

# Self Cured Flyash Brick by Forming Geopolymer

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**ABSTRACT:** A brick is building material used to make walls, pavement and other elements in construction industry. Fly ash brick technology is a process of converting the industrial waste materials into quality bricks. The advantages of using flyash brick is the brick carries good compressive strength and better thermal insulation than other fire clay bricks. One of the important ingredient of flyash brick is GGBFS. Because it act as a binding material and increase the strength of brick. However due to increased use of brick in almost all type of construction work leads to the demand of river sand. Here the use of manufactured sand compensate the demands and also increases the compressive strength. In this study an attempt has to be made to replace the river sand with the manufactured sand and copper slag in 70%,75%,80% and 20%,25%,30%. In this study flyash brick is self cured by forming geopolymer with the addition of alkaline solution.

**KEYWORDS:** Flyash, GGBFS, Copper slag, M sand, Alkaline solution, geo polymer.

## I. INTRODUCTION

Flyash brick is a building material, specifically masonry unit consists of class F flyash in major quantity and GGBS. Flyash is useful by product from the thermal power station and it has the considerable pozzolanic activity. During the formation of coal, clay is entrapped through natural process. During the combustion, carbon is burnt leaving the incombustible clay particles as ash. This national resource has been gainfully utilized and act as a supplement to the common burnt clay brick leading to the conservation of natural resource and preventing the environment.

Fly ash brick are generally made by adding various raw materials like GGBS, copper slag and M sand in various proportion and then moulded into bricks and subjected to different curing cycles at room temperature. Copper slag is used to control the water absorption capacity and increases the strength. A number of studies are going in india as well as abroad to study the impact of use of these pozzolanic materials. The flyash brick is a chemically bonded brick. These bricks are suitable for use in construction industry just common as the conventional brick. Flyash when react with alkaline solution it forms a geopolymer act as a bonding agent and increases the strength of brick.

### 1.1 OBJECTIVES:

- To manufacture the eco friendly self cured flyash brick
- To increase the compressive strength of brick
- To reduce the use of river sand due to its demand.

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- To reduce the usage of water

**II.MATERIALS USED**

The materials used in the study are explained below

**BINDER**

- Fly ash ( class F )
- Ground granulated blast furnace slag

**AGGREGATE**

- Copper slag
- Manufactured sand

**LIQUID FOR CURING**

- Alkaline solution

**III.MATERIAL PROPERTIES**

**3.1 CLASS F FLYASH**

Class F flyash is designated in ASTM C 618 and originates from anthracite and bituminous coal. It consists mainly of alumina and silica and has a higher LOI than class F flyash. Class F flyash has lower calcium content than class C flyash. The class F flyash is pozzolanic in nature and contain less than 20% lime. The class F flyash contains about 70% pozzolanic compounds(silica oxide, alumina oxide and iron oxide). To attain pozzolanic property the class F flyash needs cementing agent such as Portland cement when reacted with water it produces a cementitious compound. Adding sodium silicate to the class F flyash forms a geopolymer.

PARAMETERS	FLY ASH
Bulk density(gm/cc)	0.9-1.3
Specific gravity	1.6-2.6
Plasticity	Lower or non plastic
Shrinkage limit(vol stability)	Higher
Porosity(per cent)	30-65

### 3.2 GGBFS(Ground granulated blast furnace slag)

Ground granulated blast furnace slag 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

S.NO	CHARACTERISTICS	PERCENTAGE
1	Fineness(m <sup>2</sup> /kg)	412
2	Particle size(cumulative %)	94.25/100
3	Insoluble residue	0.23
4	Moisture content	0.14

### 3.3 M SAND

The M sand is free from elongated and flaky particles since it is shaped cubically using VSI shaping machine. The cubically shaped particles give high strength and long life. Original M sand is manufactured strictly adhering to IS 383 (1970) zone II grading. Perfect grading and cubical shape of M sand provide 25-30% more strength for masonry works compared to crusher dust. Original M sand has two grades for concreting and plastering.

