PRODUCTION OF ECO-BRICK FROM INDUSTRIAL WASTES

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Abstract - *Production of eco-friendly bricks from industrial wastes has been investigated in this project. A partial replacement of clay is obtained by adding of industrial wastes like waste water treatment (WWT) sludge, and ash with the admixtures of lime and NaOH. By using these admixtures alkali activation process is occurred and a chemical reaction takes place between alumino-sililicate materials and the alkali activator. The product formed after this reaction is the alumino-silicate hydrate gel. They have cementing and binding properties. So in this method of brick manufacturing process, there is no burning process is needed. And the cost of casting can be reduced. By the utilization of industrial wastes and the exclusion of kiln burning, this method is an environmental friendly. A sustainable method of construction is obtained by this technique.*

Key Words: **bricks, sludge, Boiler ash, alkali-activation technology, compressive strength, water absorption**

1. INTRODUCTION

Waste materials generated from many industries, treatment plants etc. are create a major environmental problem. The prime objective of the waste management is to diminish the amount of unwanted materials and to prevent potential health and environmental hazards. The wastes generated around the industries are difficult to dispose. The conventional methods of waste disposal like incineration, land filling, dumping to the water resources is not suitable to the environment. They create pollution on that area. So a suitable method of waste disposal is an essential thing. For this, reuse the waste materials from industries to the construction of other materials in a sustainable manner is a best method.

House is a dream for every person, but the cost of housing is high and which is not easy for an average people. To address this situation, study on the low cost building material is essential. Brick are building components composed of inorganic nonmetallic materials. Therefore the sludge and boiler ash developed from the different treatment plants and with some admixtures like lime (CaO) and sodium hydroxide (NaOH) as alkaline activator are suitable for the brick manufacturing as a partial replacement of soil. The cost of making bricks is reducing by using these materials and which limit the problems of industries for the disposal of wastes generated. This is also reducing the environmental problems like CO2 emissions by the un- burnt process and unlimited use of top fertile soil.

1.1 Objective of the work

- To limit extraction of top fertile soil
- To reduce the construction cost and develop a carbon neutral building material
- To determine a sustainable method of waste disposal by utilization of the wastes in brick making process
- To compare the durability, efficiency, strength and other characteristics of the eco brick with available types of bricks
- To limit the harmful gas emissions while burning

1.2 Scope of the work

- It reduces the contamination of wastes near the treatment and boiler plants
- It reduces the pollution of environment
- The brick is used as a building material
- Cost effective construction is provided
- Energy saving is practiced
- Sustainable development of the building

2. METHODOLOGY

2.1 Raw Materials Collection

The raw materials for the production of brick are collected from various sites. They are clay soil, sludge, boiler ash, lime, sodium hydroxide, water etc.

2.1.1 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. Because, these soils have sufficient strength and cohesion property. The soil is taken from the wall- tech brick site at Areacode.

2.1.2 Sludge

Sludge is a byproduct of all treatment plants. The disposal of sludge is a facing problem of the industries. The conventional disposal methods like, incineration, land filling, dumping to water resources is harmful to the environment.

For this study, the sludge is collected from the different sewage treatment plants in Malappuram. This sludge is an aerobic sludge with darkish colour.

Fig -1: Sludge

2.1.3 Boiler Ash

Boiler ash is the bottom ash, which is a part of non-combustible product of the firing process. This is get from power plant, boiler, furnace, incinerator etc. They are grey colour powdered form. For this research, the boiler ash is collected from the paper mill located at Kavanoor, in Malappuram district.

Fig -2: Sieved Boiler Ash, Soil and Sludge

2.1.4 Admixtures

Lime and NaOH are used as admixtures. By using these admixtures alkali activation process is occurred and a chemical reaction takes place between alumino-silicate materials and the alkali activator.

2.2 Casting process

2.2.1 Preparation of the Raw Materials

In this step the soil is excavated and then laid on leveled ground. Then the soil is cleaned by removing impurities such as vegetation matter, stones or pebbles etc. After removing impurities it is provided to weather for few days. Then after drying they are powdered and sieved through 300 μm sieve. Sludge, ash etc. are also dried, powdered and sieved in similar manner, before mixing.

2.2.2 Mixing

All the raw materials with required proportions are mixed together with adding sufficient amount of water to get uniform mixture. Then the mixture is kept for 2 to 4 hours. After that they are again mixed by adding water. The mixing was done manually. The table -1 shows the amount of each material taken in percentage.

