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Production of Bricks from Industrial Waste using Alkali Activated Technology

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***Abstract*—Bricks have long been a major construction material due to its durability, insulation, and fire resistance. Bricks are commonly made from clay and fired in kilns, they are mostly used for structural and landscaping purposes. With the increasing demand for sustainable materials, alternative brick production methods are being investigated, including the use of industrial waste and alkali-activated technology. This study examines the production of sustainable bricks by partially replacing clay with quarry dust and fly ash, as well as using NaOH as an alkali activator. So, in this method of brick manufacturing process, there is no burning process is needed. A sustainable method of construction is obtained by this technique.**

***Keywords*— Bricks, Sustainable, Alkali-Activated Technology**

I. INTRODUCTION

The construction industry experiences serious environmental problems, especially from resource scarcity and carbon emissions in commercial brick manufacturing. A sustainable replacement using industrial waste, namely quarry dust and fly ash, to produce bricks through alkali activation, a method where sodium hydroxide (NaOH) reacts with silica and alumina in these materials to form a durable binder. The addition of lime (CaO) further enhances strength, creating a cost-effective and sustainable replacement to traditional clay bricks. This method not only reduces waste disposal issues but also decreases the environmental impact of traditional brickmaking by removing the need for high energy firing processes. Geopolymer bricks made through alkali activation offer high durability, chemical and heat resistance, making them a sustainable solution for modern construction.

II. OBJECTIVES

This study aims to assess and compare the compressive strength of sustainable bricks with traditional bricks commonly used in construction. It studies the effect of alkali-activated technology on clay bricks and analyses how this process effects their structural properties. This study also determines the properties of sustainable bricks comparing to commercial bricks.

III. SCOPE

The scope of this project is the sustainable development of bricks, through this we can reduce environmental pollution and contamination of wastes.

IV. METHODOLOGY

The first phase of the project is topic selection, where an appropriate research field is recognized. After selecting the topic, the research gap is identified to determine the need for the study. Then raw materials are assembled, confirming the necessary components are gathered for brick production the preparation of raw materials is conducted to process them for use in manufacturing. The casting process is then conducted to cast the bricks using the raw materials. Once the bricks are cured testing is conducted to evaluate their strength and durability. Finally, a comparative analysis is carried out to evaluate the performance of sustainable bricks against commercial bricks, deciding their potential as an environmentally friendly alternative.

A. Collection Of Raw Materials

The raw materials for the production of brick are collected. They are clay soil, quarry dust, lime, sodium hydroxide, fly ash, water etc.

Fig. 1. Raw Materials Collected

1. Clay Soil

Clay is a type of fine-grained natural soil that contains clay minerals such as silica, alumina, manganese, iron etc. When adding water they exhibit plastic property. The best suited soil for making of brick is the silted clay or weathered clay.

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Because, these soils have sufficient strength and cohesion property. The soil is taken from the Panamaram, Wayanad.

2. Admixtures

NaOH and lime are used as admixtures. A chemical reaction takes place between alumino-sililicate and alkali activators due to these admixtures

3. Quarry dust

Quarry dusts are made from byproduct of stone crushing from quarry. However, it has many uses in construction industry due to aluminium-silicate present in it. Here we are using quarry dust as partial replacement of sand which we have collected from Cheruvanchery, Kannur.

4. Fly ash

Fly ash is a byproduct of coal combustion in thermal power plant which can be considered as an industrial waste due to many environmental consequences. It is composed of silica, alumina and iron oxides. Here we are using fly ash as partial replacement of clay which we have collected from Palakkad.

B. Preparation of raw material

After removing impurities from raw materials it is weathered for few days and after drying it is powdered and sieved through 300μm before mixing.

C. Mixing

All the raw materials we have collected with required proportions are mixed together with water to form a uniform mixture. After that it is kept for 2 to 4 hours before mixing again with water.

TABLE 1. MIX PROPORTION

BRICK	CLAY	QUARRY DUST	FLY ASH	NaOH	LIME
1	55%	40%	0%	3%	2%
2	55%	30%	10%	3%	2%
3	55%	20%	20%	3%	2%
4	55%	10%	30%	3%	2%
5	55%	0%	40%	3%	2%

D. Moulding

The mixture is then pressed into a cleaned and oiled mould (19 x 9 x 9 cm). Bricks are then kept in oven for 72 hours before unmoulding.

