Study of Physical, Durable and Microstructural Behaviour of Laterite Soil Based GeopolymerBricks

Shivaraju G D[1] and Dr. Asha K
[1]*Assistant Professor, Civil Engineering Department, Sri Siddhartha Institute of Technology, Tumkur, Karnataka, India and Research Scholar (VTU), Civil Engineering Department, BMS College of Engineering, Bangalore, India*
[2]*Assistant Professor, Civil Engineering Department, BMS College of Engineering, Bangalore, India*

[1]*Corresponding Author: shivarajgowdafam@gmail.com*

Received: 15-02-2024	Revised: 03-03-2024	Accepted: 26-03-2024

ABSTRACT
Bricks are the major building materials used in the field of construction. The most commonly used bricks are clay bricks and concrete blocks. The discharge of carbon di oxide into the atmosphere has been increasing day by day. For the production of burnt bricks, usually 22 tons of coal were burnt which produces nearly equal amount of carbon di oxide. The most vital role in terms of construction material is usually associated with Portland cement. Since the manufacture of cement leads to the liberation of CO2 in large quantity. So, an alternate is required to replace cement in the place as binding agent. Therefore, the alternative to these is the Geopolymer bricks. Geopolymers have great mechanical properties, and has the synthetic temperature of 25^{0}C to 80^{0}C. In this study, Laterite soil is used to prepare the bricks by using Geopolymer as a binding material by varying NaOH to Na2SiO3 ratio in Geopolymer precursor. Strength, durable and microstructural behavior of the brick is studied.

Keywords: *geopolymer, laterite soil, stone dust, fly ash*

I. INTRODUCTION

Bricks, the common material used for construction. Size of brick varies according to their requirement. The most common type of bricks used are burnt bricks and concrete blocks. Cement is the binding material used commonly. For the manufacture of cement large amount of carbon-di- oxide is liberated. An alternative to this is the use of Geopolymer as a binding material.

II. MATERIALS

Geopolymer

Geopolymer is an inert aluminosilicate substance which is derived from the polycondensation of alumina and tetrahedral silica. The most common alkaline liquid used in Geopolymerisation is a combination of Sodium Hydroxide (NaoH) and Sodium Silicate (Na_2SiO_3).

Sodium Silicate

Sodium silicates are alkaline in nature. The silicate ions react with hydrogen ions to form silicic acids, which later decomposes into dioxide gel. Sodium Silicate contains 27.9% of H_2O, 32.29% of SiO_2, 16.74% of Na_2O, 13.92% of K_2O and 1.16% of Al_2O_3.

Figure 1: Sodium silicate

ISSN (Online): 2583-2468
Volume-3 Issue-2 || March 2024 || PP. 50-57 DOI: 10.5281/zenodo.10910461

Sodium Hydroxide

Sodium Hydroxide gives more leaching of Aluminum and silicate particle. The concentration of alkali is the essential property in strength development. 8M concentration of NaOH was utilized in the work. To form 8M NaOH, (8 x 40) 320grams of sodium pellets was mixed in distilled water to make 1 litre of 8M sodium hydroxide solution.

Figure 2: Sodium Pellets

Laterite Soil

The soil sort that contains mainly aluminum and iron. Laterization is the methodology of substance weathering which conveys a wide arrangement in the thickness, assessment, science and metal mineralogy of the laterite soils. The principle advantage of laterite material is that it does not promptly swell with water. The chemical composition of laterite soil usually consists of 7.74% of aluminum as Al_2O_3, 1.4% of calcium as CaO, 34.43% of Iron as Fe_2O_3, 0.13% of Magnesium as MgO and 56.3% of Silica as SiO_2.

Figure 3: Laterite soil

Stone Dust

Stone dust is a finely crushed materials used in the construction. Stone dust almost resembles the properties of the sand, hence can be used as the replacement of sand not only improve the quality of concrete but also in constructional activity.Use of stone dust in concrete conserve the natural river sand for future generations.