Table -1: Percentage of Raw materials added

Brick	Clay %	Sludge %	Boiler ash %	Lime %	NaOH %
1	80	10	6	3	1
2	70	15	9	4	2
3	60	20	12	5	3
4	50	25	15	6	4
5	40	30	18	7	5

2.2.3 Moulding

After mixing the materials will be pressed into the mould and then bricks are placed on wooden pallets and will be kept as it is for two days. Before filling, the mould should be cleaned, oiled with sand along the sides to easy unmoulding. The mould used for this study is the wooden mould with size 19 x 9 x 9 cm.

2.2.4 Curing

After removing the mould, the bricks are transported in to an open space and they are cured for 10 to 14 days. Curing is

done for the complete setting of the brick. The water for curing should be free from impurities.

2.2.5 Drying

The bricks are allowed to dry till they are left with 5 to 7 percent moisture content. The drying period usually varies from 7 to 10 days. Then they are oven dried. This is maintained in oven for 100 to 150 degree Celsius for 24 to 48 hours.

Fig -3: Casted Bricks

2.3 Tests Performed

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

2.3.1 Compressive Strength Test

Place the specimen prepared with flat faces horizontal and mortar filled faces upwards between two sheets and carefully centered between plates of testing machine. It is ensured that the load is at uniformly. Then apply a load at a rate of 14 N/mm2 (or 140 kgf/cm^2) per minute till failure occurs. Note the maximum load at breaking and repeat the procedure for getting concordant value.

$$\text{Compressive strength in N/mm2} = \frac{\text{Maximum load at failure in N}}{\text{Area of the bed space in mm}^2}$$

2.3.2 Water Absorption Test

The absorption test is the type of test conducted on bricks to determine the moisture absorbed by the bricks when subjected to extreme conditions. The absorption test can be used as an indicator of the durability properties of bricks such as quality, degree of burning and behaviour of bricks in weathering.

Water absorption by the brick specimen is given by the formula,

$$W = \frac{M_2 - M_1}{M_1} \times 100$$

2.3.3 Hardness Test

The hardness of bricks generally implies the resistance of bricks to scratch. 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.

2.3.4 Soundness Test

Soundness Test A soundness test on bricks is carried out to determine the nature of bricks when subjected to sudden impact. For this test two bricks are taken out of stack of bricks. The bricks are then crash against each other. If it emits a clear metallic ringing sound; the brick is of good quality.

2.3.5 Impact Test

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

2.3.6 Efflorescence Test

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

2.3.7 Shape and Size Test

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

3. RESULTS AND DISCUSSION

Different types of tests are carried out for determining the performance of eco-brick. And these results are compared to the performance of locally available bricks.

3.1 Results of Tests on Brick

The tests on bricks are done by using three bricks for an experiment and an average value is calculated. The tests performed on bricks are:

3.1.1 Compressive Strength Test

Table -2 gives the compressive strength test values of casted brick specimens with varying percentages of clay, sludge, ash, lime, NaOH etc.

Table-2: Compressive strength of various brick specimen

SL NO.	BRICK DESIGNATION	CRUSHING STRENGTH (N/mm^2)
1.	Brick specimen with100% clay	3.0
2.	Brick specimen with 80% clay	3.5
3.	Brick specimen with 70% clay	6.2
4.	Brick specimen with 60% clay	10.8
5.	Brick specimen with 50% clay	12.4
6.	Brick specimen with 40% clay	12.0

The bricks available in the market have a compressive strength of different values. The ordinary brick made by clay have a compressive strength of 13N/mm2 while tested. And the Auto-claved Aerated Concrete (AAC) blocks have a compressive strength of 4.65 N/mm2. So by comparing these values eco bricks have higher compressive strength than AAC blocks and nearer to the ordinary bricks.

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

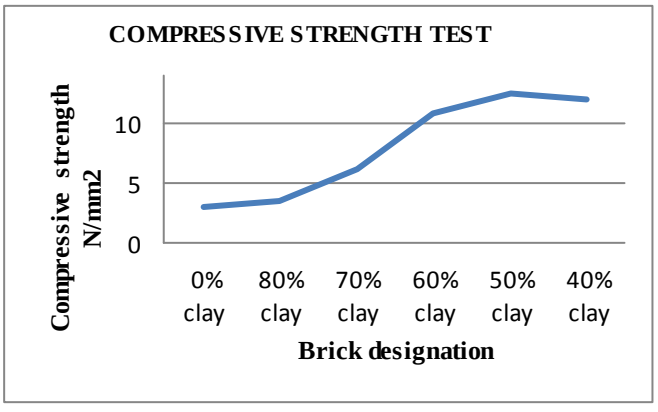

Chart -1: Compression Test on Brick

Chart-1 shows the variation of compressive strength values on brick having varying clay percentage with industrial wastes. In this test the casted specimen of brick shows an increasing pattern up to brick with 50% of replacement of clay.

