




e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 9, Issue 9, September 2020

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512

 9940 572 462

 6381 907 438

 ijirset@gmail.com

 www.ijirset.com

An Experimental Investigation of Alkali Activated Mortar with Partial Replacement of Bagasse Ash

Kamalakaran K M¹, Murugesan T²

P.G. Student, Department of Civil Engineering, Government College of Engineering, Salem, TamilNadu, India¹

Assistant Professor, Department of Civil Engineering, Government College of Engineering, Salem, TamilNadu, India²

ABSTRACT: Development of alternative binders is imperative due to the several impacts related to the ordinary Portland cement such as carbon dioxide emissions, rapid consumption rate of limited natural resources and high demand. On the other hand, more waste materials such as rice husk ash, bagasse ash, marble waste, steel slag etc., are remain unexplored on earth causing severe impacts on environment but with lots of useful properties. Geo-polymer concrete has emerged as a potential alternative material for a number of special applications. For that sugarcane bagasse ash is obtained as a by-product from sugar industries in enormous quantities in major sugar producing countries. The disposal of sugarcane bagasse after extracting its juice for production of sugar, its disposal problematic due to land constrains and environmental restrictions. Bagasse ash has reactive silica content more than 70% and can be blended with other industrial by-products such as slag and fly ash which are rich in alumina, silica and calcium sources to develop sustainable and high-quality alkali activated concrete. The present study deals with the experimental investigation on partial replacement SCBA in Slag based Alkali activated mortar and also find its mechanical behavior.

KEYWORDS: Sugarcane bagasse ash (SCBA), Ground Granulated Blast Furnace Slag (GGBFS), Ambient Curing, Compression test, Split tensile strength.

I. INTRODUCTION

Now a days Cement mortar is the world widely most used man made construction material. It is obtained by mixing cement, fine aggregate, water and admixtures in required proportions. In this cement acts as a binder. In consideration often serious impact of carbon dioxide emissions from the process of manufacturing cement on the environment, there is a need to develop useful alternatives to Ordinary Portland Cement (OPC). Production of OPC is responsible for approximately 6 to 7 % of the world's carbon dioxide emissions. Hence it is necessary to found the alternative binding material. Also Cement prices are expected to double by on upcoming years. This can be attributed to the scarcity of raw materials. In addition to cost, the extensive depletion of limited natural resources for the manufacturing process of construction materials has compelled the construction industry to seek alternative raw materials that are cheaper, easily available, and sustainable. Industrial or agro industrial by- products that are silica-rich and alumina-rich are preferably suited for supplementary cementitious materials due to their abundance, minimal processing requirement, and superior reactivity.

In this context geo-polymers have emerged as potential binder for the concrete industry. Silicates and aluminates present in the source material get dissolved in the alkali activator solution and subsequently polymerize into molecular chains and become the binder. Calcined clay, fly ash or slag can be used as the source material. In most cases such as when using fly ash or calcined clay, geopolymer binders needs heat curing and ambient curing. With this, it is important to develop good strength and workable slag alkali activated binder. This can be accomplished by a partial replacement of the slag with other source materials. On the other hand, we are favoured with the more unexplored waste materials on earth. With major development in concrete industry, the waste materials utilization in the manufacturing of concrete, being used as replacement material or ingredients is being practiced extensively all over the world. Some of the composite material are used to replace the cement such as fly ash, rice husk ash, sugarcane bages ash, steel slag, fibers, grit, dregs etc.

On that Sugarcane bageses ash contains more amount of amorphous silica, so it will not affect the strength of concrete by replacement and increases 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. Bagasse ash are used to remove oil spills,

and also used as a fertilizer. So using the waste material in the productive and innovative way prevents the environment from being polluted. The utilization of bagasse ash in the manufacturing of construction products has been constrained because of inadequate understanding of the material and lack of suitable methodology for use on a large scale. Most of the previous research studies examined the uses & properties of Sugarcane bagasse ash for concrete industry. So for our studies we have deals with the influence of Sugarcane bagasse ash (SCBA) as the alternative binder for Ground Granulated Blast Furnace Slag (GGBFS) in Potassium Based Alkali Activated mortar. Potassium based Activator is used than that of sodium based activator in our investigation is due to potassium based activator attain early strength than sodium based due to higher K_2O content in SCBA, which along with alkaline potassium oxide present in the activator, helps us to cationic reaction between them.