Figure 4: Stone dust

ISSN (Online): 2583-2468
Volume-3 Issue-2 || March 2024 || PP. 50-57 DOI: 10.5281/zenodo.10910461

Fly Ash

Fly ash is the by-product produced from the ignition of coal. Fly ash comprise most part of Silicon-di-oxide, mullet and iron oxide. There exist a few advancements in utilization of fly ash in various ranges of construction fields, one such application is its usage in Geopolymer composites.

Figure 5: Fly ash

III. METHODOLOGY

Preparation of Geopolymer Solution

8M NaOH is prepared by dissolving (8 x 40) 320 grams of Sodium pellets in distilled water to prepare 1 litre of Sodium Hydroxide. The solution is prepared at least a day before Geopolymer precursor is prepared. Sodium silicate is added to sodium Hydroxide in the proportion of 1:1, 1:1.5, 1:2 and 1:2.5. The solution is mixed well until the solution looks homogeneous. The solution is left for room temperature for 24 hours.

Casting of Cylindrical Specimen with Geopolymer

Laterite soil, fly ash and stone dust are dry mixed thoroughly in the ratio of 60:10:30 respectively. 16% of Geopolymer solution is added and mixed well. The cylindrical specimen of size 38mm x 76mm are greased well and the wet mix is added in the cylinder moldin 3 batches and tamped well until there are no air voids. The specimens are left in the mould for 24 hours to attain green strength.Later the specimens are removed from the moulds.

Casting of brick Specimen with Geopolymer

Laterite soil, fly ash and stone dust are dry mixed thoroughly in the ratio of 60:10:30 respectively. 16% of Geopolymer solution is added and mixed well. The brick specimen of size 190mm x 90mm x 90mm are greased well and the wet mix is added in the brick mould in 3 batches and tamped well until there are no air voids. The specimens are left in the mould for 24 hours to attain green strength. Later the specimens are removed from the moulds.

Method of Curing

The unmoulded specimens are carefully placed in oven. The specimens are cured at an optimum temperature of 60^0C for 24 hours, thishelps in removing the water glass content from the Geopolymer. Later the specimens are removed from oven and left for cooling in room temperature.

Figure 6: Oven curing

ISSN (Online): 2583-2468
Volume-3 Issue-2 || March 2024 || PP. 50-57 DOI: 10.5281/zenodo.10910461

IV. TESTING OF SPECIMEN

1. Compressive Strength

The compressive strength of the oven dried specimens are obtained from the compression testing machine. The specimens are tested at a loading rate of 4kN/min in compressive testing machine. The cylindrical specimens are tested at a loading rate of 1.5N/sec in unconfined testing machine.

Figure 7: specimen kept for testing in CTM

2. Dry Density Test

The dry density test is carried out by measuring the weight of the brick which is oven dried for 24 hours at 110^0C to the volume of the brick. Dry density is represented by g/cc. Dry density is calculated by the following formula:

Dry density = oven dry weight/ volume of sample

3. Water Absorption Test

Randomly specimens are selected and oven dried for 24 hours at 110^0C. Once the specimens attain room temperature, the mass of specimen is noted say M1. The dried specimens are immersed in water for 24 hours at room temperature. Later the specimens are removed and wiped with a dry cloth, then the mass of the specimen is noted say M2. The percentage of water absorption is obtained bythe formula:

Water absorption = (M2-M1)/M1 x 100

4. Alternative Drying and Wetting Test

Masonry building are subjected to occasional climatic variations. The dry weight of the specimen subjected to testing is measured. After the specimens are immersed in water for 24 hours at room temperature and then the mass of the brick is noted. The removed specimens are then oven dried at 110^0C for 24 hours and the mass of the specimens are noted, which completes one cycle. The same procedure is repeated for 7 cycles and then the strength of the specimen is tested.

