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Experimental Investigation on Geo-polymer Bricks

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Abstract - *Environmental contamination is the world's most serious concern today. The manufacture of Portland cement, in particular, results in the emission of pollutants such as CO_2, resulting in environmental contamination in the construction industry. By increasing the use of by-products from industries in our construction industry, we can lessen the polluting effect on the environment. Geopolymer brick is an innovation in the brick business that is mostly made from industrial by-products such as fly ash and GGBS, resulting in lower pollution levels. Experiments on Geopolymer bricks manufactured with fly ash and GGBS as source materials and river sand as fine aggregates, and a solution of sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) as an activator were carried out in this study. For all of the mixtures, the molarity of sodium hydroxide was kept constant at 1M, and the ratio of sodium silicate to sodium hydroxide solution was varied between 1, 0.5and 2. The dimensions of the brick examples are 230mm x 110mm x 70mm. The test specimens were put through their paces in terms of compressive strength, water absorption, and efflorescence. After 3 and 7 days of ambient room temperature curing, the compressive strength and weight of geopolymer bricks were determined. At all ages, the weight and compressive strength of bricks as the ratio of SSS to SHS was increased, and the strength of geopolymer bricks is imparted by sodium silicate solution. By The study's purpose was to reduce or reuse industrial wastes to protect the environment, as well as to increase low-cost bricks for the construction industry's long-term growth.*

***Key Words*: CLASS-F FLYASH,GGBS(Ground Granulated Blast Slag),Sodium Silicate Solutions(SSS), Sodium Hydroxide Pellets (SHP)**

1. INTRODUCTION

We must replace fly ash with the other binders which have no negative environmental impact to manufacture environmentally friendly bricks . Thermal power plants can be used as binders to assist relieve the problem. The new geopolymer brick technique is a possible technique in this area. Geopolymer technology can reduce CO2 emissions from the fly ash and GGBS sectors, which could help to avert global warming. Additionally, proper industrial waste disposal can contribute to the reduction of rubbish discharge into the atmosphere.

Inorganic geopolymers, such as zealots, are alumina-silicate (Si-O-Al) based ceramic materials. When an alkaline activated solution combines with silica and alumina minerals, a tri polymeric long chain with an amorphous coordinate covalent network is produced. Polymer research encompasses all aspects of chemistry, engineering, and polymer science. The two types of polymers are organic (carbon-based) and inorganic polymers (Ex. Silicon-based). The three types of organic polymers include natural polymers (rubber, cellulose, etc.), chemically manufactured polymers (textile fibers, plastics, films, etc.), and natural biopolymers (biology, medicine, etc.). The term geopolymer refers to the geologically produced raw materials used in the fabrication of silicon-based polymers.

1.2 DEVELOPMENT OF GEOPOLYMER BRICKS:

Class F fly ash contains a lot of silica and alumina. The massive concentration of silica and alumina in fly ash (class-F) combines with alkali-activated sodium hydroxide and sodium silicate pre-mixed solution when used to create bricks. This chemical activity produces a gel that acts as a binder, eliminating the need for cement in the brick-making process.

2. LITERATURE REVIEW

STUDY ON THE BEHAVIOR OF GEOPOLYMER BRICKS UNDER DIFFERENT CURING TEMPERATURES AND ALKALINE SOLUTION CONCENTRATIONS.

Issue: 07 Nov 2020

Authors: .S.Sasikumar, Dr. M. Natarajan, Dr. N. Balasundaram, Dr.V.Karthik

Geopolymer bricks could be a viable alternative to traditional clay bricks. GPB specimens made with Class F fly ash had greater power ratings than those made with Class C fly ash. It was previously determined that the best results are obtained using a 10M alkaline solution and a 600C warm air oven curing temperature. Beyond 10M, the strength attribute has no greater effects than alternative concentrations and raises the GPB charge. The power of GPB mixes grows as the curing temperature rises, however, 90^0C does, not yield workable results.

