GEOPOLYMER BRICKS USING M-SAND

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Abstract— Geopolymer Brick is an alternative for the burnt clay bricks and also M-sand is an alternative for natural sand. Geopolymer bricks are made by using the industrial wastes such as Ground Granulated Blast Furnace Slag (GGBS), fly ash with M-sand. The fly ash collected from Mettur Thermal Power Station has been used. The fly ash and GGBS react with alkali activator solution of sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3). The size of geopolymer brick is 225 x 110 x 75mm. The fly ash and GGBS based geopolymer bricks were cured under ambient temperature for 24 hours. The compressive strength, water absorption and acid resistance tests were carried out. The strength of geopolymer bricks were compared with locally available conventional bricks. The various combinations of Geopolymer Bricks using M-sand are cast and cured under the ambient condition. The compressive strength of geopolymer bricks of M-sand result is better than the natural sand.

Keywords— Geopolymer Bricks; Fly ash; GGBS; M-sand; Sodium Silicate; Sodium Hydroxide; Activator Solution.

I. INTRODUCTION

Geopolymer technology was developed by DAVIDOVITS in 1980 by silicon and aluminium or from by-products materials of fly ash. Geopolymer technology reduces the CO_2 emissions. The ratio of silicon and aluminium is 2 to 3.5. The chemical composition of the geopolymer material is similar to natural zeolitic materials, but the microstructure is amorphous. Higher concentration of sodium hydroxide solution results in higher compressive strength of geopolymer products. The Class F fly ash is produced from the combustion of anthracite or bituminous coal. Due to shortage of natural sand, low compressive strength and to maintain the shape of geopolymer bricks, natural sand is totally avoided. The alternative material to fine aggregate is M-sand which are used in practice.

II. LITERATURE STUDY

Hardjito. D and Rangan. B.V [1] presents a detailed report on the variable parameters of geopolymer concrete such as molarity, solution to binder ratio, curing temperature, curing period and helped in fixing those variables. Also, the mechanical strength properties of geopolymer were well analysed and reported. Hardjito. D and Rangan. B.V [2] studies the influence of curing type and method is reported clearly and stated that age of geopolymer after curing does not affects its strength properties and hence strength at 3 days of age shall be well adopted.

Lloyd and Rangan. B. V [3] aids in designing geopolymer mixes with simple brief methods and illustrated with examples making it easier with understanding of geopolymer concrete. Claudio Ferone and Francesco Colangelo [4] investigated the mechanical performances of weathered coal fly ash based geopolymer bricks. Higher water content reduces the compressive strength at the same time increase the curing duration increases. Antony Jeyasekar. C and Thirugnanasambandam. S [5] carried out experiments on development of fly ash based geopolymer concrete precast elements. Jayaraman. A and Senthil Kumar. V [6] investigated optimization of fully replacement of natural sand by M-Sand in high performance concrete with nano silica. It was inferred from the literature that replacement of normal sand with M-Sand produces no appreciable increases in compressive strength. Antony Jeyasehar. C, Salahuddin. M and Thirugnanasambandam. S [7] studied the development of fly ash based geopolymer concrete precast elements, funded by Ministry of Environment and Forests, Annamalai Nagar. Rinku Kumar and Naveen Hooda [8] studied an experimental study on properties of fly ash bricks. The bricks produced were about 29% lighter than clay bricks and was found to be compact, homogeneous and free from any defects like holes, lumps, etc as compared to normal bricks. Anu. R and Thirugnanasambandam. S [9] presents a detailed report on the variable concertation of molarity by compressive strength, water absorption and durability tests. Thirugnanasambandam. S and Antony Jeyasekar. C [10] carried out experiments on Ambient Cured Geopolymer Concrete Products. It is proved that the geopolymer technology is the alternative method to create a binder instead of cement.

III. MATERIALS USED

The geopolymer brick was prepared using fly ash, GGBS, M-sand, sodium silicate and sodium hydroxide.

A. Fly Ash

Fly ash is a waste product obtained from Thermal Power Plant Industries and is produced during the operation of coal-fired.

B. Ground Granulated Blast Furnace Slag [GGBS]

GGBS is a waste product produced when iron is melt in blast furnace in 1400-1600^{0}C temperature. The specific gravity of GGBS is 2.9.

C. Sodium Hydroxide [NaOH]

The sodium hydroxide is available in pellets form, also called as caustic soda. Sodium hydroxide is used as a common base in chemical laboratories.

D. Sodium Silicate [Na_2SiO_3]

The sodium silicate is available in liquid form, also called as water glass or liquid glass. There silicates are supplied to the detergent company and textile industry as bonding agent.

E. Activator Solution

Generally, alkaline liquids are prepared by mixing the sodium silicate and sodium hydroxide solution at the room temperature. Concentration of sodium hydroxide 3M, 4M, 5M, 6M and 7M were used. NaOH pellets is diluted and mixed with sodium silicate. Sodium silicate and sodium hydroxide are taken in the ratio of 2.5. The ratio of fly ash and sand is 1:3 with ratio of activator solution to fly ash ratio is taken as 0.45.

