International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.14 No.01, pp 130-139, 2021

An Experimental Study on Effect of Utilization of Industrial Waste By-Products in Preparation of Green Bricks

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Abstract : Now-a-days brick is one of the most common masonry units used as building material in the construction of industry. Hence the huge demand occurred in building material industry especially in the last decade owing to the increasing population. The traditional methods consume 350 million tons of fertile soil and 25 million tons of coal annually. Consequently, it becomes a big issue of environmental concern.
Recycling of waste materials such as fly ash, quarry dust, lime powder, eggshell powder, glass powder, ceramic waste etc.; are alternatives for the raw materials instead of clay and fly ash that may contribute to the preparation of green bricks, exhausting of natural resources, conservation of non- renewable resources, by using waste materials often cause cost reduction, energy-saving and few hazards in the environment. Optimum percentage of waste materials using various combinations of material in the brick like clay and fly ash are studied and their effect on different properties of bricks have been discussed. The parameter studied considered in this study is compressive strength, water absorption and durability of brick.
Keywords : Green Brick, Fly ash, Ceramic waste, Glass powder, Eggshell powder, Quarry dust, lime, Compressive strength, Water absorption.

1. Introduction

In both developed and developing countries, the problem of waste management has already become an issue to be addressed immediately. This problem is compounded by the rapidly increasing amounts of industrial wastes of a complex nature and composition. Enhanced construction activities, shortage of conventional building materials and abundantly available industrial wastes have promoted the production and process development for more sustainable practices(1-19). The rapid increase in the capacity of thermal power generation in India has resulted in the production of a huge quantity of fly ash, which is approximately 90

DOI= http://dx.doi.org/10.20902/IJCTR.2021.140111

million tons per year. The prevailing disposal methods are not free from environmental pollution and ecological imbalance. Large stretches of scarce land, which can be used for shelter, agriculture or some other productive purposes, are being wasted for disposal of fly ash. The waste materials like eggshell powder, quarry dust, lime, ceramic, glass powder, are available in mutual proximity in many regions. This review highlights the effect of waste materials on the brick properties like physical and mechanical Properties. Optimum combination of the materials to produce good quality of brick was studied. The main aim of this project to reduce environmental pollution by industrial wastes. And to increase the strength of the bricks with the waste products and to investigate the compressive strength of the fired clay brick and fly ash bricks to know the physical properties of bricks (1-19).

2. Materials and method

2.1Materials:

The materials used for clay and fly ash bricks are clay, fly ash, glass powder, ceramic powder, lime, quarry dust, egg shell powder.

2.2Fabrication of bricks

The mix proportions of Clay bricks and Fly ash bricks used in this study are given in Table 1 and Table 2.

Table 1. Clay bricks Mix Proportion

Trial no.	Clay and silt	Fly ash	Ceramic powder	Glass powder	lime
1	100%	0%	0%	0%	0%
2	90%	4%	1%	1%	4%
3	80%	8%	2%	2%	8%
4	70%	12%	3%	3%	12%
5	60%	16%	4%	4%	16%
6	50%	20%	5%	5%	20%

Table 2 Fly ash bricks Mix Proportion

Trial no.	Fly Ash & Gypsum	Glass Powder	Eggshell Powder	Quarry Dust	Lime
1	**100%**	**0%**	**0%**	**0%**	**0%**
2	**90%**	**1%**	**2%**	**2%**	**5%**
3	**80%**	**2%**	**4%**	**4%**	**10%**
4	**70%**	**3%**	**6%**	**6%**	**15%**
5	**60%**	**4%**	**8%**	**8%**	**20%**
6	**50%**	**5%**	**10%**	**10%**	**25%**

2.3 Methodology for Bricks:

The methodology of green bricks are given in figure1.