EXPERIMENTAL STUDY ON THE BEHAVIOUR OF GEOPOLYMER BRICKS Issue: 02 Feb 2018

Authors: Pavithra N, Divya G, Suganthi M, Omprakash S.

- The goal of this paper is to learn more about the sturdiness and strength of bricks made using type F fly ash, slag, metakaolin, and quarry dust.
- Slag (ten percent) and quarry dust (35 percent to 30 percent, 60 percent to 40 percent) are replaced with up to 20% white metakaolin and chemical compounds in this process (sodium hydroxide and sodium silicate).
- In contrast to typical clay bricks and fly ash bricks, geopolymer bricks can be made using low calcium fly ash and molarities that provide enough strength.
- It is clear from the statement that using 15% metakaolin provides higher compressive energy on the seventh day of checking out, i.e. 10.11 N/mm^2.

And the results of compressive strength at the 14 and 28th days indicate that the most energy of compressive strength is found at 15% of metakaolin. 15.405 N/mm^2 and 23.66 N/mm^2, respectively.

3. MATERIALS AND METHODOLOGY

3.1 Fly ash

Fly ash is a thin grey powder made up primarily of spherical, glassy particles that is a byproduct of coal-fired power plants. Mineral impurities in coal (clay, feldspar, quartz, and shale) fuse in suspension during burning and are carried out of the combustion chamber with the exhaust gases. The fused material cools and hardens as it rises, forming spherical glassy particles known as fly ash. Class F fly ash was used in this project because it has self-cementing and pozzolanic qualities. The chemical and mineral elements of fly ash determine its color. Thcolorence of lime content material within the fly ash imparts tan and mild hues, whilst the presence of iron content material imparts a brownish shade.

Fig No 3.1: Fly ash

Table No 3.1: Properties for fly ash

S.NO	PROPERTIES	FLY ASH
1	COLOUR	GREY
2	SPECIFIC GRAVITY	2.92
3	BULK DENSITY	$2.3g/m^3$
4	FINENESS	$3000cm^2/g$

3.2 GGBS. (Ground granulated blast furnace slag)

Ground granulated blast furnace slag (GGBS) is a byproduct of iron production that increases the workability, strength, and durability of concrete when added to it. This substance is made by heating iron ore, limestone, and coke to around 1500 degrees Celsius. In a blast furnace, the process of GGBS does not form directly. Molten iron and molten slag are byproducts of iron production. The molten slag comprises silica and alumina, as well as oxides in small amounts.

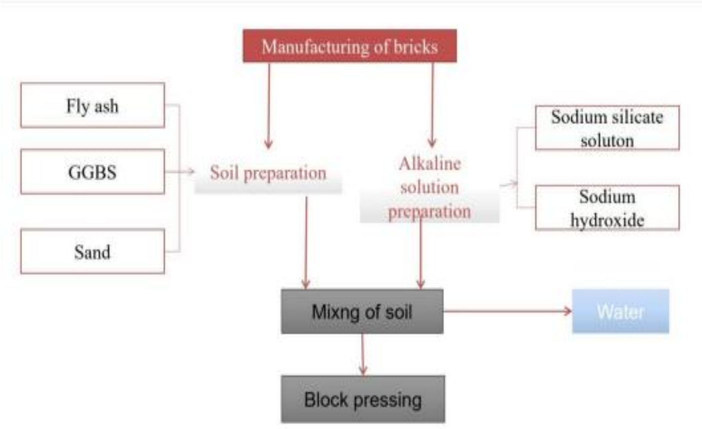
After cooling, the slag is granulated. It is permitted to pass through high-pressure water to accomplish this. This causes the particles to quench, resulting in granules with a diameter of less than 5mm. It is then dried and processed into a fine powder in a spinning ball mill, resulting in ground granulated blast furnace slag.