5. Durability Test

(a) Sulphate Attack Test

As per the experiment 5% of MgSO4 solution is formed by diluting 5 grams of MgSO4 particles in 100ml of distilled water. Sufficient amount of solution is prepared to immerse the specimen for about 28 days. Later the specimens are removed from the solution and wiped and tested for compressive strength.

(b) Chloride Attack Test

As per the experiment 5% of NaCl solution is formed by diluting 5 grams of NaCl particles in 100ml of distilled water. Sufficient amount of solution is prepared to immerse the specimen for about 28 days. Later the specimens are removed from the solution and wiped and tested for compressive strength.

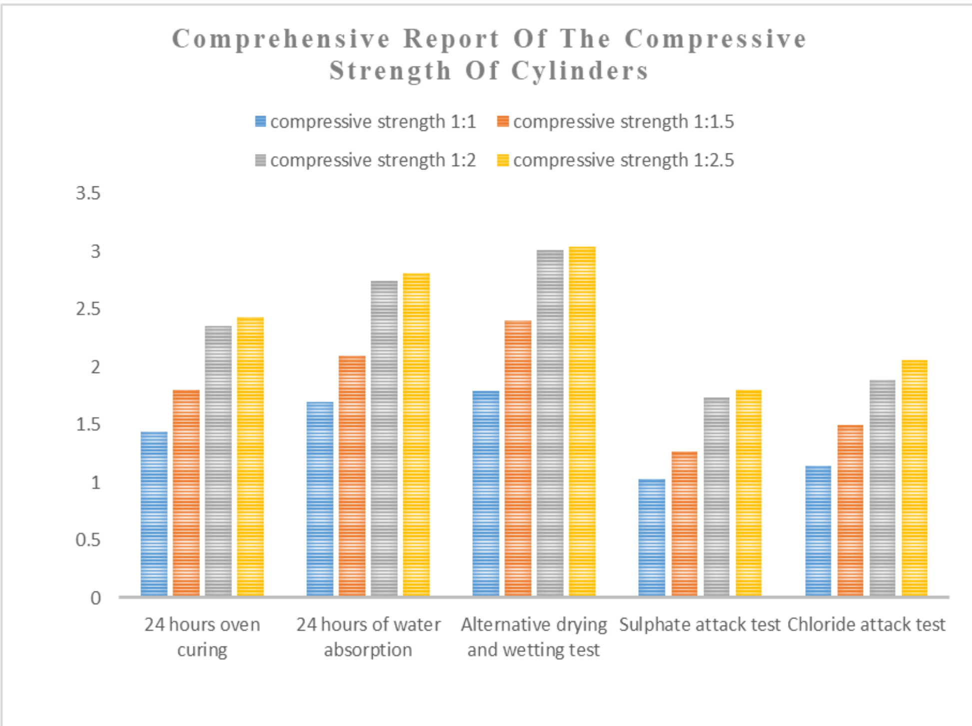
V. RESULTS AND DISCUSSIONS

1. Compressive Strength

a. Comprehensive Report of Cylinders

Sl. No.	Test	1:1	1:1.5	1:2	1:2.5
1	24 hours oven curing	1.44	1.804	2.35	2.43
2	24 hours of water absorption	1.7	2.1	2.74	2.81
3	Alternative drying and wetting test	1.79	2.4	3.01	3.04
4	Sulphate attack test	1.03	1.27	1.73	1.80
5	Chloride attack test	1.14	1.5	1.89	2.057