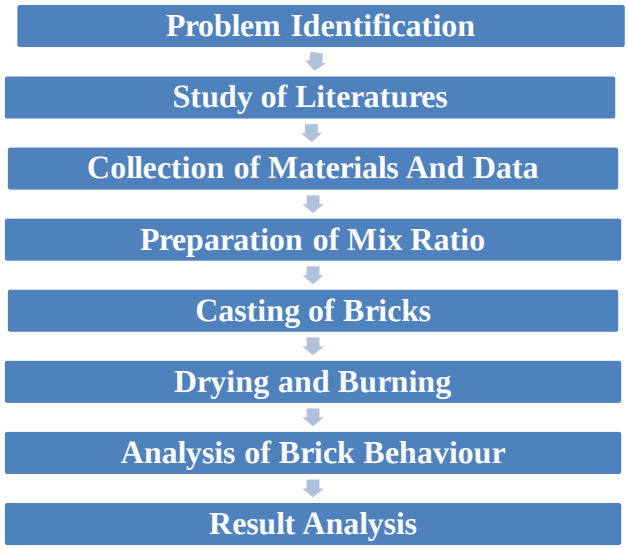


Figure.1 Methodology of Green Bricks

3. Experimental Study

3.1 Tests conducted on Clay and fly ash bricks

3.1.1 Compressive strength (As per IS 3495 part 1)

The compressive strength of bricks is determined by the specimen is placed on the platform by the face of 190 x 90 mm. After placing the specimen on the platform the oil pumping unit is closed and then the motor is started for loading on the brick. The load is applied to the brick specimen. The reading on the dial gauge is noted for further calculations.

3.1.2. Water absorption (As per IS 3495 part 2)

Immerse completely dried specimen in clean water at a temperature of 27 f 2°C for 24 hours. Remove the specimen and wipe out any traces of water with a damp cloth and weigh the specimen. Complete the weighing 3 minutes after the specimen has been removed from the water. Water absorption shall not be more than 20 percent by weight up to class 12'5 and 15 percent by weight for higher classes.

3.1.3. Hardness

In this test, a scratch is made on a brick surface with the help of a fingernail. If no impression is left on the surface, brick is treated as to be sufficiently hard.

3.1.4. Soundness

Two bricks are taken, one in each hand, and they are struck with each other lightly. A brick of good quality should not break and a clear ringing sound should be produced.

3.1.5. Efflorescence

This test should be conducted in a well-ventilated room. The brick is placed vertically in a dish 30 cm x 20 cm approximately in size with 2.5 cm immersed in distilled water. The whole water is allowed to be

absorbed by the brick and evaporated through it. After the bricks appear dry, a similar quantity of water is placed in the dish, and the water is allowed to evaporate as before.

The brick is to be examined after the second evaporation and reported as follows:

- Nil: When there is no perceptible deposit of salt
- Slight: When not more than 10% of the area of brick is covered with salt
- Moderate: When there is heavy deposit covering 50% of the area of the brick but unaccompanied by powdering or flaking of the surface.
- Heavy: When there is heavy deposit covering more than 50% of the area of the brick accompanied by powdering or flaking of the surface.
- Serious: When there is a heavy deposit of salts accompanied by powdering and/or flaking of the surface and this deposition tends to increase in the repeated wetting of the specimen.

Bricks for general construction should not have more than slight to moderate efflorescence.

3.1.6. Structure

A brick is broken and its structure is examined. It should be homogeneous, compact, and free from any defects such as holes, lumps, etc.

4. Experimental program

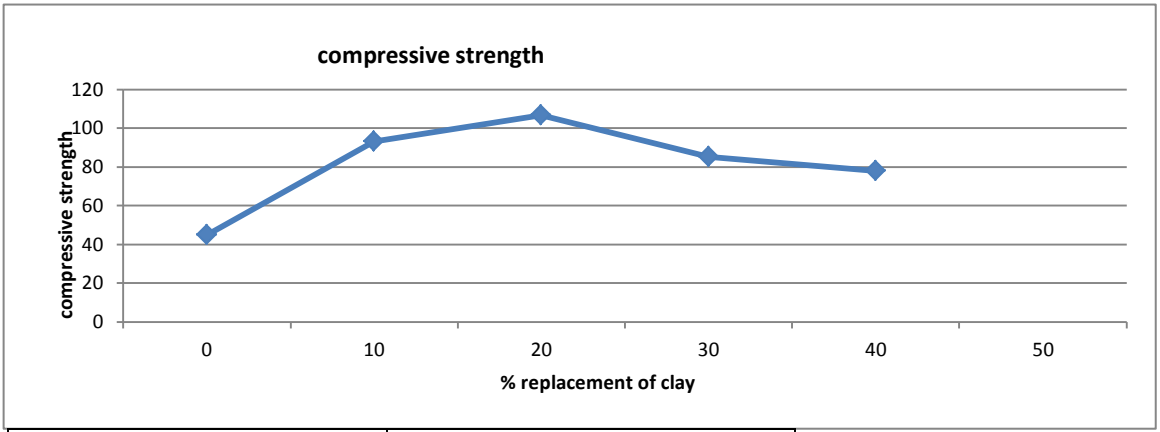
4.1. Compressive strength

For clay bricks: The compression test is done with the help of a compression testing machine. The compressive strength is obtained by applying a crushing load on the bricks. As per IS:3495-Part 1-1992, removed unevenness observed in the bed faces to provide two smooth and parallel faces by grinding(Figure.2). The test results (Table.3 and Fig.3) are as follows-