II. MATERIAL CONSTITUENTS

1. **Raw Sugarcane Bagasse Ash:** Bagasse ash is a by-product obtained from a sugarcane milling process in sugar factories. Sugarcane is a plant that its juice can be processed into sugar. This plant is grow only in tropical regions. Bagasse as by-product of sugar production has variety of benefits including fodder, raw material for fertilizer, raw material of ethyl alcohol, raw material for pulp, fabric particle board and for fuel of boiler in sugar factory plan the sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemi cellulose and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. It is however, generally used as a fuel to fire furnaces in the same sugar mill that yields about 8-10% of ashes containing chemical composition dominates by Silicon dioxide (SiO_2), Aluminium iron and Calcium oxides. The process of obtaining sugarcane ash from sugar industry is shown in the flow chart process of the Fig.1, shown below.

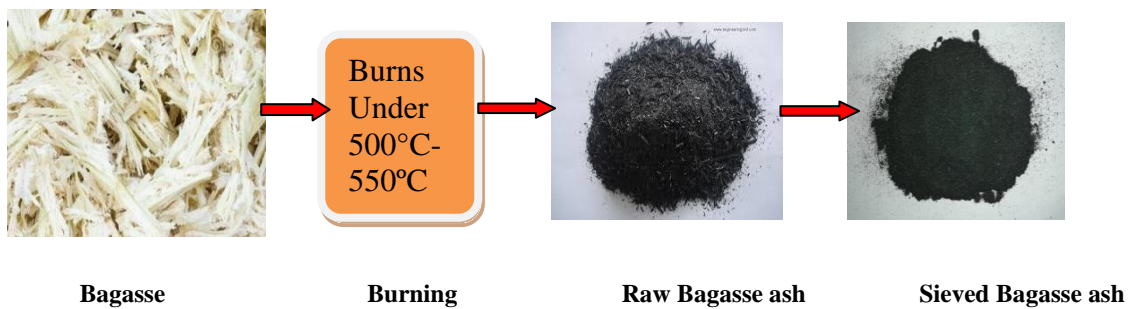


Fig.1. Process of obtaining Bagasse Ash

2. **Ground Granulated Blast Furnace Slag (GGBFS):** GGBFS is obtained by quenching molten iron slag (a by-product of iron and steel making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. The chemical composition of a slag varies considerably depending on the composition of the raw materials in the iron production process. Silicate and Aluminates impurities from the ore and coke are combined in the blast furnace with a flux which lowers the viscosity of the slag. In the case of pig iron production, the flux consists mostly of a mixture of limestone and in some cases dolomite. In the blast furnace the slag floats on top of the iron and is decanted for separation. Slow cooling of slag melts results in an unreactive crystalline material consisting of an assemblage of Ca-Al-Mg silicates. To obtain a good slag reactive or hydraulicity, a slag melt needs to be rapidly cooled or quenched below 800°C in order to prevent the crystallization of merwinite and melite. To cool and fragment the slag a granulation process can be applied in which molten slag is subjected to jet streams of water or air under pressure. Alternatively, in the pelletization process the liquid slag is partially cooled with water and subsequently projected into the air by a rotating drum. In order to obtain a suitable reactivity, the obtained fragments are ground to reach the same fineness as Portland cement.



Fig. 2. Ground Granulated Furnace Slag (GGBFS)

3. Fine aggregate: The particles of granular materials are so fine that they pass through a 4.75mm sieve. It is essential material in concrete consist of natural sand. The purpose of fine aggregate is to fill the voids, on coarse aggregate and to act as workability agent. It was screened to remove deleterious materials and tested as per procedure given in IS: 2386-1963. Specific gravity of fine aggregate is 2.36, Grading zone -Zone II, Water absorption-0.47%, Bulk density-1.55g/cc, Moisture content-nil.

4. Water: Water plays an important role in the concrete production (mix) in that it starts the reaction between the cement and the aggregate. It helps in the hydration of the mix. In this project the water used potable water available in the laboratory which is free from contaminants and used for mixing and curing the concrete specimens optimization quantity of the potable water whose pH value range from 6 to 8 and water free from organic matter is used for making concrete.

5. Potassium hydroxide: It is also known as lye and caustic potash and it is an inorganic component with chemical formula KOH. It is a potent base and available in pellets, flakes, powder form at different concentration. Potassium hydroxide appears as a clear aqueous solution. Its main purpose in concrete industry is Corrosive to metal and tissues and also noncombustible.

It also used in many industries as a strong chemical base in the manufacture of pulp and paper, textile, drinking water, soap and detergents and as a drain cleaner. Production in 2004 was approximately 60 million tonnes, while demand was 51 million tonnes.



