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An Experimental Investigation on Concrete by Partially Replacing Cement Using Bagasse Ash Powder

Manish Ram E[1] and Sindhu Vaardhini U[2]

Assistant Professor, Department of Civil Engineering[1]

PG student, Department of Construction Management[2]

Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India

Abstract: *Utilization of the waste products in the agricultural industry has been the focus of Research for economic, environmental, and technical reasons. Sugarcane Bagasse Ash (SCBA) is one of the promising material, with its potential proved to be used as a partial replacement of cement as well as mineral admixtures for producing concrete; properties of such concrete depend on the chemical composition, fineness, specific surface area of SCBA. An experimental investigation will be carried out to examine the impact of replacing cement by bagasse ash to the mechanical and physical properties of pastes and mortars, fresh and harden concrete such as consistency, setting time and workability, compressive strength. Sugarcane Bagasse Ash powder used by replacing fly ash at 40%, 50%, and 60%. Compressive strength and water absorption test will be carried out for evaluating the performance of the material.*

I. Introduction

The sugar industry is one among the well established industries in India which is a boon to farmers. As per the statistics of the Indian Sugar Mill Association, around 538 sugarcane factories are in operation in the country presently. In this century, most of the sugar industries in India have been developed as self-sustained ones by various means. It is one among the industries that generate electricity and export the excess to the government through the powergrid. Sugarcane is a chief kharif crop in India and is cultivated on a large scale in the country. In the world, India has secured the second position in sugarcane production. On an average, sugarcane production in India is about 300 -350 million tons in the last five years. Bagasse, a fibrous residue from the sugarcane has a very high gross calorific value of around 2250 kcal/kg in wet state and hence it finds a high potential usage in power production. Earlier, boilers were used to utilize the bagasse for generating steam which in turn is utilized in the form of fuel. These boilers operated at a temperature of around 200 ^{o}C - 600^{o}C.But, it resulted in incomplete combustion of bagasse and yields a low fuel value. As a consequence, in the 1980s the sugarcane bagasse cogeneration unit was started to meet the power demand in India. In the modern era, as the demand for fossil fuels increases this cogeneration unit is a promising alternative for power production. As a result almost all major sugar industries have cogeneration unit for power generation from bagasse. The Indian Ministry of New and Renewable Energy estimated about 7000 MW of surplus power production from the cogeneration units of sugar mills in the fore coming years. This unit operated at very high temperature and pressure resulting in sugarcane bagasse ash as a residue.

II. Literature Review

Moises Frias (2007).., The importance of calcining temperature in the pozzolanic activity of sugarcane straw waste was evaluated For this purpose the sugarcane straw waste was burned between 800^{0}C to 1000^{0}C for 20 min to obtain SCBA. Then the ash was grounded and sieved to <90μm and used in the study .The study revealed that at high temperature SCBA exhibits enhanced crystalline containing alpha cristobalinite. However, the reaction products formed during the pozzolanic reaction are not crystalline and Thermo Gravimetric Analysis (TGA) and Differential Thermal Analysis (DTA) curves showed the formation of Calcium Silicate Hydrate(CSH) phase. Further, the kinetic coefficients arrived indicated that the sugarcane straw ash calcined at 800^{0}C and 1000 ^{o}C have high and similar pozzolanic reactivity.

Ajay Goyal(2017).., also agreed that the controlled burning results in the increased reactivity of Sugar Cane Bagasse (SCB) ashes along with the little crystallization of minerals. The morphological and mineralogical studies conducted after control burning of SCB ashes at 600°C for 5hour revealed the increased reactivity of sugarcane bagasse ash. In addition, the compressive and flexural strength tests performed on the SCBA blended mortars confirmed its authentic behaviour and also confirmed that up to 15% substitution of OPC with SCBA could be used for obtaining better strength results Finally, at bottom BA at 800°C.Then all samples were sized below 90µm.The results revealed that the pozzolanic activity for bottom ash was nil , whereas very low for filter ash. The study suggested that the scarce pozzolanic activity was due to the contamination of bagasse ash with soils. Further, the morphology of ashes indicated that coarse particles in all ashes were formed by silica which was Quartz.

