Study on the development and behavior of green geopolymer bricks

Revathi S[1], Vidhya K[2] , Kavitha E[3], Shivasakthivadivelan R A[4]

[1] Research Scholar, Department Of Civil Engineering, Mahendra Engineering College, Namakkal 637503, Tamilnadu, India.
[2] Professor and Head, Department Of Civil Engineering, Mahendra Engineering College, Namakkal 637503, Tamilnadu, India.
[3,4] Research Scholars, Department Of Civil Engineering, Mahendra Engineering College, Namakkal 637503, Tamilnadu, India.

Abstract - *Bricks are the most predominantly used construction materials since the ancient period owing to their availability, economy, and simplicity of manufacturing. The traditionally available clay bricks usage is gradually depleted due to scarcity and raw material depletion. Industrial by-products of high potential are of interest in the current days to develop various greener building products. Geopolymer bricks are remarkable amongst various construction products for their extraordinary properties under various strength and longevity parameters. The geopolymer bricks find vast application in various developed and developing countries owing to their significant properties. The article deals with the development of a greener geopolymer brick with industrial wastes. The properties of the bricks are assessed and the results are interpreted.*

Key Words: Bricks, Geopolymer bricks, Industrial by-products, properties of bricks.

1. INTRODUCTION

Due to the population boom and increased demand for natural resources, there is a huge demand for housing globally. In recent years, there has been a lot of interest worldwide in creating sustainable construction materials using possible industrial byproducts. The use of cement in the production of concrete will be eliminated thanks to a new technology developed in the 1980s by French scientist Davidovits[6]. By doing away with natural clay, the same idea is currently applied in the production of bricks. Substituting an alkaline solution for water in the dry raw mixture made it possible to cause the fly ash in brick to cement. Geopolymerization of bricks depends on the Al ion's capacity to produce crystallographic and chemical variations with Si content and a variety of other factors, such as the type of source materials, the type of curing, the curing temperature, the curing time, the age of the testing, and the type and concentration of alkaline solution[3]. Utilizing supplemental cementitious materials in place of cement has reduced CO2 emissions, making the application of geopolymer technology more important [2. The utilization of industrial by products of good silica alumina potential materials support and favour geopolymerization. The building industry contributes about 39% of the annual global CO2 emissions, according to "World Energy Statistics and Balance database 2019." [4]. It is crucial and the ideal time to focus more on industrial wastes and effectively reduce the consumption of natural resources.

2. LITERATURE SURVEY

Geopolymer brick behaviour was tested with by [8] under the combined influence of pressure, temperature, and curing. Pressure was changed between 0 and 20 and 40 MPa, together with ambient and high temperature fluctuations, and behaviour was examined with variable curing times between 7 and 28 days. Longer curing times and high pressure of 40 MPa during hot curing resulted in superior geopolymer properties for bricks. The combined physiomechanical behavior of the geopolymerized bricks had also been confirmed by the microstructure investigation.

The durability and fundamental properties of the industrial ash brick were investigated with by [10]. The best percentage of pond ash-based ash brick is established, and the viability of pond ash inclusion in brick manufacturing is estimated. The microlevel characterisation of pond ash is investigated, and the performance of the ash bricks is assessed.

Fly ash (FA), electric arc furnace slag (EAF), and waste foundry sand were used in the investigation by (Apithanyasai et al. 2020) on the geopolymer manufacture of bricks (WFS). Utilized were sodium silicate and sodium hydroxide, both of which have molarities of 10M. There was an excellent compressive strength as a result of the percentage of waste foundry sand, fly ash, and electric arc furnace slag, which was 40:30:30. Assessments of toxicity and environmental effects were made using the leaching test.

The construction and characterisation of eco-permeable bricks made from industrial waste was tested by [7]. Gypsum, fly ash, blast furnace slag, and steel slag are used to make the bricks. At a curing temperature of 60oC, the maximum compressive strength of 27.4 N/mm2 is obtained. The eco permeable brick is found to have a flexural strength of 4.5 N/mm 2. It is noted that 96% of solid waste was used in the production of the eco-permeable bricks. The results of the toxicity tests lead to the conclusion that the eco-permeable bricks are safe for the environment.