Fig. 3. Potassium hydroxide pellets

6. Potassium silicate:It is a source of highly soluble Potassium and Silicon and it is manufactured by Calcinations process that combines Silica sand (SiO₂) and Potassium Carbonate (K₂CO₃) at 1100-2300oF for upto 15 minutes. Then the two materials fuse into glass, which can be dissolved with high pressure steam to form a slightly viscous liquid or cooled, with clear and ground into a powder form. CO₂ is evolved on it. Then the solution can be dried to form hydrous powder crystals of potassium silicate. These are manufactured as solids or thick liquids, depending on proposed use having a density from 1.6g/cubic cm to about 1.4g/cubic cm. For instance, water glass functions as a sealant in metal components. Finally, even though potassium silicate manufacture is a mature industry, there is current research for new applications given its heat conductive properties.



Fig.4. Potassium silicate solution

7. Alkaline Activated solution: Alkaline Activated solution (AAS) used here was a mixture of potassium silicate solution and potassium hydroxide (KOH) pellets with desired molarities of 8M. The Potassium hydroxide and potassium silicate (K₂SiO₃) mixed in the desired proportion of 1:1.5.



III. MATERIALS PROPERTIES

Table 1. Chemical properties of GGBFS

Constituents	Component (in %)
Calcium oxide (CaO)	38-50
Silicon Dioxide (SiO ₂)	27-39
Magnesium Oxide (MgO)	<10
Aluminium Oxide (Al ₂ O ₃)	8-20

Table 2. Physical properties of GGBFS

S.NO	Types of Test	Values
1.	Specific gravity	2.23
2.	Fineness	6% (IS sieve no.9)
3.	Bulk density(g/cm ²)	1.355
4.	Specific Surface Area(cm ² /gm)	4205.72

Table 3. Physical properties of Bagasse Ash

Parameters	Values obtained	Relevant Standards
Normal consistency	43%	IS4031-2005
Soundness	1.2 mm	IS 1727-Part 3
Initial setting time	123 mins	IS4031-2005
Final setting time	340 mins	IS4031-2005
Specific gravity	1.94	IS4031-2005

Table 4. Particle size distribution of Fine aggregate by Sieve Analysis

Sieve size	Weight retained (kg)	Weight retained (%)	Cumulative weight retained (%)	Passing percentage
10mm	-	-	-	100
4.75mm	0.016	1.6	1.6	98.4
2.36mm	0.042	4.3	5.9	94.1
1.18mm	0.181	18.1	24.0	76.0
600mic	0.221	22.1	46.1	53.9
300mic	0.38	35.0	81.1	15.9
150mic	0.171	17.1	98.2	1.8
75mic	0.012	1.2	99.4	0.6
pan	0.006	0.6	100	0
			Σ=456.3	

Fineness modulus of fine aggregate = $456.3 / 100 = 4.563$



Table 5. Properties of Potassium Hydroxide

Chemical Formula	KOH
Density	2.13g/cm ³
Melting point	318°C
Solubility	Soluble in glycerol negligible in ammonia insoluble in ether
Refractive index	1.3576

Table 6. Properties of Potassium Silicate

Chemical Formula	K ₂ SiO ₃
Density	2.61g/cm ³
Melting point	1088°C
Solubility	Insoluble in alcohol
Refraction index	1.52

Table 7. Standard Mix Proportion for Alkali Activated Mortar

Binder to sand	1:2
Binder to Activated solution	1:0.5
Activators - KOH to K ₂ SiO ₃	1:1.5

Table 8. Mix details for SCBA in GGBFS, Sand & Activators

Mix Id	GGBFS (%)	SCBA (%)	SAND (%)	ACTIVATORS (%)
CC	100	0	100	100
B1	90	10	100	100
B2	80	20	100	100
B3	70	30	100	100
B4	60	40	100	100

Table 9. Standard Mix Proportion of Split Tensile Strength of Cylindrical specimens:

Mix Proportion	Ratio
Cement	1.00
Sand	1.96
Coarse Aggregate	2.81
Water	0.40

Table 10. Mix details for SCBA in Cement, Sand & Coarse aggregate

Mix Id	CEMENT (%)	SCBA (%)	SAND (%)	Coarse Aggregate (%)
CC	100	0	100	100
B1	90	10	100	100
B2	80	20	100	100
B3	70	30	100	100
B4	60	40	100	100

IV. SPECIMEN CASTING, CURING AND TESTING





V. EXPERIMENTAL RESULTS

COMPRESSION TEST :

The compression test result is the average of at least three standard cube strength specimens made from the same concrete sample and tested at the same age. The strength requirements for concrete are at an age of 28 days of curing as 85% of strength is obtained within 28 days. The concrete cubes, after 28 days were tested for their compressive strength in the following manner. After cleaning the bearing surface of the compression testing machine, the axis of the specimen was carefully aligned with the center of thrust of the plate. No packing was used between faces of the test specimen and plate of testing machine. The load was then gradually applied at a rate of approximately 140kg/cm² per minute until the resistance of specimen to increasing load broke down and no greater load could be sustained. The compressive strength calculated in kg/cm² from the maximum load sustained by the mortar cube before failure. The table (9) shows the result of average Compressive Strength of Mortar Cubes in Ambient Curing on the following days 7,14,28 and 56 days respectively.