Ganesan(2007)..,Early high strength, reduced water permeability and significant resistance to chloride penetration and diffusion on SCBA concrete were reported by the investigation was on the strength properties, water absorption, permeability characteristics, chloride ion diffusion and resistance to chloride ion penetration of BA concrete in 1:3 mixes. Mill fired BA used in the study was further burned at 650°C for 1 hour and ground to 5.4µm mean grain size. As a result, the study reported that 20% of BA was found to be the optimum cement replacement percentage in concrete.

Srinivasan (2010)..,The density of concrete decreased with increase in the amount of SCBA which could promote the manufacture of light weight concrete was identified by (2010). Various tests on boiler bagasse ash replaced concrete such as compaction factor test,slump cone test on fresh concrete and compressive strength, split tensile strength, flexural strength, and modulus of elasticity of hardened concrete were performed at different ages in this study.

Greater compressive strength, tensile strength, and flexural strength compared to that of conventional concrete was observed. The optimum replacement of SCBA for cement was found to be 10%.The results also suggested that the use of super plasticizer was not essential in concrete as the partial replacement of SCBA itself increased the workability of fresh concrete.

III. Materials Required

In this chapter different materials and methods has been use for bagasse ash brick.

3.1 Use of Materials

1. Bagasse ash
2. Fly Ash
3. Clay
4. Water

A. Bagasse Ash

Bagasse is a residue obtained from the burning of bagasse in sugar producing factories. Bagasse is the cellular fibrous waste product after the extraction of the sugar juice from cane mills. It is currently used as a bio fuel and in the manufacture of pulp and paper products and building materials.

Figure: Sugar Cane Bagasse Ash

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For each 10 tons of sugarcane crushed, a sugar factory produces nearly 3 tons of wet bagasse which is a by-product of the sugar cane industry. When this bagasse is burnt the resultant ash is bagasse ash. Western Maharashtra is having maximum number of sugar factories, these factories faces a disposal problem of large quantity bagasse. The effective utilization of these waste products is a challenging task for a researcher through economical and environmental impact.

	Chemical properties								Physical properties			
	Chemical composition (wt. %)								Density	Blaine surface area	Particle size	color
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	LOI	g/cm^3	cm^2/g	μm	
OPC	18.4	5.6	3.0	66.8	1.4	2.8	0.5	2.0	3.15	3250	36.2	Dark grey
SCBA	62.43	4.38	6.98	11.8	2.51	1.48	3.53	4.73	2.52	5140	28.9	Redish grey

Table: Physical and Chemical properties of OPC and SCBA

•OPC – OTHER POWDER CLAY

SBCA – SUGARCANE BAGASSE ASH

B. Fly Ash

Fly ash, the fine particulate waste material produced by pulverized coal-based thermal power station, is an environmental pollutant, it has a potential to be a resource material. It is nowadays used in cement, concrete and other cement based applications in India. As per IS 3812: 2003, the generic name of the waste product due to burning of coal or lignite in the boiler of a thermal power plant is pulverized fuel ash. Pulverized fuel ash can be fly ash, bottom ash, pond ash or mound ash. Fly ash is the pulverized fuel ash extracted from the fuel gases by any suitable process like cyclone separation or electrostatic precipitation.

Figure: Fly Ash

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			Class F	Class C
Chemical Requirements	$SiO_2 + Al_2O_3 + Fe_2O_3$	min%	70[1]	50
	SiO_3	max%	5	5
	Moisture Content	max%	3	3
	Loss on ignition (LOI)	max%	5[1]	5[1]
Optional Chemical Requirements	Available alkalies	max%	1.5	1.5
Physical Requirements	Fineness (+325 Mesh)	max%	34	34
	Pozzolanic activity/cement (7 days)	min%	75	75
	Pozzolanic activity/cement (28 days)	min%	75	75
	Water requirement	max%	105	105
	Autoclave expansion	max%	0.8	0.8
	Uniform requirements[2]: density	max%	5	5
	Uniform requirements[2]: Fineness	max%	5	5
Optional Physical Requirements	Multiple factor (LOI x fineness)		255	--
	Increase in drying shrinkage	max%	.03	.03
	Uniformity requirements: Air entraining agent	max%	20	20
	Cement/Alkali Reaction: Mortar expansion (14 days)	max%	0.020	--

Table: Physical and Chemical properties of fly ash

C. Clay

Clay is a fine-grained natural rock or soil material that combines one or more clay minerals with traces of metal oxides and organic matter. Clays are plastic due to their water content and become hard, brittle and non–plastic upon drying or firing. Geologic clay deposits are mostly composed of phyllosilicate minerals containing variable amounts of water trapped in the mineral structure.