3. MATERIALS USED & MIX PROPORTIONING

The materials used in this investigation to manufacture the geopolymer bricks are.

- Fly Ash
- GGBS
- Fine Aggregate (M-Sand)
- Alkaline Activators (NaOH & Na_2SiO_3)
- Gypsum
- Water

Fly ash is the ash obtained as a byproduct from thermal power plants during coal combustion for electricity generation. The fly ash is of class F type as per ASTM C 618 Standards and is obtained from Mettur Thermal Power Plant, Tamilnadu, India.

A by-product of the blast furnaces used to create iron, GGBS (Ground Granulated Blast-furnace Slag) is a cementitious material that is mostly utilised in concrete.It is coolected from JSW cements Pvt. Ltd, salem,Tamilnadu.

M sand is currently most frequently utilised in construction projects. It had a nice texture and appearance. For brick masonry casting, readily available M sand is used.

The activators utilised in the geopolymerization process are sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3).In order to balance cost and effectiveness, sodium hydroxide with a normalcy of 8M is utilised [9].

Gypsum enhances both the reduction of strength loss owing to soaking even at short curing times as well as the stability of stabilised fly ashes over repeated cycles of wetting and drying. Sodium hydroxide and sodium silicate are used as alkaline activators. The molarity of sodium hydroxide is maintained as 8M for all the mixes.

The physical properties of the materials used is presented in table 1.

Table 1. Physical properties of materials

S.No	Property	GGBS	Fly ash	M sand
1	Specific gravity	2.59	2.23	2.32
2	Surface area(m^2/kg)	325	350	252
3	Bulk density (kg/m^3)	1299	1160	1453

The mix proportion of various materials used for the geopolymer brick is presented in table 2.

Table 2 Mix proportion for geopolymer brick

S.No	Brick ID	GGBS	Fly ash	M sand	Gypsum
1	GP 1	10	60	25	5
2	GP 2	20	50	25	5
3	GP 3	30	40	25	5
4	GP 4	40	30	25	5
5	GP 5	50	20	25	5
6	GP 6	60	10	25	5

4. RESULTS AND DISCUSSION

Experimental determinations of the several basic brick parameters, such as compressive strength, water absorption, and weight density of the bricks, are made, and the test results are presented.

Table 3. Test results for the basic properties of bricks

S. No	Brick ID	Compressive strength at 28 days in MPa	Water absorption in %	Weight density (kN/m^3)
1	GP 1	11.58	9.52	15.69
2	GP 2	12.95	9.06	15.78
3	GP 3	15.69	8.84	16.12
4	GP 4	17.58	8.90	16.89
5	GP 5	15.24	8.96	16.52
6	GP 6	10.69	9.11	16.45
7	Fly ash brick(FB)	7.66	12.12	16.36

4.1 Compressive strength

The compressive strength of the green geopolymer brick is determined from the experimental findings and the pictorial representation of the compressive strength is presented in Figure 4.1.

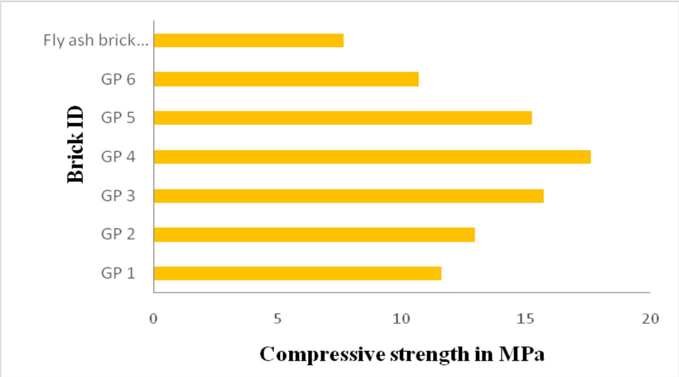

Figure 4.1 Compressive strength of geopolymer brick

From the figure 4.1 it is inferred that the geopolymer bricks possessed a very significant compressive strength compared with the traditionally available flyash bricks. The geopolymer brick with ID GP4 possess highest compressive strength when compared to all other geopolymer bricks .The composition of flyash constituting 30% GGBS constituting 40% resulted in highest compressive strength.