Fig. 2. Moulded Brick

E. Curing

After unmoulding fresh bricks are moved into an open space and is cured for 14 days in clean water to ensure proper setting.

Fig. 3. Casted Bricks

IV. TESTS PERFORMED

Different lab tests are carried out for finding efficiency and strength of the bricks. They are as follows:

A. Compressive Strength Test

To perform a compressive strength test on bricks, select the brick. Its surface must be smooth and clean. Measure their dimensions accurately and find the loaded area. Place the brick axially in a Compression Testing Machine. Gradually apply load at 14 N/mm² per minute until the brick fails, then record the maximum load. The compressive strength is calculated using the formula:

$$\text{Compressive strength } (in\ N/mm^2) = \frac{\text{Load at failure}}{\text{area of brick}}$$

Fig. 4. Compressive Strength Test

B. Water Absorbtion Test

The water absorption test on bricks are done to determine their porosity and suitability for construction. While doing this test first record their dry weight as W1. Next, fully immerse these bricks in water for 24 hours, then take them out, wipe off excess water, and record their wet weight as W2. The water absorption percentage is calculated using the formula:

$$\text{Water absorption} = \frac{W2-W1}{W1} \times 100$$

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Fig. 5. Water Absorbtion Test

C. Hardness Test

The hardness of brick indicates the resistance of brick. For this test, the brick is scratched with sharp tool. If the scratching does not leave behind any impression on the brick, it is considered as a hard brick.

D. Soundness Test

A soundness test on bricks is done to determine the nature of bricks when subjected to sudden impact. For doing this test two bricks are taken and then these bricks are crashed against each other. If it emits a clear metallic ringing sound; the brick is of good quality.

E. Impact Test

In the impact test of the bricks, the brick is dropped from a height of 1 meter on the ground. After falling the brick should not break into pieces. If the brick does not get cracked or crushed into pieces then it indicates the best quality of the brick.

F. Efflorescence Test

The presence of soluble salts in the bricks leads to efflorescence on the bricks which decreases the quality of bricks. A good brick should be free from soluble salts.

G. Shape and Size Test

For the maintenance of uniformity in the construction, the bricks must have proper shape and uniform size. A good brick must have a good and rectangular shape with sharp edges.

V. RESULTS AND DISCUSSION

Different types of tests are done for determining the performance of brick. And these results are compared to the performance of commercial bricks. The tests performed and its results are given below.

A. Compressive Strength Test

Table 2 gives the compressive strength test values of bricks with varying percentages of fly ash and quarry dust.

TABLE 2. COMPRESSIVE STRENGTH OF BRICKS

SI No.	BRICK DESIGNATION	COMPRESSIVE STRENGTH (N/mm^2)
1	Brick specimen with quarry dust 40% fly ash 0% (Q4F0)	3.15
2	Brick specimen with quarry dust 30% fly ash 10% (Q3F1)	6.36
3	Brick specimen with quarry dust 20% fly ash 20% (Q2F2)	9
4	Brick specimen with quarry dust 10% fly ash 30% (Q1F3)	9.4
5	Brick specimen with quarry dust 0% fly ash 40% (Q0F4)	10.7

Based on the above table a graph is plotted with brick having various quarry dust and fly ash percentage on X axis and compressive strength on Y axis.

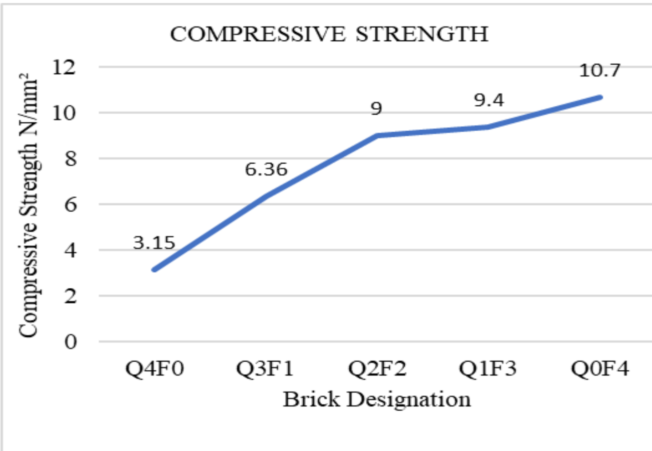

Fig. 6. Compression Test on Brick

As per IS specification the brick brought from market have compressive strength similar to first class brick which can be used for construction purposes. From the above result it is clear that brick with quarry dust 0% and fly ash 40% have maximum compressive strength and can be used for construction work.

