

S.no	Physical properties	Values
1.	Specific gravity	2.66
2.	Water absorption	2%
3.	Fineness modulus	4.66
4.	Type	Well graded soil

C.Coarse Aggregate

Coarse aggregate is a material that will pass the 20mm sieve and will be retained on the 12.5mm sieve. As with fine aggregate, for increased workability and economy as reflected by the use of less cement, the coarse aggregate should have a rounded shape.

Table3.Properties of coarse aggregate

S.no	Physical properties	Values
1.	Specific gravity	2.52
2.	Water absorption	0.51%
3.	Fineness modulus	7.17
4.	Type	Crushed

D.Rice husk ash

Rice husk is an agro-waste material which is produced in about millions of tons. Approximately, 20Kg of rice husk are obtained from 100Kg of rice. Rice husks contain organic substances and 20%of inorganic material. RHA is obtained by the combustion of rice husk.

Fig 1. Rice husk ash

Table 4.Properties of rice husk ash

S.no	Physical properties	Values
1.	Specific gravity	2.13
2.	Bulk density	70-145kg/m^3
3.	Fineness modulus	2.3

E.Bagasse ash

Bagasse ash is a waste material obtained by burning the bagasse fiber in the boiler for vapor and power generation in the factory. This ash is utilized for agricultural purposes though its effect on the fertility of soil is not that significant compare to the problems it may bring to the environment since it emits noxious gasses like Carbon.

Fig 2. Bagasse ash

Table 5.Properties of Bagasse ash

S.no	Physical properties	Values
1.	Specific gravity	2.65
2.	Bulk density	350kg/m^3
3.	Fineness modulus	2.85

F.Water

Water is the most important and least expansive ingredient of concrete. A part of mixing water is utilized in the hydration of cement to form the binding matrix in which the inert aggregates are held in suspension until the matrix has hardened.Generally cement requires about 3/10 of its weight of water for hydration. But the concrete containing water in this proportion will be very

harsh and difficult to place.

G.Admixture

Admixtures are ingredients other than water, aggregates, hydraulic cement, and fibers that are added to the concrete batch immediately before or during mixing. These properties may be modified to increase compressive and flexural strength at all ages, accelerate initial set, increase slump and workability.Bythe above considerations we are using **Conplast SP 430** as a chemical admixture.

Table 6.Chemical properties of RHA ,BA and cement

Compound	RHA % Composition	BA % Composition	CEMENT % Composition
SiO_2	88.32	78.34	20.99
Al_2O_3	0.46	8.55	6.19
Fe_2O_3	0.67	3.65	3.86
Cao	0.67	2.15	65.96
Na_2O	0.12	0.12	0.17
K_2O	2.91	3.46	0.60
P_2O_5	0.52	1.07	0.05

8.DESIGN OF M30 CONCRETE MIX AS PER IS-10262-2009

Cement (kg)	FA (kg)	CA (kg)	Water (kg)
337.87	740	1156.34	185.83
1	2.19	3.42	0.55

DETAIL OF MIX VARIATIONS

The percentage of partial replacement of cement with rice husk ash and bagasse ash is increased in the order of 5%.

Table 7.Mix proportions of concrete

Cement(%)	RHA(%)	BA(%)
100	-	-
70	30	0
70	25	5
70	20	10
70	15	15
70	10	20
70	5	25
70	0	30

9.EXPERIMENTAL RESULTS

A. Compressive strength

Table 8.Compressive strength of concrete specimens for 7 and 28 days

Mix proportion	Mean compressive strength(N/mm^2)	
	7 days	28days
Mix 1	18.17	33.9
Mix 2	8.5	12.33
Mix 3	12.83	24
Mix 4	17.66	31.5
Mix 5	9.3	21.83
Mix 6	8.33	18.33
Mix 7	15.6	22
Mix 8	8	11.83