4.2 Water absorption

The water absorption representation of the geopolymer brick and the flyash brick is presented in figure 4.2.

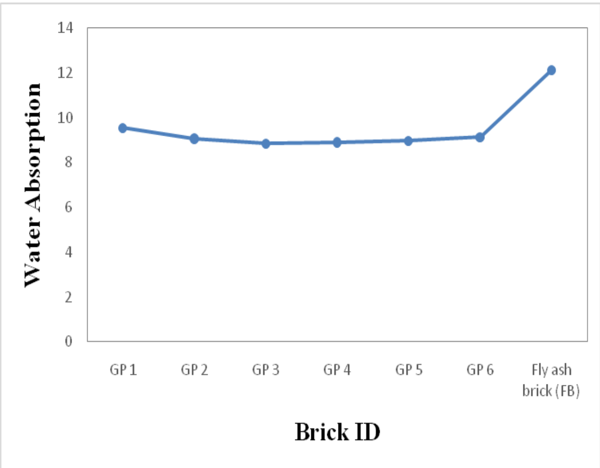

Figure 4.2 Water absorption representation

The water absorption representation in figure 4.2 reveals the fact that the geopolymer breaks process very minimal water absorption property when compared with the flyash bricks. It could also be inferred that. Five numbers of brick samples for each mix combination are tested for water absorption property determination. The water absorption value is very minimum for the geopolymer brick GP4 compared with all other trial mixes. The geopolymer bricks possess a dense, complicated microstructure and as a result the pores are minimized and hence the water absorption is very minimal.

4.3 Weight density

The weight density of the geopolymer bricks and flash bricks is presented in Figure 4.3.

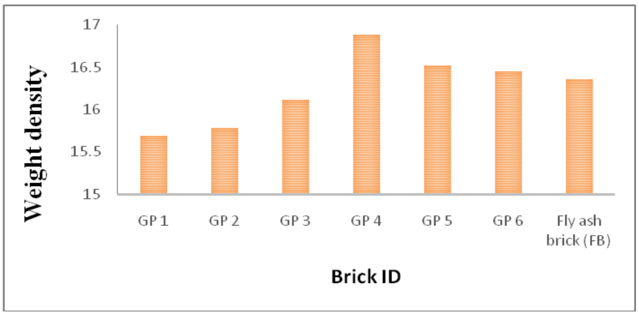

Figure 4.3 Weight density of bricks

Three brick samples are chosen for determining the weight density for each mix composition. The weight density representation is depicted in figure 4.3. The density of the geopolymer bricks is increased, corresponding to the increase in compressive strength of the bricks. There exists a direct relationship between the compressive strength and weight density of the bricks. Due to their large surface area and fineness, Fly ash and GGBS, when added to brick specimens, help minimise pore size and favour weight gain up to a specific threshold.

5. CONCLUSIONS

The following conclusions are drawn from the experimental findings,

1. Geopolymer bricks appear to be a reasonable strategy that enables the preservation of the environment, further reduction of pollutants, and advancement towards greener technology.
2. The green Geopolymer brick paves a way for significant industrial waste utilization for construction products.
3. The geopolymer brick with ID GP4 possessed highest compressive strength among all the geopolymer mixes which is 2.29 times the strength of the traditional fly ash bricks.
4. The water absorption and weight density parameters of the geopolymer brick were within the prescribed standards of IS 3495:1992.
5. The geopolymer bricks possessed superior properties compared with the traditional bricks and it is one of the future technology for the construction-related activities.

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