B. Water Absorbtion Test

Water absorption is an important test on brick specimen. Table-3 shows the effects of water absorption test for different brick and these values are compared with bricks available in markets.

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TABLE 3. WATER ABSORBTION OF BRICKS

SI No.	BRICK DESIGNATION	WATER ABSORPTION (%)
1	Brick specimen with quarry dust 40% fly ash 0% (Q4F0)	18.57
2	Brick specimen with quarry dust 30% fly ash 10% (Q3F1)	17.09
3	Brick specimen with quarry dust 20% fly ash 20% (Q2F2)	15.88
4	Brick specimen with quarry dust 10% fly ash 30% (Q1F3)	12.47
5	Brick specimen with quarry dust 0% fly ash 40% (Q0F4)	10.68

From the above table a graph is plotted for water absorption of brick various percentage of quarry dust and fly ash.

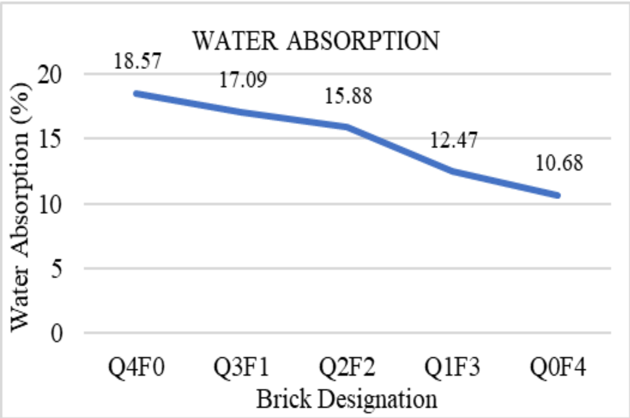

Fig. 7. Water Absorbtiom Test on Brick

As per IS specification, for first class bricks the water absorption should be less than15%. The brick made with 0% to 10% quarry dust and 30% to 40% fly ash have the value less than 15%. So they can be used for construction works.

C. Efflorescence Test

Table 4 shows the observations for efflorescence test. From these results it is find that there is no efflorescence observed for bricks. So these bricks can be used for construction works.

TABLE 4. EFFLORESCENCE OF BRICKS

SI No.	BRICK DESIGNATION	EFFLORESCENCE
1	Brick specimen with quarry dust 40% fly ash 0% (Q4F0)	Nil
2	Brick specimen with quarry dust 30% fly ash 10% (Q3F1)	Nil
3	Brick specimen with quarry dust 20% fly ash 20% (Q2F2)	Nil
4	Brick specimen with quarry dust 10% fly ash 30% (Q1F3)	Nil
5	Brick specimen with quarry dust 0% fly ash 0% (Q0F4)	Nil

D. Hardness Test

Table 5 shows the results of hardness test on brick. Hardnessis tested using nails. From this test all bricks are hard. And they can be used for construction purpose.

TABLE 5. HARDNESS OF BRICKS

SI No.	BRICK DESIGNATION	HARDNESS
1	Brick specimen with quarry dust 40% fly ash 0% (Q4F0)	Hard
2	Brick specimen with quarry dust 30% fly ash 10% (Q3F1)	Hard
3	Brick specimen with quarry dust 20% fly ash 20% (Q2F2)	Hard
4	Brick specimen with quarry dust 10% fly ash 30% (Q1F3)	Hard
5	Brick specimen with quarry dust 0% fly ash 0% (Q0F4)	Hard

VI. CONCLUSION

Production of bricks using alkali-activated technology from industrial wastes such as fly ash and quarry dust shows a sustainable and alternative to conventional bricks. By varying the percentage of these waste materials, different properties of the bricks such as compressive strength, water absorption, efflorescence, were observed and is compared with locally available bricks. The results indicate that alkali-activated bricks exhibit comparable or high strength while significantly reducing environmental impact by utilizing industrial by products. Additionally, the reduction in clay usage and firing processes makes these bricks a cost-effective and energy-efficient solution.

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