### 3.4 COPPER SLAG

Copper slag is a by-product of copper extraction by smelting, impurities become slag which floats on the molten metal. Slag that is quenched in water produce angular granules which are disposed of as waste. The granulated slag(<3 mm size fraction) has both insulating and drainage properties which are used to avoid ground frost in winter which in turn prevents pavement cracks. The properties of copper slag is explained below

S.NO	COMPOSITION	% By MASS
1	Fe <sub>2</sub> O <sub>3</sub>	55-60
2	Fe <sub>3</sub> O <sub>4</sub>	<10
3	SiO <sub>2</sub>	27-33
4	CaO	1-3.5
5	S	0.2-1.5
6	Cu	<1
7	Al <sub>2</sub> O <sub>3</sub>	<3
8	Specific gravity	4.12
9	Bulk density(g/cc)	2.31
10	Fineness modulus	3.4

### 3.5 ALKALINE SOLUTION

The alkaline solution used for the experimental investigation are discussed below

It is the mixture of sodium hydroxide and sodium silicate. Sodium hydroxide is available in flakes or pellet form. Sodium silicate is available in gel form. It is observed that sodium hydroxide geopolymer exhibit better zeolitic property when compared to the potassium hydroxide geopolymer. It is also cheaper than the potassium hydroxide geopolymer. The chemicals used in this project is brought from super chemicals, Chennai.

Specification of sodium hydroxide flakes

MAXIMUM LIMITS OF IMPURITIES	96%
Carbonate	2%
Chloride	0.1%
Phosphate	0.001%
Silicate	0.02%
Sulphate	0.01%
Arsenic	0.001%
Iron	0.005%
Lead	0.001%
Zinc	0.02%

Specifications of sodium silicate liquid

S.NO	CHARACTERISTICS	SPECIFICATION
1	Na <sub>2</sub> O	15.5%+- 1
2	Na <sub>2</sub> O:SiO <sub>2</sub> Ratio	1:2.2+-0.1 to 1:2.4+-0.1
3	Colour	White liquid
4	Total solids	50%+-2%

#### IV. EXPERIMENTAL PROGRAMME

##### 4.1 MATERIALS AND PROCUREMENT

The materials used in the project work and the source is given below

S.NO	MATERIALS	SOURCE
1	Fly ash ( class F)	Balaji RMC plant, madurantakam.
2	GGBFS	Astra chemicals, Chennai.
3	Copper slag	Star trace private limited, Chennai.
4	M sand	KVCET, madurantakam.
5	NaOH	Micro fine chemicals, Chennai.
6	Na <sub>2</sub> SiO <sub>3</sub>	Super chemicals, Chennai.

##### 4.2 PREPARATION OF ALKALINE SOLUTION

Dissolved water is used to make the alkaline solution to avoid the mineral interference. The alkaline solution is to be prepared 24 hours in advance before use. The sodium hydroxide to be used is in pellet form and sodium silicate in gel form. The mass of NaOH varies depends on the concentration of solution in terms of its molarity. For example if the concentration is 6M, the mass of NaOH is 240gms, where 40 is the molecular weight of NaOH.

The same amount of sodium silicate is added to prepare the alkaline solution i.e. in the ratio of 1:1. 240gms of sodium hydroxide pellets is added to 1 litre of dissolved water. Dissolve the sodium hydroxide pellet by continuous stirring. Then the equal amount of sodium silicate solution is added to the prepared solution as a coolant agent, then it is put aside for 24 hours before use.

That the mass of NaOH solids was only a fraction of mass of the NaOH solution and water is the main

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component. The solution is normally soapy in nature and even a single drop of solution fall on the skin it may cause a skin irritation. Hence proper care should to be taken while handling the solution.



Fig 4.2(a) Adding sodium hydroxide to dissolved H<sub>2</sub>O



Fig 4.2(c) Alkaline solution

#### CALULATION FOR MAKING ONE BRICK

The dimension of the brick is 23cmX11cmX7cm Volume of the brick is =  $1.771 \times 10^{-3} \text{ m}^3$

Mass of the brick if 3.5 Kg

Mass of binder for one brick = 1083.17gms in 70:30 proportion Mass of fluid for one brick = 325 gms

Fluid to binder ratio = 0.3

Mass of aggregate for one brick = 2166.34 gms in various proportion.