Table 1: Comprehensive report of the compressive strength for cylinders



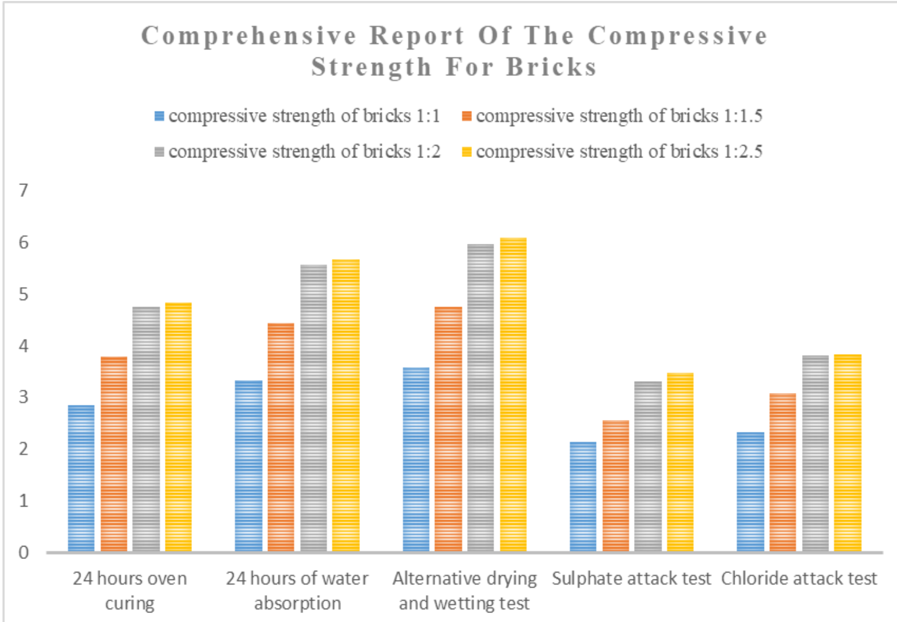
Graph 1: Comprehensive report of the compressive strength for cylinders

b. Comprehensive Report of Bricks

Sl. No.	Test	1:1	1:1.5	1:2	1:2.5
1	24 hours oven curing	2.85	3.79	4.76	4.84
2	24 hours of water absorption	3.34	4.44	5.56	5.67
3	Alternative drying and wetting test	3.58	4.76	5.96	6.09
4	Sulphate attack test	2.14	2.55	3.30	3.47
5	Chloride attack test	2.32	3.08	3.82	3.83

Table 2: Comprehensive report of the compressive strength for bricks

ISSN (Online): 2583-2468
Volume-3 Issue-2 || March 2024 || PP. 50-57 DOI: 10.5281/zenodo.10910461