Fig No 3.2: GGBS

Table No:3.2

S.NO	PROPERTIES	GGBS
1	COLOUR	WHITE
2	SPECIFIC GRAVITY	2.8
3	BULK DENSITY	$1200Kg/m^3$
4	FINENESS	$350m^2/Kg$

3.3 METHODOLOGY



3.3.1 PROCESS FOR MANUFACTURING BRICKS.

In this process, Rangan's method was governed for manufacturing bricks. The alkaline solution, one day before mixing the materials alkaline solution has to be done with sodium silicate solution and sodium hydroxide solution which work as an activator in geopolymer bricks manufacturing. After one day of alkaline solution preparation, soil preparation has to be prepared by different proportions of fly ash and GGBS like 95-5%, 90- 10%, and 80-20%. Here the alkaline solution is added to the soil mix. After the mixing, apply grease to the molds and then filled with the mixture with proper compaction to remove air gaps. Here 230mm x 110mm x 70mm size of molds are used.

Fig No 3.3: Preparing paste for Brick molds

3.4 MIX DESIGNS.

Ratio (Flyash/GGBS)%	MOLARITY	RATIO (SODIUM SILICATE /SODIUM HYDROXIDE)
95:5	1	0.5
90:10	1	0.5
80:20	1	0.5
95:5	1	1
90:10	1	1
80:20	1	1
95:5	1	2
90:10	1	2
80:20	1	2

4. TEST RESULTS AND COST ANALYSIS

4.1 COMPRESSION TEST:

As per IS 3495 (Part 1): 1992 Compressive strength is a material's or a structure's ability to sustain pushing forces that are directed axially. Bricks with dimensions of 230 mm x 110 mm x 70 mm were cast, and specimens were tested for compressive strength after three days. The load is applied to the bricks, and where the failure occurs is noted as failure load. The specimens are then placed in a compression testing machine.

The formula is used to calculate compressive strength. Fck=Pc/A

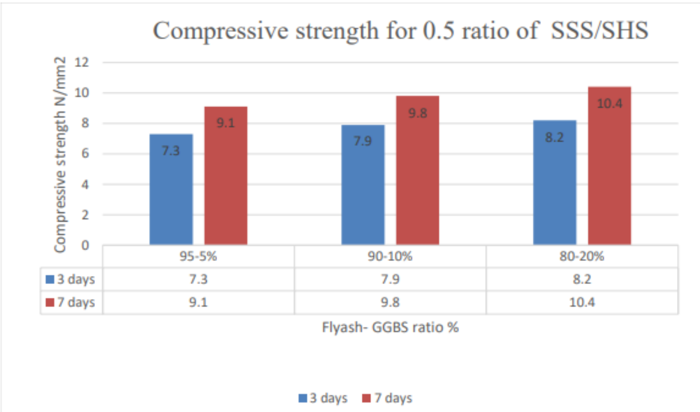
Where Pc=load at failure in N A=loaded area of brick in mm^2

Geopolymer brick was placed at typical room temperature during the curing process.After casting for about one day, the bricks are taken out of the mold and left in the chamber for three days.