As per IS specification the brick brought from market have compressive strength similar to first class brick and having a class designation of 12.5. These can be used for construction purposes. From the above result it is clear that brick with 50 % clay have maximum compressive strength and is used for construction work.

3.1.2 Water Absorption Test

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

Table-3 Water absorption of various brick specimen

SL NO.	BRICK DESIGNATION	WATER ABSORPTION (%)
1.	Brick specimen with100% clay	22.81
2.	Brick specimen with 80% clay	20.70
3.	Brick specimen with 70% clay	20.13
4.	Brick specimen with 60% clay	17.26
5.	Brick specimen with 50% clay	12.71
6.	Brick specimen with 40% clay	10.98

From the above table a graph is plotted for water absorption of brick various percentage of clay and industrial wastes.

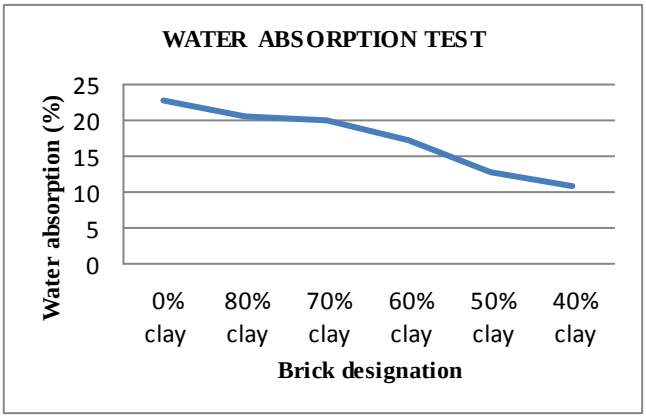

Chart -2: Water Absorption Test on Brick

Chart -2 shows the variation of water absorption on different classes of brick. From these results, it shows that maximum water absorption is at 0% and the value is decreasing with increasing the waste materials. The ordinary brick have water absorption of 14.25%.

As per IS specification, for first class bricks the water absorption should be less than15%. The brick made with 50% and 40% clays have the value less than 15%. So they can be used for construction works.

3.1.3 Efflorescence Test

Table-4 shows the observations for efflorescence test. From these results it is find that a slight efflorescence is observed for more than 50 % waste materials used. So these bricks are only used for minor works.

Table -4 Efflorescence of various brick specimen

SL NO.	BRICK DESIGNATION	EFFLORESCENCE
1.	Brick specimen with100% clay	Nil
2.	Brick specimen with 80% clay	Nil
3.	Brick specimen with 70% clay	Nil
4.	Brick specimen with 60% clay	Nil
5.	Brick specimen with 50% clay	Nil
6.	Brick specimen with 40% clay	Slight

3.1.4 Hardness Test

Table -5 shows the results of hardness test on casted brick specimen. By using the finger nail the hardness is tested. From these test all bricks are hard. And they can be used for construction works.

Table -5 Hardness of various brick specimen

SL NO.	BRICK DESIGNATION	HARDNESS
1.	Brick specimen with100% clay	Hard
2.	Brick specimen with 80% clay	Hard
3.	Brick specimen with 70% clay	Hard
4.	Brick specimen with 60% clay	Hard
5.	Brick specimen with 50% clay	Hard
6.	Brick specimen with 40% clay	Hard

CONCLUSION

Eco-friendly brick manufacturing is completely needed to overcome the conservation of non-renewable resources. This project helps to minimize the depletion of top fertile soil of the formable land by utilizing industrial waste. With the use of alkali activation technology, the effect of carbon dioxide emission in to the Environmental was completely reduced. By performing different lab tests on brick specimen each type of brick was different values depending on the percentage of waste materials added. The tests conducted on brick are the compression test, water absorption test, efflorescence test, hardness test, etc. From these tests we can find that 50 % clay and 50 % waste materials are more suitable for making eco-brick. The optimum value is getting for that type of brick. Those types of bricks are come under the first class brick and which is suitable for major construction works.

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