Graph 2: Comprehensive report of the compressive strength for bricks

2. X-Ray Diffraction

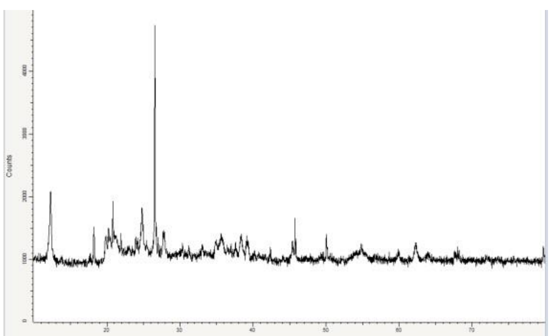


Figure 8: XRD for the ratio 1:1

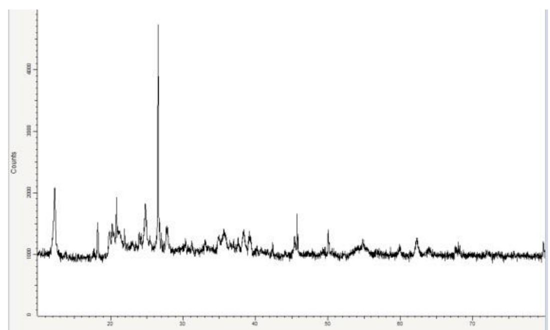


Figure 9: XRD for the ratio 1:1.5

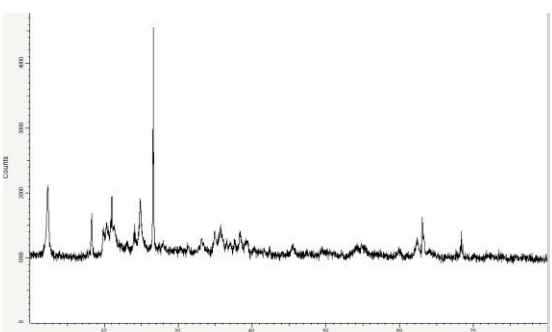


Figure 10: XRD for the ratio 1:2

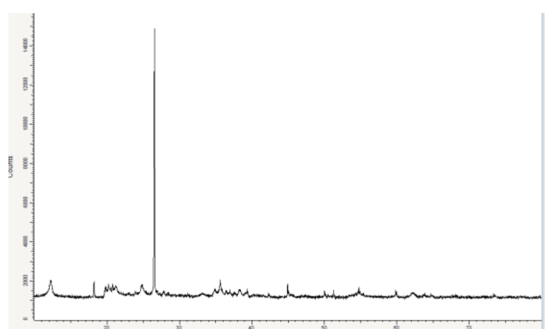


Figure 11: XRD for the ratio 1:2.5

ISSN (Online): 2583-2468
Volume-3 Issue-2 || March 2024 || PP. 50-57 DOI: 10.5281/zenodo.10910461