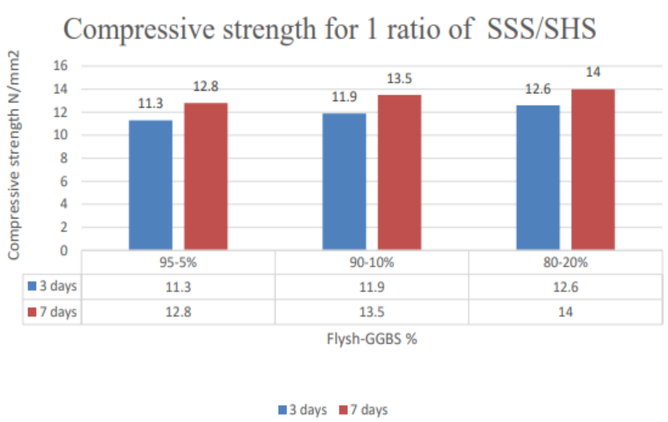
Fig 4.1 Compression test

Table No:4.1

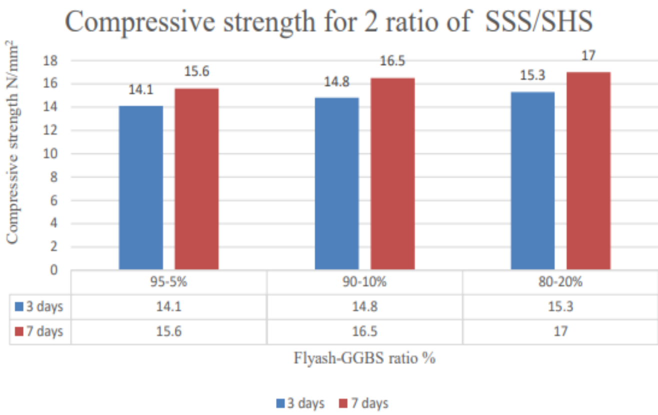
Unit weight (kg/m3)	Compressive test for 3 days (N/mm2)	Compressive test for 7 days (N/mm2)	Ratio (Flyash/GGBS)%	MOLARITY	RATIO (SODIUM SILICATE /SODIUM HYDROXIDE)
1000	7.3	9.1	95:5	1	0.5
1000	7.9	9.8	90:10	1	0.5
1000	8.2	10.4	80:20	1	0.5
1000	11.3	12.8	95:5	1	1
1000	11.9	13.5	90:10	1	1
1000	12.6	14	80:20	1	1
1000	14.1	15.6	95:5	1	2
1000	14.8	16.5	90:10	1	2
1000	15.3	17	80:20	1	2



Graph No 4.1 : Compression strength for 0.5 ratio of SSS/SHS



Graph No 4.2: Compression strength for 1 ratio of SSS/SHS



Graph No 4.3: Compression strength for 2 ratio of SSS/SHS

- Here the increase in the percentage of Flyash to GGBS (95-5,90-10 and 80-20%) will increase the strength of the bricks
- Also, the increase in the ratio of SSS/SHs will increase the strength.

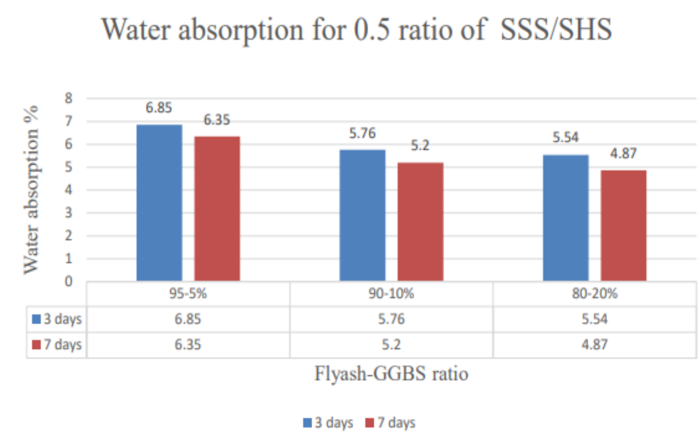
4.2 WATER ABSORBTION TEST:

As per IS 3495 (Part 2): 1992 Submerge the specimen in fresh and clean water for 24 hours at room temperature once it has completely dried. After 24 hours, take the specimen out of the water, wipe off the water with a dry cloth, and weigh the specimen. Weigh the specimen three minutes after it has been taken out of the water.The following formula could be used to calculate the mass of water that has been absorbed after 24 hours of immersion in cold water: (M2 –M1 / M1) x 100