Figure: Clay

D. Water

Mixing water should not contain undesirable organic substances or inorganic constituents in excessive proportions. In this project clean potable water is used. Water in three states: liquid, solid (ice), and gas (invisible water vapor in the air). Clouds are accumulations of water droplets, condensed from vapor saturated air. Water on Earth moves continually through the water cycle of evaporation and transpiration (evapotranspiration), condensation, precipitation, and runoff, usually reaching the sea. Evaporation and transpiration contribute to the precipitation over land. Water used in the production of a good or service is known as virtual water.

IV. Experimental Programme

4.1 Properties of Materials

A. Properties of Sugarcane Bagasse Ash

S No	Properties	Technical Data
1	Specific Gravity	2.19
2	Colour	Black

Table: Properties of Sugar Cane Bagasse Ash

B. Properties of Fly Ash

S No	Properties	Technical Data
1	Specific Gravity	2.08
2	Colour	Whitish grey to grey with slight black

Table: Properties of Fly Ash

C. Properties of Clay

S No	Properties	Technical Data
1	Specific Gravity	2.72
2	Liquid Limit	33
3	Plastic Limit	20
4	Plasticity Index	13

Table: Properties of Clay

4.2 Specific Gravity

A. Specific Gravity of Bagasse Ash

The Le Chatlier flask is filled with kerosene up to the level of marking. The apparatus is left free for some times so that the kerosene along the side settle down. Then the initial reading is noted. A known mass of bagasse ash (60g) is introduced into the flask gradually and is made to settle at the bottom. Care should been taken to avoid clogging of ash at the neck. The flask is gently rolled at inclined position to assist the air bubbles to reach surface. Then the final reading in noted.

Table: Specific gravity of bagasse ash

Sl. No.	Description	Reading	Units
1	Initial Reading	0.2	Cm
2	Final Reading	19.3	Cm

Specific gravity of ash = 60 / (19.3-0.2)
Specific gravity of ash = 2.19

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B. Specific Gravity of Fly Ash

The pycnometer is dried thoroughly and its weight is taken as W1. Fill two third part of pycnometer with ash and is weighed as W2. The pycnometer is filled with water up to the top without removing the ash. Then it is shaken well and stirred thoroughly with the glass rod to removed, the pycnometer is completely filled with water up to the mark. Then outside of the pycnometer is dried with a clean cloth and is weighed as W3. The outside of the pycnometer is cleaned thoroughly. The pycnometer is completely filled with water up to top. Then outside of the pycnometer is dried with a clean and is weighed as W4.

Table: Specific gravity of fly ash

Sl. No.	Observation	Values
1	Wt. of empty container W_1 (kg)	0.625
2	Wt. of container + sample W_2 (kg)	1.169
3	Wt. of container + sample + water W_3(kg)	1.826
4	Wt. of container + water W_4(kg)	1.500
5	Specific Gravity (No Unit)	2.08

Specific gravity of fly ash, G = W_2-W_1 \ (W_4-W_1)-(W_3-W_2)

Specific gravity of fly ash, G = 2.08(No Units)

4.3 Size Analysis

A. Grain Size Analysis of Fly Ash

The sieve analysis is conducted to determined the particles size distribution in a sample of ash. Grading pattern of fly ash is assessed by sieving a sample successively through the entire sieves mounted one over the other in order of size, with larger sieves on the top. The material retained on each sieve after shaking, represents the fraction of ash coarser

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than the sieves below and finer than the sieve about. A measures of the fineness of an ash, a factor obtained by adding the total percentage of ash sample retained on each of the following sieves and dividing the sum by 150 , 300 , 600 , 1.18mm, 2.36mm and 4.75mm.

The air-dry sample 2kg taken and sieved successively on the appropriate sieves starting with the largest size sieves as started in the table. Sieving is carried out on a machine not less than 10 minutes required for each test.

Table: Sieve analysis for fly ash

Sl. No.	Sieve Size (mm)	Weight Retained (Kg)	Percentage Weight Retained	Percentage Weight Passing	Cumulative Percentage Weight Retained
1	2.36	0.005	0.5	99.5	0.5
2	1.18	0.085	8.5	91	9
3	0.600	0.120	12	79	21
4	0.300	0.405	40.5	38.5	61.5
5	0.150	0.310	31	7.5	92.5
6	0.075	0.070	7	0.5	99.5
7	Pan	0.005	0.5	100	100
				$\sum$	116

Weight of sample taken = 1000 g
Fineness Modulus of fly ash = 1.16
Fineness Modulus of fly ash = 1.16
As per IS383-1970
Fineness modulus range is refered as Zone 0.