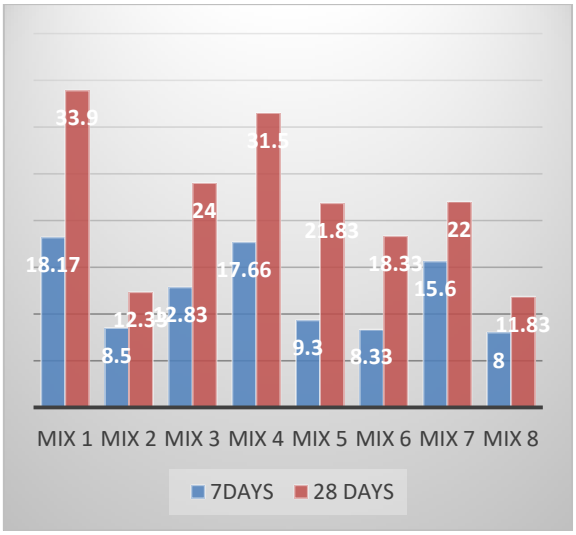

Fig 3 Effect on compressive strength of concrete

B.Split tensile strength

Table 9.plit tensile strength of concrete specimens for 7 and 28 days

Mix proportion	Mean split tensile strength(N/mm^2	
	7 days	28days
Mix 1	2.32	2.80
Mix 2	1.23	1.71
Mix 3	1.21	2.16
Mix 4	**2.13**	**2.45**
Mix 5	1.09	2.18
Mix 6	1.15	1.62
Mix 7	1.06	1.32
Mix 8	1.02	1.13

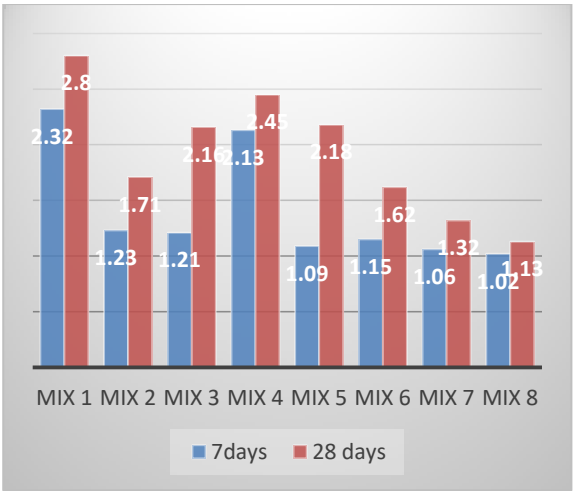

Fig 4 Effect on split tensile strength of concrete

C.Flexural strength

Table 10.Flexural strength of concrete specimens for 7 and 28 days

Mix proportion	Mean compressive strength(N/mm^2)	
	7 days	28days
Mix 1	3.89	4.3
Mix 2	1.06	2.24
Mix 3	3.34	3.26
Mix 4	**3.68**	**4.06**
Mix 5	2.16	3.21
Mix 6	1.8	2.8
Mix 7	2.76	3.6
Mix 8	1.07	2.12

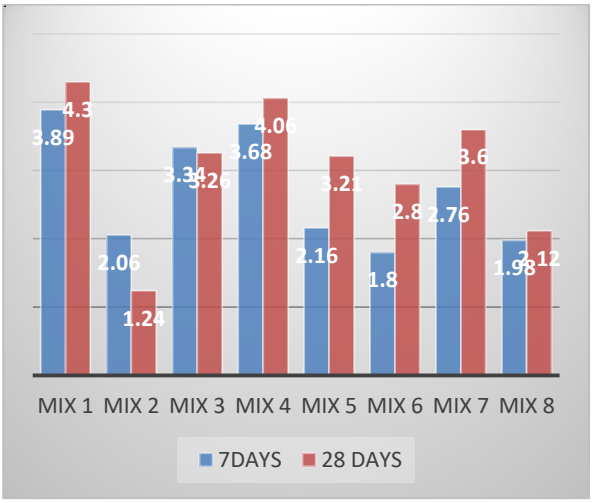

fig 5 Effect on flexural strength of concrete

D.Acid attack test

For acid attack, 5% dilute hydrochloric acid (HCl) by volume of the water.After that cubes were immersed in the above said acid water. After 28 days of curing, the cubes were taken out and the surfaces of the cubes were cleaned. Then the weight of the concrete cubes were taken and tested by non destructive test methods.

NON-DESTRUCTIVE TESTING

Nondestructive testing is a wide group of analysis techniques used to evaluate the properties o f a material, component or system without causing damage. It is a powerful method for evaluating existing concrete structures with regard to their strength and durability apart from assessment and control of quality of hardened concrete. The investigation of crack depth, micro cracks, and progressive deterioration are also studied. So we are using two non-destructive testing methods:

1.Schmidt's Rebound Hammer

Table 11.Acid attack test results reduction in weight of cubes after acid attack

Mix proportion	Weight of concrete before acid attack (kg)	Weight of concrete after acid attack (kg)	Reduction in weight of concrete (kg)
Mix 1	6.63	6.42	0.21
Mix 2	6.52	6.40	0.12
Mix 3	6.34	6.15	0.19
Mix 4	**6.6**	**6.49**	**0.11**
Mix 5	6.58	6.39	0.19
Mix 6	6.55	6.39	0.16
Mix 7	6.37	6.21	0.17
Mix 8	6.54	6.41	0.13

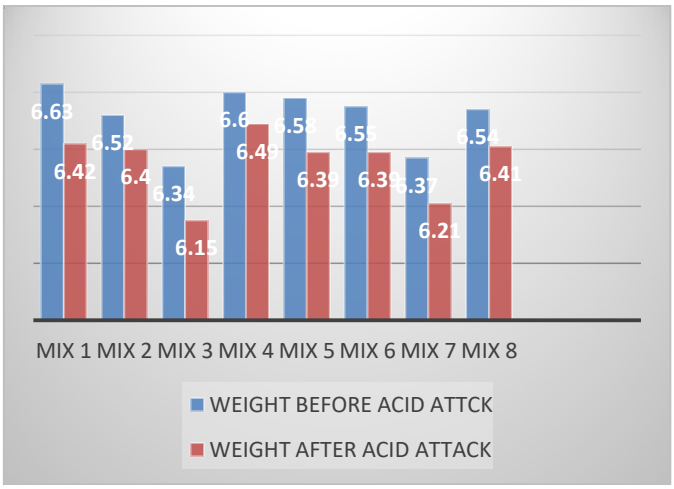

Fig 6 Effect on acid attack of concrete

E.Non destructive test(REBOUND HAMMER)

The Schmidt hammer method is today routinely used to test the strength and the quality of rock and hardened concrete. There are several in-

situ methods are available to access the condition of existing building structure. This is one of the most primitive and simplest tests to evaluate strength of concrete although results using this test vary significantly based on surface, carbonation.Apply light pressure on the plunger, it will release it from the locked position and allow it to extend to the ready position for the test. Press the plunger against the surface of the concrete, keeping the instrument perpendicular to the test surface.Apply a gradual increase in pressure until the hammer impacts. The strength is to be found for each replacement after acid attack and sulphate attack. The average of about 5 readings is taken.

Table 12.Rebound hammer test results on cubes after acid attack test

Mix	Compressive strength (Before acid Attack)	Compressive strength (After acid Attack)	Reduction compressive strength after acid attack (%)
Mix 1	33.9	31.2	7.97
Mix 2	12.33	11.75	4.71
Mix 3	24	22.75	3.67
Mix 4	31.5	29.6	4.375
Mix 5	21.83	20.25	4.96
Mix 6	18.33	17.5	2.93
Mix 7	22	20.75	5.68
Mix 8	11.83	11.25	4.9

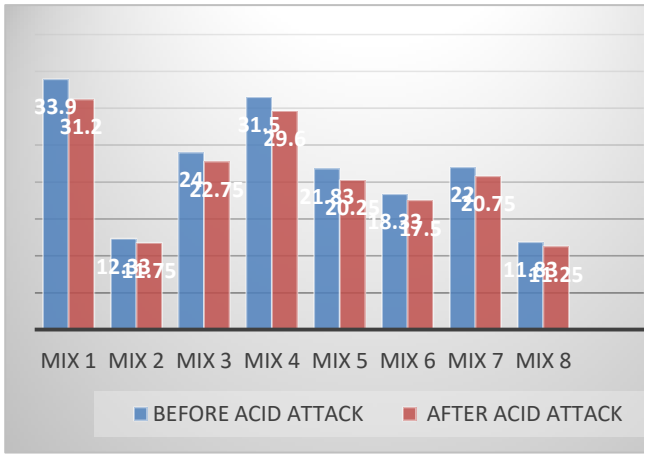

Fig 7 Effect on rebound hammer test of concrete

10. CONCLUSION

From the results obtained, the conclusions can be drawn as follows:

The RHA and BA can be used as a cement replacement material and it gives opportunity to the construction industries to reduce their cost and thereby preserving the environment quality.The concrete with replaced material of rice husk ash and bagasse ash for cement shows comparable strength to that of control cement concrete.From the experimental work and test results it was found that the combination of **20%** of RHA and **10%** of BA can be used as a replacement of 30% of cement in order to obtain high performance concrete with good strength and durability properties.The test results of compressive strength, split tensile strength and flexural strength have indicated that the strength of concrete increases with respect to the percentage of ashes present.The durability property such as acid attack was done.

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