F. M-Sand

Sand is the one of the main constituents of concrete making in construction industry. In order to full fill the requirement of fine aggregate, some alternative material must be found. The cheapest and the easiest way of getting substitute for natural sand is by crushing natural stone to get artificial sand of desired size and grade which would be free from all impurities is known as Manufactured sand. Filler grade material is defined by the industry as the material having less than 0.075mm (75 microns) in size. M-sand has the following properties. Specific gravity of M-sand is 2.60. Fineness modulus : 2.89. Conforming to Zone-II.

IV. MANUFACTURING OF GEOPOLYMER

The materials required for geopolymer brick is shown in Figure 1.

Figure. 1. Raw Materials and Mixing of Geopolymer mortar

The laboratory program conducted in this investigation focused on five basic mixes based on the molarities of NaOH such as 3M, 4M, 5M, 6M and 7M of NaOH. The ratio of fly ash and M-sand was kept constant on 1:3. Brick moulds of size 225 x 110 x 75mm were filled with geopolymer brick in three layers and compacted. To know the effect of concentration of NaOH on strength of brick, 3 to 7 Molarity of NaOH were used in this research. The geopolymer brick with varying NaOH concentration under curing are shown in Figure 2.

Figure. 2. Casting and curing of Geopolymer Bricks

It may attain almost its 70% strength within the first 3 to 4 hours of hot curing. The rate of increase of strength is rapid in the initial 24 hours of curing beyond that the gain of strength was

moderate. The ambient cured geopolymer bricks were tested in compressive testing machine and the average results are shown in Table 1.

TABLE 1 COMPRESSION STRENGTH OF GEOPOLYMER BRICKS

Sl. No.	Concentration of NaOH	Average Compressive Strength on Geopolymer Bricks (MPa)
1	7M	12.80
2	6M	11.50
3	5M	7.50
4	4M	5.30
5	3M	2.80

The normal strength of bricks available in the market is 5 MPa which is greater the minimum strength required as per (IS: 1077: 2007) code as 3.5 N/mm^2. From the results of different molarities of geopolymer bricks, 5M was chosen for the casting of geopolymer bricks. Geopolymer bricks, cast with fly ash and GGBS as source material. Geopolymer bricks was prepared source material by (50% fly ash + 50% GGBS) with M-sand is 1:3 ratio. The alkaline solution was prepared as per specification mentioned above. The purpose of addition of GGBS is for finding two curing method of specimen. These specimens were tried at roof top in ambient condition for 24 hours.

V. WATER ABSORPTION TEST

The geopolymer bricks and conventional clay bricks were immersed in water for 24 hours (Figure 3). Then, bricks were taken now and wiped by cloth. The percentage of water absorption of bricks are calculated and shown in Table 2.

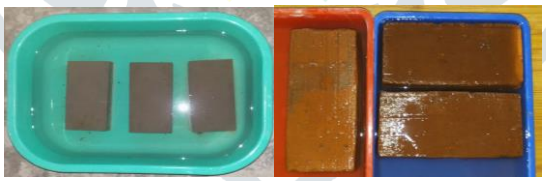

Figure. 3. Water Absorption Test

Table 2. Water Absorption of Bricks

SI. No.	Types of Bricks	Water Absorption (%)
1	Geopolymer Brick (M-Sand)	4.06
2	Conventional Brick	15.29

As per IS code the minimum percentage of water absorption of bricks is 20%. The geopolymer brick (M-sand) is absorbed 4.06% of water and Conventional brick absorbed 15.29% of water.

VI. DURABILITY TEST ON BRICKS

Acid resistance test was conducted with 1% of H_2SO_4. The geopolymer bricks (M-sand) and conventional bricks were immersed in acid solution for 28 days (Figure 4). Then, the specimens were taken out from the acid solution and the surfaces of the bricks were cleaned. The loss of weight and the loss of compressive strength of the specimens were found and given in Table 3.

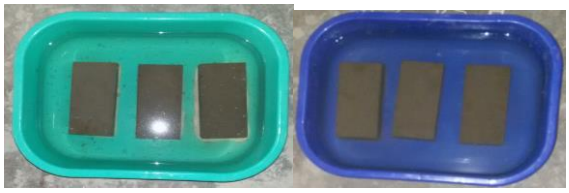

Figure. 4. Acid Resistance Test

Table 3 Test Results of Acid Resistance of Bricks

Sl. No.	Types of Brick	Loss of Weight (%)	Loss of Compressive Strength (%)
		H_2SO_4 (1%)	H_2SO_4 (1%)
1	Geopolymer Brick (M-Sand)	2.26	18.96
2	Conventional Brick	2.40	23.61

VII. CONCLUSIONS

Based on the experimental study carried on geopolymer bricks (M-sand) and conventional clay bricks, the following conclusions are derived.

The 5M NaOH geopolymer bricks with 50% FA + 50% GGBS cast and cured in ambient curing. The compressive strength of ambient cured geopolymer bricks shows compressive strength of 7.50 MPa. The percentage of water absorption of 5M NaOH geopolymer bricks (M-sand) made with 50% FA + 50% GGBS obtained as 4.06% only which is very low when compared to other conventional bricks. The percentage of weight loss observed after 28 days immersed in 1% concentration of Sulphuric acid (H_2SO_4) in geopolymer and conventional bricks is2.26% and 2.40% respectively. The percentage of loss of compressive strength observed after 28 days immersed in 1% concentration of Sulphuric acid (H_2SO_4) in geopolymer and conventional bricks is18.96% and 23.61% respectively.

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