3. Scanning EM

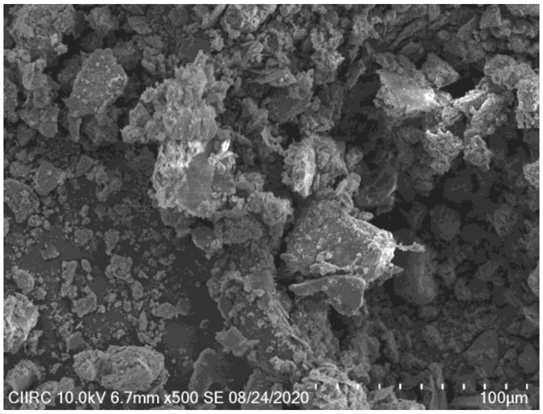


Figure 12: SEM for the ratio 1:1

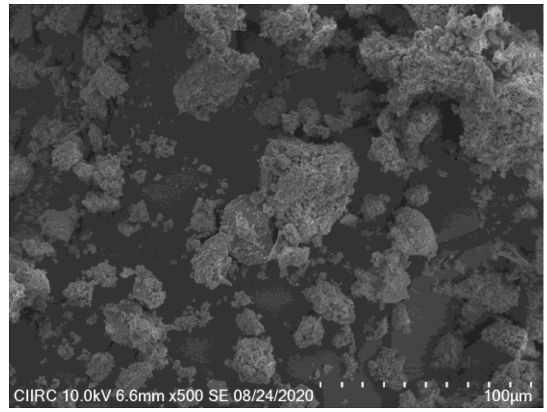


Figure 13: SEM for the ratio 1:1.5

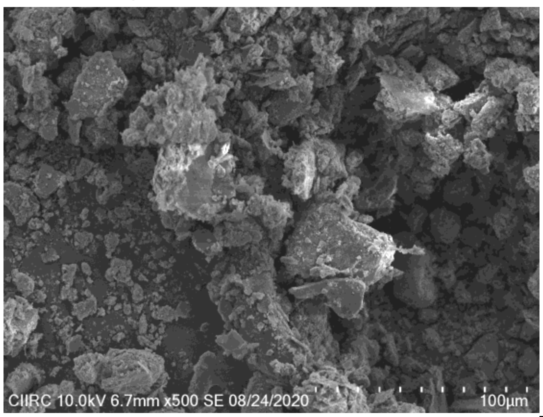


Figure 14: SEM for the ratio 1:1

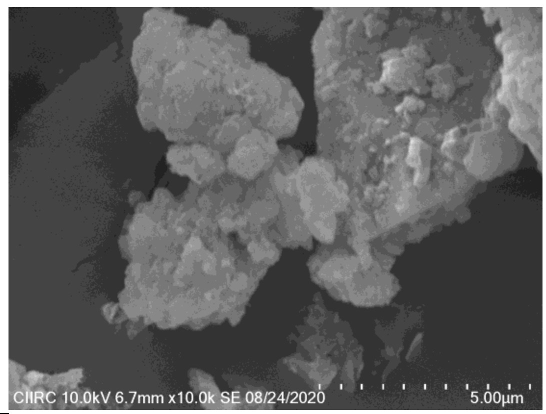


Figure 15: SEM for the ratio 1:1.5

VI. Conclusions

- The mix proportion containing the Geopolymer in varying quantity along with soil, stone dust and fly ash shows a considerable change in the compressive strength from the ratio 1:1 to 1:2. But there is a slight change in the compressive strength from the ratio 1:2 to 1:2.5.
- It was observed that the compressive strength was increased by 16% to 17% after 24hours of water immersion.
- The water absorption of all the specimens was in the range of 6 % to 7%.
- The alternate drying and wetting test gave the results for bricks for varying ratios of NaOH to Na2SiO3 i.e., 1:1, 1:1.5, 1:2 and1:2.5 was 3.58, 4.17, 5.13 and 5.39 respectively which are liable for all the varied climatic changes of drying and wetting.
- The compressive strength of specimen was reduced by 20 % to 24% after Sulphate attack test.
- The compressive strength of specimen was reduced by 35 % to 48% after Chloride attack test.

REFERENCES

1. B. Vijaya Rangan, Djwantoro Hardjito, Steenie E. Wallah, & Dody M.J. Sumajouw. *Studies on fly ash – based geopolymer concrete*.
2. Tinayu Xie, & Togay Ozbakkalgu. (2015). Behavior of low-calcium fly and bottom ash-based Geopolymer concrete cured at ambient temperature. *Ceramics International*.
3. Weibo Ren, Jinyu Xu, Junliang Liu, & Haoyang Su. (2015). Dynamic mechanical properties of geopolymer concrete after water immersion. *Ceramics International*.
4. Ramin Hosseini Kupaei, U. Johnson Alengaram, Mohd Zamin Bin Jumaat, & Hamid Nikraz. (2013). Mix design for fly ash-based oil palm shell geopolymer lightweight concrete. *Construction and Building Materials*.
5. Gowthami MER. (2016). Manufacture of geopolymer fly ash bricks using class C fly ash. *International Journal of*

ISSN (Online): 2583-2468
Volume-3 Issue-2 || March 2024 || PP. 50-57 DOI: 10.5281/zenodo.10910461

Advanced Researched and Development.
6. Hans F. Winterkorn, & E. C. Chandrashekaran. Laterite soils and their stabilization. *ASTM Special Technical Publication No. 79*, p. 83.
7. J.O.Akinmusuru. (1984). Lateritic soil-cement bricks for rural housing. *The International Journal of Cement Composites and Light Weight Concrete, 6*.
8. Kolli. Ramujee, & M. Potharaju. (2016). Mechanical properties of geopolymer concrete composites. *5th International Conference of Materials Processing and Characterization*.
9. C. D. Udawattha, A.V.R.D Lakmini, & R.U Halwatura. (2018). Fly ash-based geopolymer mud concrete block. *Moratuwa Engineering Research Conference*.
10. Venugopal K, Radhakrishna, & Vinod sasalatti. (2016). Development of alkali activated solid and hollow geopolymer masonry bricks. *IOP Conf. Series: Materials Science and Engineering*.
11. Shankar H. Sanni, & Khadiranaikar R.B. (2012). Performance of geopolymer concrete under severe environmental conditions. *International Journal of Civil and Structural Engineering*.
12. L. Krishnan, S.Karthikeyan, S. Nathiya, & K.Suganya. (2014). Geopolymer concrete an eco-friendly construction material. *International Journal of Research in Engineering and Technology, NCAMESHE*.