4.4 Plastic Limit

A. Plastic Limit of Clay

The plastic limit of a clay is the lowest water content determined in accordance with the following procedure at which the clay remains plastic. A ground glass plate or piece of smooth, unglazed paper on which to roll the sample. For plastic limit only, take a 20 gram sample (approximate) from the thoroughly wet and mixed portion of the clay prepared for the liquid limit of clay. Roll this mass between the fingers and the ground- glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. The rate of rolling shall be between 80-90 strokes per minute; a stroke being one complete motion of the hand forward and back to the starting position. When the diameter of the thread becomes about 3.2mm (1/8 inch), break the thread up into 6 or 8 pieces. Squeeze the pieces together into a uniform mass, roughly ellipsoidal in shape and reroll.

Calculations:

$$\% \ Plastic\ Limit = \frac{Weight\ of\ water \times 100}{Weight\ of\ water} = \frac{0.83 \times 100}{3.93} = 20.61$$

B. Plasticity Index

The plasticity index of a soil is the numerical difference between its liquid limit and its plastic limit.

Calculations

Plasticity Index = liquid limit - plastic limit

Plasticity Index = 33 - 20 = 13

The difference calculated as indicated, as the plasticity index, except under the following conditions:

1. When the liquid limit or plastic limit cannot be determined, report the plasticity index as NP (non-plastic).
2. When the plastic limit is equal to, or greater than, the liquid limit, report the plasticity index as NP (non-plastic).

Hence the consistency of clay is Low plasticity.

4.5 Preparation Process

Bagasse ash, Fly ash, Clay were weighted separately and mixed together in a dry manner. The amount of water is calculated and mixed thoroughly. The mix was done by hand and precautions were taken to ensure uniform mixing of ingredients.

Sample	Fly Ash	Bagasse 28 Ash	Clay

Figure: Brick Hand Mould

V. Casting of Test Specimen

For this investigation we had cast bricks in different ratio. The size of the specimen is210mm × 110mm × 75mm were tested with different proportions of 40% , 50% and 60% with replacement of fly ash and bagasse ash. The mixing process was done by using weight by weight proportionality method. We are planning to do two tests in the brick such as water absorption test and compression test. In order to do these tests we need two samples in each proportion and one sample for showcase. So we need three bricks in total. We are planning to use 10 kg of mixture for each procedure. The mix proportions are tabulated as below.

Units	KG	KG	KG
BF40%	4	4	2
BF50%	3	5	2
BF60%	2	6	2

Mix Proportions

The mixture was proportionally mixed in this proportion and then casting using the die. Even we added the clay we didn't make the heat brick as this is the fly ash brick.

Figure: Casted Brick Kept for Air Cur

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VI. Experimental Method

6.1 Test Method for Mechanical Properties

A. Compressive Strength Test

Compressive test was carried out on bricks. The size of the specimen is 210mm × 110mm ×75mm. Three specimens were tested for each percentage at 7 days, 14 days, 28 days. From these three specimens average strength was taken. The specimen were submerged in clean fresh water in a curing tank and kept there until taken out just period to test. The specimens are not to be allowed to become dry at any time until they have been tested. The specimens are tested immediately on removal from the water while they are still in a wet condition. The dimensions of the specimens are their weights were recorded before testing. Compressive strength at 7 days, 14 days, 28 days was found out.

The bearing surfaces of the testing machine were wiped clean the other materials, which may come in contact with the compression plates. While placing the bricks in the machine, care was taken such that the load was applied to opposite sides of the bricks as casted and not to the top and bottom. The axis of the specimen was carefully aligned with the center of thrust of the spherically seated plate. As the spherical-seated block is to bear on the specimen, the movable portion was rotated gently by hand, so that uniform seating was obtained. The maximum load applied to the specimen was recorded and any usual appearance in the type of failure was noted. The compressive strength of the specimen was calculated by using formula

F= P/A

Where, P= Load at which the specimen fails in newt

A= Area over which the load applied in mm2

F= Compressive stress in N/mm2

Figure: Experimental setup for Compression Test

B. Water Absorption Test

Water absorption test on bricks are conducted to determine durability property of bricks such as degree of burning, quality and behavior of bricks in weathering. A brick with water absorption of less than 7% provides better resistance to damage by freezing. The degree of compactness of bricks can be obtained by water absorption test, as water is absorbed

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by pores in bricks. The water absorption by bricks increase with increase in pores. So, the bricks, which have water absorption less than 3 percent can be called as vitrified.