Table 11. Compressive Strength of Mortar Cubes on following days.

MIX	Compressive Strength at following days (MPa)			
	7 th day	14 th day	28 th day	56 th day
CC	17.38	24.08	28.09	31.43
B1	20.06	26.08	31.10	34.44
B2	18.05	23.41	29.09	31.77
B3	13.70	19.06	25.08	26.75
B4	10.70	15.72	21.40	23.74

SPLIT TENSILE STRENGTH:

This method consists of applying a diametric compressive force along the length of the cylindrical specimen. This loading induces tensile stresses on the plane containing the applied load. Tensile failure occurs rather than compressive failure. Plywood strips are used so that load is applied uniformly along the length of the cylinder. The maximum load is divided by appropriate geometrical factors to obtain the splitting tensile strength. A diametric compressive load is then applied along the length of the cylinder until it fails because PCC is much weaker in tension than compression, the cylinder will typically fail due to horizontal tension and not vertical compression. The table(10) shows the result of Split Tensile Strength of Cylinder Specimen for the following mixes at 28 days respectively.

Table 12. Split tensile strength of cylinder Specimens after 28 days

MIX	Load in Tonnes	Load in Newton (N)	Diameter (mm)	Length (mm)	Tensile strength on Cylinder (N/mm ²)
CC	21.0	206010	150	300	2.92
M1	23.0	225630	150	300	3.19
M2	21.5	210915	150	300	2.99
M3	20.0	196200	150	300	2.78
M4	18.0	176580	150	300	2.50

VI. CONCLUSION

From the above Experimental investigation we have concluded that,

- i. The compressive strength of mortar cubes have obtain higher strength than normal Conventional Alkali Activated Mortar upto 20 % replacement of Bagasse Ash in the curing of Ambient curing.
- ii. On that Replacement upto 10% have attain maximum strength , after that gradually strength will decreases.

- iii. For same wise, the Split Tensile strength of Cylinder Specimens have obtain maximum strength on upto 10% replacement of bagasse ash in cement concrete. Then on that 20 % split tensile as much same as normal conventional cement concrete.
- iv. On that replacement level, After that 20 % replacement (30% and 40% replacement of bagasse ash) the both compressive & split tensile strength of the specimen strength is very lower than that of Conventional mix on it.
- v. So, finally we have concluded that the replacement of bagasse ash as a Binding material upto 20 % have obtain normal conventional strength, for optimum upto 10% replacement only.
- vi. This increase in strength of Bagasse ash as a binder material in concrete mix is due to presence of Silica in Sugarcane bagasse ash react with residual CH after the formation of C-S-H and increase the amount C-S-H gel, and result in increase the strength upto Optimum replacement level.

REFERENCES

- [1] S. Deepika , G.Anand, A.Bahurudeen and Manu Santhanam in “Construction products with Sugarcane Bagasse Ash Binder”.
- [2] Dr.M.VijayaShekar Reddy, K.Ashalatha, M.Madhuri, P.Sumalatha in “Utilization of Sugarcane Bagasse Ash (SCBA) in Concrete by partial replacement of Cement”.
- [3] Madhuri.G, SrinivasaRao.K ,“Engineering Properties of Alkali Activated Slag Concrete Under Ambient And HeatCuring”.
- [4] S. Deepika, G.Madhuri, A.Bahurudeen, Manu Santhanam in “Development of Sugarcane Bagasse Ash Blended Geopolymer for use inConcrete”.
- [5] Arivazhagan.S,“SustainableStudiesonConcretewithGGBFS as a Replacement Materials in Cement”.
- [6] P.Jagadesh;A.Ramachandramurthy;R.Murugesanin“overviewonproperties of sugarcane bagasse ash (SCBA) as Pozzolanic”.
- [7] IS 383:1970, Specification for Coarse and Fine Aggregates from Natural Sources forConcrete.
- [8] IS 4031 -2005, “Methods for physical tests for hydrauliccement”.
- [9] IS 1727:1967, “Methods of Test for Pozzolanicmaterials”.
- [10] IS 456 -2000 “Code of Practice for Plain and Reinforced Concrete”.
- [11] IS 10262 -1981 “IS Method of Mix Design”.



INNO  **SPACE**
SJIF Scientific Journal Impact Factor

**Impact Factor:
7.512**

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details