Fig 4.2(b) Adding sodium silicate

#### 4.3 CASTING OF BRICK:

The materials like flyash, GGBS, copper slag and M sand is mixed in dry condition and it is kept for kneading of about 3 to 4 mins. After this the alkaline solution is added to the dry mix and mix well upto its consistency. The mixture is allowed to fall into the mould and the mixture is compacted in three layers. Each layer 25 number of blows has to be given with the help of rammer. And finally the brick is demoulded and kept for self curing.



Fig 4.3 (a) While mixing



Fig 4.3(b) While compaction



Fig 4.3(c) After demoulding

### V. TEST FOR COMPRESSIVE STRENGTH

The compressive strength test is conducted to find the load bearing capacity of material. The compressive strength test is done by CTM for 3, 7, 14 and 28 days of self curing.



Fig 5 Test for compressive strength

### 5.1 RESULTS FOR COMPRESSIVE STRENGTH

TABLE 5.1 SHOWS THE COMPRESSIVE STRENGTH FOR 3<sup>RD</sup> AND 7<sup>TH</sup> DAYS.

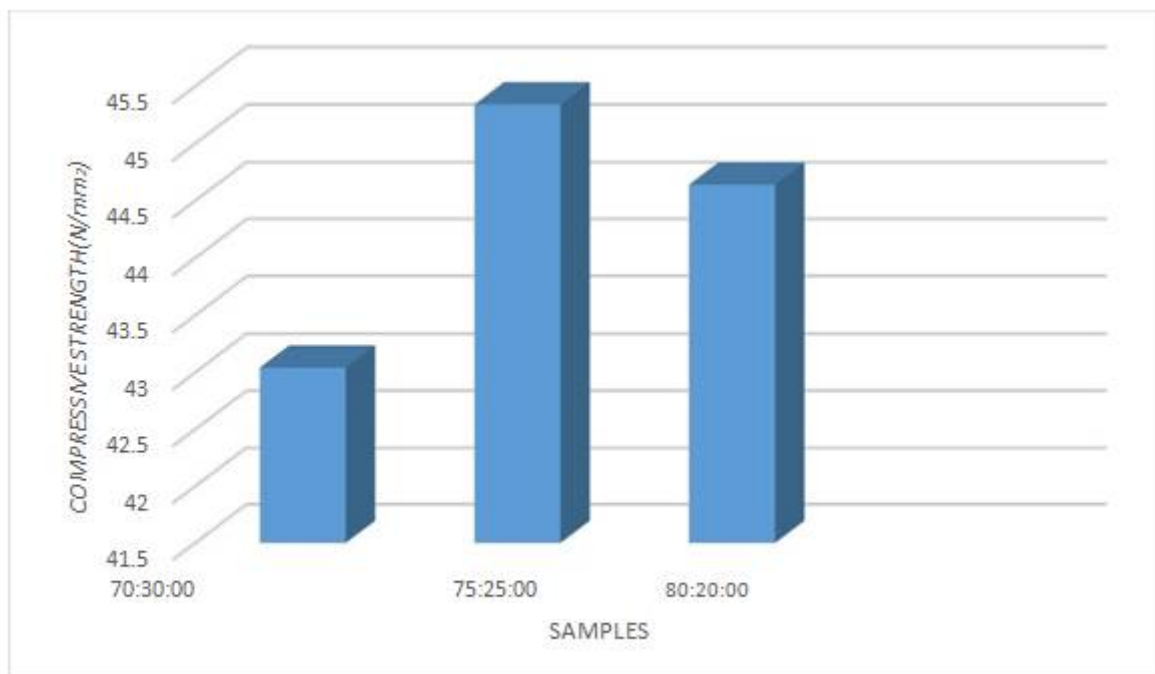
S. NO	S A M P L E	PERCENTAGE		3 <sup>rd</sup> DAY		7 <sup>TH</sup> DAY	
		FLYASH:GGBS	MSAND:COPPER SLAG	LOAD IN (KN)	COMPRESSIVE STRENGTH (N/mm <sup>2</sup> )	LOAD IN (KN)	COMPRESSIVE STRENGTH (N/mm <sup>2</sup> )
1	S1	70:30	70:30	630	24	684	27.04
2	S2	70:30	75:25	848	33.5	950	37.5
3	S3	70:30	80:20	645	25.5	722	28.54

TABLE 5.2 SHOWS THE COMPRESSIVE STRENGTH FOR 14<sup>TH</sup> AND 28<sup>TH</sup> DAYS.