Dry the specimen in a ventilated oven at a temperature of 105 °C to 115°C till it attains substantially constant mass. Cool the specimen to room temperature and obtain its weight (M1) specimen too warm to touch shall not be used for this purpose. Immerse completely dried specimen in clean water at a temperature of 27+2°C for 24 hours. Remove the specimen and wipe out any traces of water with damp cloth and weigh the specimen after it has been removed from water (M2). Water absorption, % by mass, after 24 hours immersion in cold water in given by the formula,

$$W = \frac{M_2 - M_1}{M_1} X\ 100$$

When tested as above, the average water absorption shall not be more than 20% by weight up to class 12.5 and 15% by weight for higher class.

Figure: Experimental setup for Water Absorption test

VII. Experimental Result

7.1 Results

A. Compressive Test

The compressive strength is considered one of the most important properties and is often used as an index of the overall quality. It can be observed from table that the compressive strength of different percentage of bagasse ash with adding optimize percentage of fly ash is nearly equal.

This test is done to know the compressive strength of brick. It is also called crushing strength of brick. Generally 4 specimens of bricks are taken to laboratory for testing and tested one by one. In this test a brick specimen is put on crushing machine and applied pressure till it breaks. The ultimate pressure at which brick is crushed is taken into account. The typical compressive strength values are shown in table 8.1.1

S No	Sample	Crush Strength at 14 N/mm^2
1	BF 40%	3.08
2	BF 50%	3.12
3	BF 60%	3.39

Table: Strength results of compression for bricks

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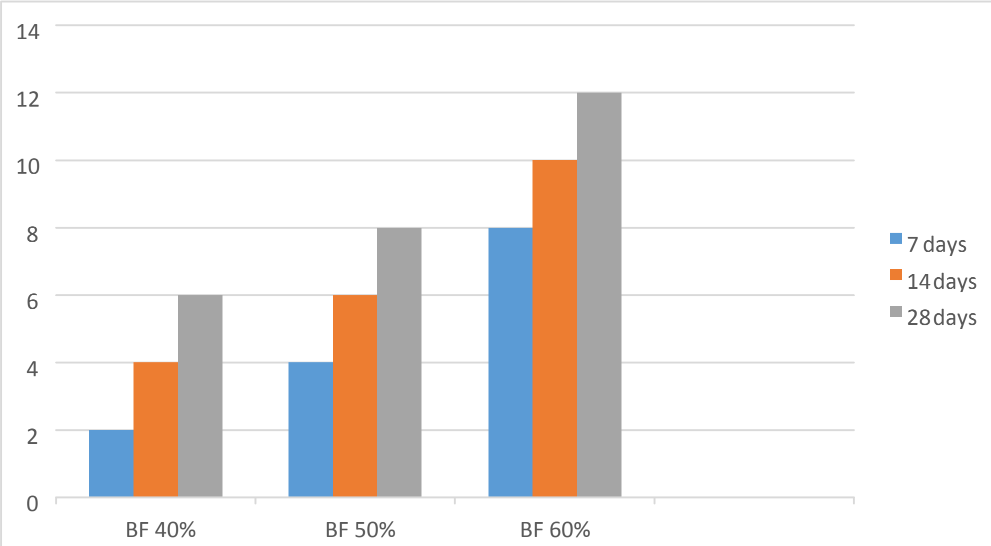

Figure: Development of Compressive Strength

B. Water Absorption Test

In this test bricks are weighed in dry condition and let them immersed in fresh water for 24 hours. After 24 hours of immersion those are taken out from water and wipe out with cloth. Then brick is weighed in wet condition. The difference between weights is the water absorbed by brick. The percentage of water absorption is then calculated. The less water absorbed by brick the greater its quality. Good quality brick doesn't absorb more than 20% water of its own weight.