Fig 2 Compressive Strength Test

Table 3 compressive strength of clay bricks

Trail No.	Compressive strength Kg/Cm^2
1	45.016
2	92.99
3	106.52



4	85.105
5	78.02
6	69.92

Fig 3. Compressive Strength Vs % Replacement of Clay

For fly ash bricks :

The compressive strength of fly ash brick is three times greater than the normal clay brick. The fly ash brick has a compressive strength of 10-12 N/mm². Bricks to be used for different works should not have compressive strength less than as mentioned above. The universal testing machine is used for testing the compressive strength of bricks. After the curing period gets over bricks are kept for testing. To test the specimens the bricks are placed in the calibrated Compression testing machine of capacity 3000 KN applied a load uniform at the rate of 2.9 KN/min. The load at failure is the maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine (table.4 and figure.4).

Table 4 Compressive strength of fly ash bricks

Trial No.	7 Days(N/mm^2)	14 Days(N/mm^2)	28 Days(N/mm^2)
1	1.81	4.43	7.97
2	1.44	6.08	9.98
3	2.22	6.8	10.34
4	3.03	5.97	10.04
5	3.12	4.5	11.14
6	4.21	3.67	9.28

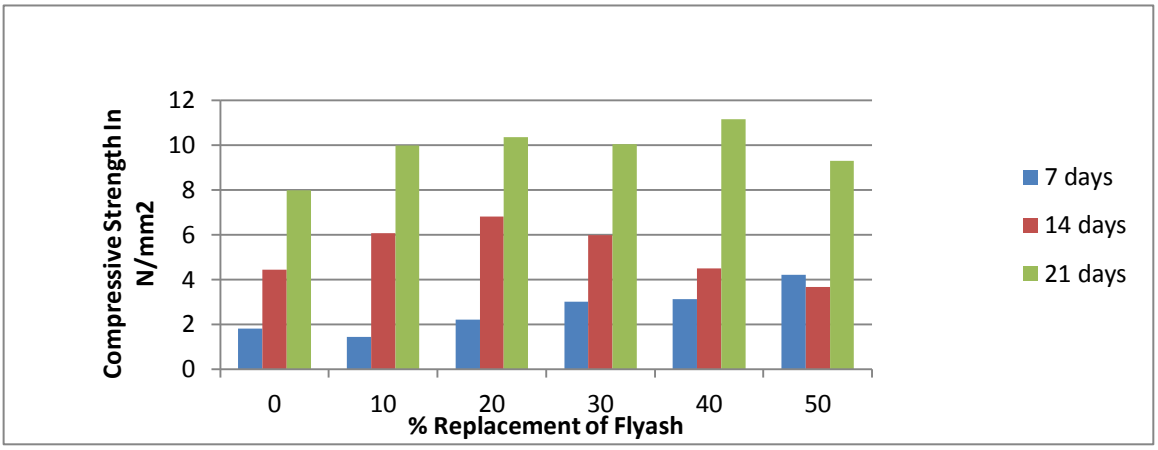


Fig 4 Variation of Compressive Strength with Percentage Replacement of Fly Ash

4.2. Water Absorption

The brick samples are taken and then soaked in fresh portable water for a time period of 24 hours (Figure.5). The results are reported in table 5 and table 6.

Fig 5 Water Absorption Test

Table 5 Water absorption of clay bricks

S.No	Water Absorption (%)
1	10.43
2	16.63
3	13.0
4	12.20
5	18.38
6	12.99

Table 6 water absorption of fly ash bricks

S.No	Water Absorption (%)
1	12.6
2	13.3
3	15.1
4	15.6
5	15.7
6	16.2

4.3. Hardness

The brick samples are scratched with the finger nail; there was no scratch mark on the brick(Figure 6).

Fig 6 Hardness Test

4.4. Soundness

After striking the bricks did not break and clinging sound was obtained (figure.7).

Figure7 Soundness Test

4.5. Efflorescence

There is a slight efflorescence (when not more than 10% of area of brick is covered with salt.

4.6. Structure

A brick was taken randomly and broken into two pieces there was no structural defect in the bricks.

5. Results and Discussion

5.1. Compressive strength

The crushing strength of clay bricks is found to be 7.804 N/mm2 and fly ash bricks are found to be 7.45 N/mm2. Thus there is a net 20.36% increase is crushing strength for clay bricks as a part to fly ash bricks (Figure.7).