S. NO	SAMPLE	PERCENTAGE		14 <sup>TH</sup> DAY		28 <sup>TH</sup> DAY	
		FLYASH:GGBS	MSAND:COPPER SLAG	LOAD IN (KN)	COMPRESSIVE STRENGTH (N/mm <sup>2</sup> )	LOAD IN (KN)	COMPRESSIVE STRENGTH (N/mm <sup>2</sup> )
1	S1	70:30	70:30	820	32.4	1088	43.04
2	S2	70:30	75:25	996	39.4	1147	45.34
3	S3	70:30	80:20	860	34	1129	44.64

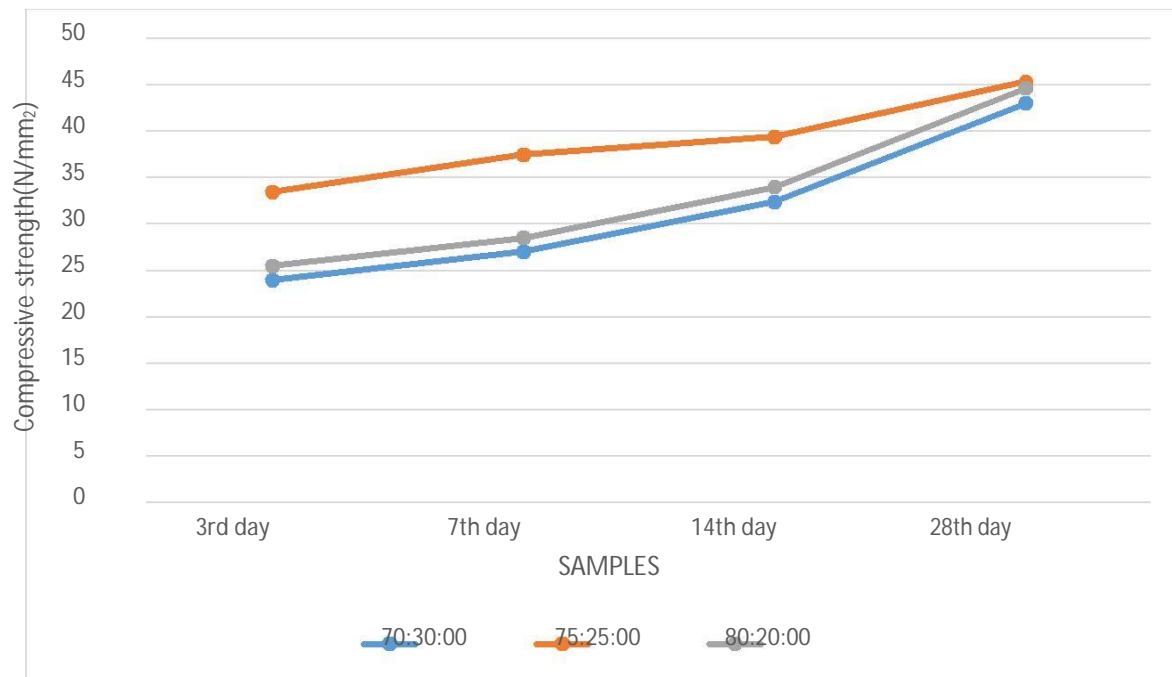
The proportion of flyash:GGBS = 70:30 gives better compressive strength compared to other proportions.

Graph 5.3 shows the analysis of maximum compressive strength at 28<sup>th</sup> days.





Line graph 5.4 shows the analysis of compressive strength at 3<sup>rd</sup>, 7<sup>th</sup>, 14<sup>th</sup> and 28<sup>th</sup> days.



## VI. CONCLUSION

- Usage of river sand is avoided leads to the conservation of natural resources.
- As per codal provision the minimum compressive strength for any class of flyash brick should not be less than 3.5 N/mm<sup>2</sup>. The maximum compressive strength obtained for the flyash and GGBS percentages of 70 and 30 and for the M sand and copper slag percentages of 75 and 25.
- The maximum compressive strength obtained is 45.34 N/mm<sup>2</sup>.

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