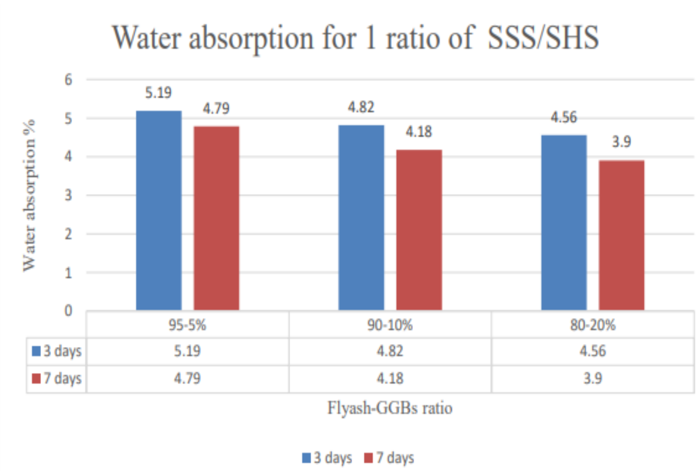
Fig 4.2 Water absorption

Table No:4.2

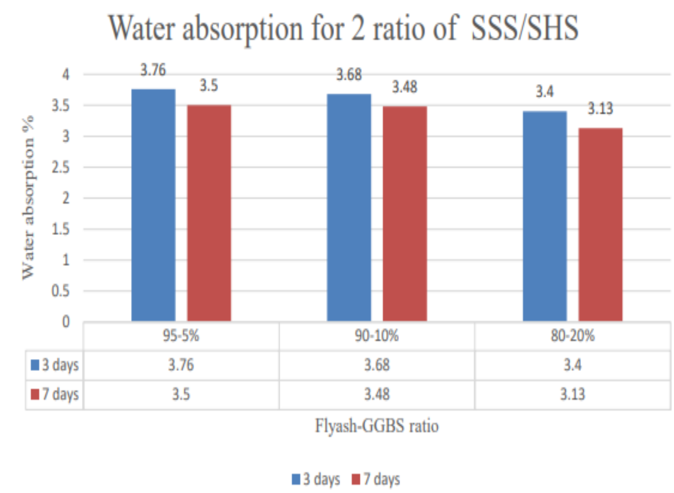
Unit weight (kg/m3)	Test for 3 days	Test for7 days	Ratio (Flyash/GGBS)	Molarity	Ratio (sodium silicate /sodium hydroxide)
1000	6.85%	6.35%	95:5	1	0.5
1000	5.76%	5.2%	90:10	1	0.5
1000	5.54%	4.87%	80:20	1	0.5
1000	5.19%	4.79%	95:5	1	1
1000	4.82%	4.18%	90:10	1	1
1000	4.56%	3.9%	80:20	1	1
1000	3.76%	3.5%	95:5	1	2
1000	3.68%	3.48%	90:10	1	2
1000	3.4%	3.13%	80:20	1	2



Graph No 4.4: Water absorption for ratio 0.5 of SSS/SHS



Graph No 4.5: Water absorption for ratio 1 of SSS/SHS



Graph No 4.6: Water absorption for ratio 2 of SSS/SHS

Here the observation shows that the water absorption is less than 7% for all samples with different percentages of fly ash to GGBS (95-5, 90-10 & 80-20%) and different ratios of SSS/SHS (0.5, 1 & 2)

5. CONCLUSIONS

- The increase in the percentage of Flyash to GGBS (95-5,90-10 and 80-20%) will increase the strength of the bricks Also, the increase in the ratio of SSS/SHs will increase the strength.
- According to IS-3495(part-1):1976, bricks' compressive strength must not be less than 7.5N/mm^2 .
- The results of this study's observations indicate that the compressive strength for the ratio 1 of SSS/SHS is of a sufficiently high quality .
- Water absorption is less than 7% for all samples with different percentages of fly ash to GGBS (95-5, 90-10 & 80-20%) and different ratios of SSS/SHS (0.5, 1 & 2).
- By increasing the ratio of SSS/SHS & the percentage of Flyash to GGBS the percentage of water absorption is decreasing, which increases the durability properties of bricks.

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