Sample	Weight of dry brick (W1 kg)	Weight of wet brick (W2 kg)	Weight of water absorbed (W2-W1) kg	% Water absorbed (kg)
BF 40%	2.702	3.099	0.397	14.39
BF 50%	2.731	3.124	0.393	15.69
BF 60%	2.668	3.126	0.458	17.16

Figure: Strength results of water absorption

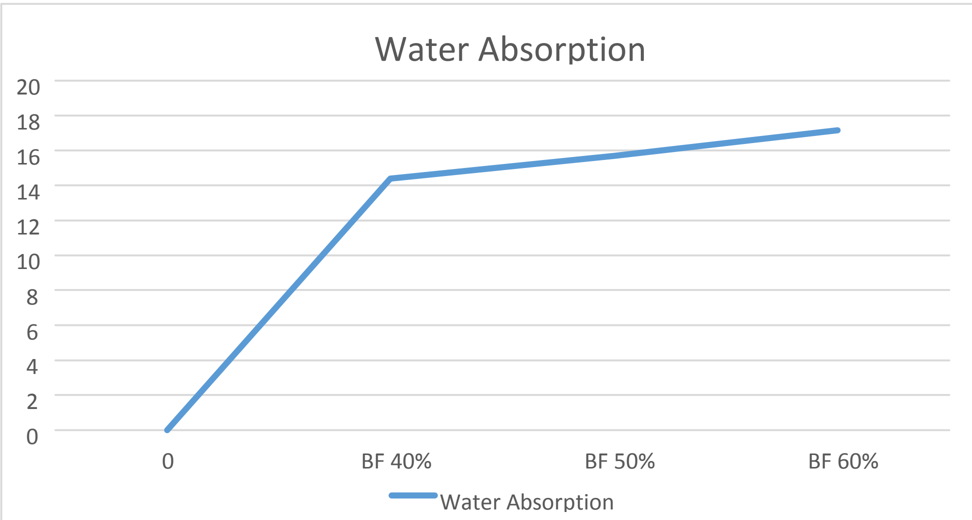

Figure: Development of water absorption

VIII. Conclusion

From the analysis of the results given above, the followings conclusions can be made:

- Use of bagasse ash in brick can solve the disposal problem; reduce cost and produce a 'Greener' Eco friendly bricks for construction.
- Environmental effects of wastes and disposal problems of waste can be reduced through this research.
- A better measure by an innovative Construction Material is formed through this research.
- This study helps in converting the non-valuable bagasse ash into bricks and makes it valuable.
- It reduces the cost of material per brick.
- From the tests conducted in laboratory, in all tests it is observed that up to 20% bagasse ash all the characteristics of bricks are adequate and desirable for use in building construction.
- As addition of bagasse ash more than 50% causes more water absorption, reduction in compressive strength, less hardness, under burnt.
- So we recommend that up to 40 to 50 % bagasse ash can be replaced by clay in bricks.

References

[1]. Tayyeb Akram Shazim Ali Memon, Humayun Obaid, manfacture of near to the ground cost self compacting concrete by bagasse ash, journal of building and building material,(18 April 2008)

[2]. Dilip Hiradram Lataye, Indramani Mishra, Indra Deo Mall, Adsorption of 2-picoline onto bagasse fly ash from aqueous declaration. Chemical Engineering Journal, Volume 138,Issues 1-3 May 2008.

[3]. G. C. Cordeiro, R. D. Toledo Filho, L. M. Tavares, E. M. R Fairbairn satisfying consequence of sugar cane bagasse ash in Portland cement and concrete composition.

[4]. Bhanumathidas N and Kalidas N, _Fly ash: The resource for construction industry,,, April 2003.

[5]. Reddi S.A and Gurumurthy D. M., The Indian Concrete Journal, Pg. 997-1004, 2009.

[6]. Singh M, Garg M. Durability of cementitious binder derived from industrial wastes. Mater Structure 1997; 30:607–12.

[7]. Olmez H, Erden E. The effects of phosphor gypsum on the setting and mechanical properties of Portland cement. Cement Concrete Resource 1989;19:377–84.

[8]. Singh M, Garg M. Phospho gypsum-fly ash cementitious binder – its hydration and strength development. Cement Concrete Resource 1995; 25:752–8

[9]. Garg M, Singh M, Kumar R. Some aspects of the durability of Phospho gypsum– lime–fly ash binder. Construction Build Materials 1996; 10:273–9.