Table 7 Comparison of Compressive Strength Values of Bricks

Type of bricks	Average crushing strength	% Increase in average crushing strength
Clay Bricks	7.804	-
Fly Ash Bricks	9.8	20.36

5.2. Water Absorption

The average absorbed moisture content of clay bricks is found to be 13.94% and for fly ash bricks are found to be 14.75%. Thus, there is a net 5.49% decrease in moisture absorbed for clay bricks as a part to fly ash bricks (Figure 8).

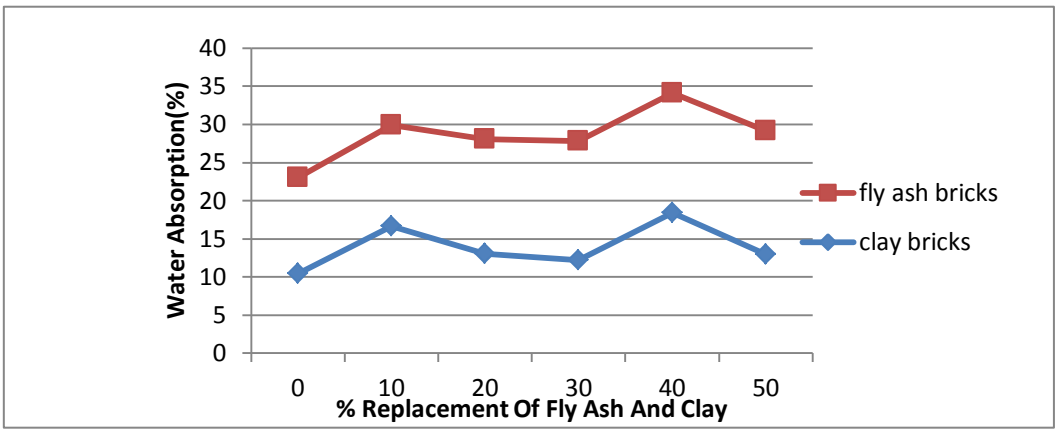


Fig 8 Water Absorption Result

5.3. Hardness Test:

The hardness test for clay bricks and fly ash bricks were conducted, test brick was taken and scratch was made on bricks surface with the help of fingernail and found no impression after scratching in both the cases.

5.4. Efflorescence Test:

The Efflorescence test for clay bricks and fly ash bricks were conducted and the results were compared in which Grey or white deposits are slight in normal bricks and less than 10% on the surface area in fly ash bricks.

5.5. Structure Test:

The Shape and Size test is done for clay and fly ash bricks to examine the structure of a brick when the brick is broken and it was found both types of bricks are free from any defects such as holes, lumps, etc. but fly ash bricks are compact and homogeneous.

6. Conclusion

- Based on the view of strength and durability characteristics of these green bricks, it can be used in the place where the fly ash, lime, quarry dust, eggshell powder, glass powder available in more quantity to solve the consequences of pollution and at the same time to build houses economically by utilizing industrial wastes.
- The maximum compressive strength of all six proportions in clay bricks obtained for optimal mix percentage of clay-80% fly ash-8% ceramic-2% glass powder-2% lime-8% as 106.52kg/cm2.

- The mechanical properties of fly ash such as compressive strength were studied for different mix proportions, at different curing ages. From the results it was inferred that among the six proportions the maximum optimized compressive strength is obtained for optimal mix percentage of Flyash-60% Lime-20% Quarry dust-8% glass -4/% eggshell powder-8% as 11.14 N/mm2.
- The dimension and the structure test have shown that the brick is hard and there is no defect in the brick.
- Fly Ash Bricks were found to be sufficiently hard as scratching by the fingernail on the surface left no impression on it as compared to normal fly ash bricks.
- The Efflorescence of all bricks tested was found to be slight as white or grey deposits were less than 10% on the surface of the bricks which is almost the same as that in the normal bricks.
- The soundness of the bricks is also good in clay bricks to give a clear ringing sound without breakage. A ringing sound in the Fly ash Bricks was observed to be far better than that in normal bricks.
- Structure of the bricks was found to be compact, homogeneous, and free from any defects like holes, lumps, etc as compared to normal bricks.
- The average absorbed moisture content of clay bricks is found to be 13.94% and for fly ash bricks are found to be 14.75%. Thus, there is a net 5.49% decrease in moisture absorbed for clay bricks as a part to fly ash bricks.
- The crushing strength of clay bricks is found to be 7.804 N/mm^2 and fly ash bricks are found to be 7.45 N/mm2. Then this is 20.36% more than the clay bricks.

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