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An experimental investigation of the use of industrial waste and sewage sludge for the production of bricks

Ritu Daheriya
ritu0daheriya@gmail.com
NRI Institute of Research and Technology, Bhopal, Madhya Pradesh

V V Singh
khatri.rajesh0@gmail.com
NRI Institute of Research and Technology, Bhopal, Madhya Pradesh

ABSTRACT

In many countries, sludge is a serious problem due to its high treatment costs and the risks to the environment and human health. The sludge presents an increasingly difficult problem to cities of all sizes because of the scarcity of suitable disposal sites, increasing labor costs, and environmental concerns. The study investigated the use of sludge incorporated with clay. In this study, bricks were produced with sewage sludge additions ranging from 10, 20, 30, 40 and 50 % by dry weight respectively and compare produce brick with regular brick. After the testing of all the brick samples for the compressive strength it comes to know that bricks made up of sludge up to 10 percent can be used for the construction of all the structures as it has the satisfactory results in the form of the hardness. Also from this investigation, we can solve disposal problem completely and also construct and economical structure with easy designing.

Keywords: *Bricks, Sludge, Waste management, Strength.*

1. INTRODUCTION

As we know the human life is totally dependent upon the natural resources available on the earth, so it is our prime duty to save the natural resources. We can save the Natural resources by recycling, reuse the waste materials. By using waste material after recycling we can save the natural resources. Waste material includes plastics, glasses, construction material, sewage sludge, Fly Ash etc. Most of all the waste products are getting recycled using latest techniques, But Dry sludge is the material which is being used only for the Fertilizer system as manure with any treatment. Dry sludge without any treatment causes soil pollution which can be hazardous to the human health. Otherwise, the Sludge is dumped into the land, which is also a major issue for the environment. Sludge is produced on site by treating the wastewater using a septic tank and Off-site by using Activated sludge system. The primary aim of wastewater treatment is to remove the solid particles present in it. As wastewater contains the organic materials also, which later on converted into the bacterial cells. These solid waste and bacterial cells can be removed by the treatment of wastewater.

In the earlier days, 6000 B.C. bricks were prepared by an ancient method, in which the moist clay was pressed into the rectangular moulds by hand and then let it dry in sun light. To prevent the moist clay from the sticking to the moulds, the moulds were dipped into the water before being filled. After this method, the civilians found that the fired bricks are more favorable as compare to the sun-dried bricks. The fired clay bricks are more durable and weathering resistant. These fired clay bricks were made under the wooden fire which maintained for some days. In nowadays, the bricks are made with the partial or fully replacement of clay soil with the various waste materials like rice husks, sludge, marble dust, tea wastes etc. This paper presents use of dry sludge in the manufacturing of bricks as a raw material or as the partial replacement of the clay soil in the bricks. There are number of experiments have been carried away in many countries for the use of sludge in the bricks.

2. PROBLEM STATEMENT

Keeping in view the huge amount of these waste materials, their disposal problems their use in the production of brick appears a good alternative. Use of these waste materials as replacement of clay for brick production, the present work was undertaken with following objectives:

- To develop a process of brick production using sludge along with fly ash.

- Brick production with different proportion of material and compare its properties with conventional bricks.
- To study the effect of dry sludge on brick properties.
- Techno-economic comparison of the designed brick with traditional brick.

3. MIX DESIGN

There are six different series of mixing ratios were tried. However, the batching proportions of raw materials required to produce brick with nominal dimensions of 20 x 10 x 10 centimeters are shown in below table.

Table 1: Mix Design for Bricks (in %)

% of Sludge	Soil	Sand (Murrum)	Fly Ash	Water
0 %	71	29	0	As per requirements
10 %	52	26	12	
20 %	45	23	12	
30 %	38	20	12	
40 %	31	17	12	
50 %	24	14	12	

4. MAKING OF BRICK

In this work, raw materials namely sludge, Fly Ash, and clay are as the major ingredients. They are mix with each other in proportion as mention in table 4.7 to produce brick. The following steps are taken for making brick.

- First of all raw material with required proportion i.e. sludge and clay are mix together and added water to a sprinkle. And the mixing of material properly it is kept in the same manner for 12 to 16 hours.
- After 12 to 16 hours the mixture is again mixed properly by adding some water. The all the mixing is done manually with hand and feet.
- After mixing the lump of the mix is taken, rolled in sand and slapped into mould. The mould used for this study is metal mould and this mould is empty at drying area where brick is arranged for dry in sunlight.
- When brick is kept in sunlight after every two days they are turned over to facilitate uniform drying and prevent from warping.
- After 8 to 10 days they are ready to be burnt in kiln. The green bricks arranged in kiln and insulation is provided with a mud pack. Fire holes are left to ignite the kiln are later sealed to keep the heat inside.
- This is maintained for a week. After a week kiln is disassembled and brick are sorted according to color. Colour is an indication of the level of burning.

Fig. 1: Making of brick

Fig. 2: Brick ready for testing

5. TEST CONDUCTED ON BRICKS

5.1 COMPRESSIBILITY TEST (AS PER IS-3495(PART-1):1992

To determine the compressive strength of bricks the compressive strength of bricks are obtained by placing the brick on the flat horizontal surface between the plates of the testing machine. The axial load is applied at a uniform rate until the brick gets a failure. The compressive strength of the brick is obtained by using the formula,
Compressive strength=Maximum load at failure/ average area of the surface.

Fig. 3: Compressibility Test

5.2 WATER ABSORPTION TEST (AS PER IS-3495(PART-2):1992

Dry the brick in an oven at a temperature of 105-115°C, cool the brick to the room temperature and it is weighed (M_1). Then immersed the dry brick in water completely at room temperature for 24hrs and remove the brick from the water and wipe out the traces of water with a cloth and the brick is weighed (M_2).
Water absorption= (M_2-M_1)/ (M_1) X100
Where M1 = Dry weight of Sample
M2 = Weight after 24 hrs in water

Fig. 4: Water Absorption test

5.3 EFFLORESCENCE TEST

The efflorescence test of the brick is conducted by placing the end of the brick in the dish and the distilled water is filled up to the depth of 25mm.The whole arrangement is made at the room temperature with the well-ventilated room until all water in the dish is absorbed by the brick and the surface water evaporate. The dish is covered in order to reduce excess evaporation. When the water is absorbed the bricks appeared to be dry, place a similar quantity in the dish allows it to evaporate as made before.

Fig. 5: Efflorescence Test

The efflorescence is obtained after second evaporation is made.
Nil- No observable deposit of efflorescence
Slight-Less than 10 % area of bricks covered a thin deposit of salt.
Moderate-Covering up to 50% area of the brick
Heavy-Covering 50% or more area of the brick

5.4 SOUNDNESS TEST

The two bricks are taken and made struck with each other. Brick of good quality should not break and produce a ringing sound.

5.5 HARDNESS TEST

Scratch is made on the brick surface with the help of finger nail. If no impression on the surface, the brick is sufficiently hard.

5.6 DIMENSIONS TOLERANCE TEST

The test is performed to check whether the bricks are of required dimensions or not. It is completed in the following manner:

Fig. 6: Dimensions tolerance test

6. RESULTS AND DISCUSSIONS

6.1 COMPRESSIBILITY TEST RESULT

The results of the compressive strength test on the brick made from both fly ash and sludge ash mixtures with three trials are shown in fig.5.1 and table 5.1.

Table 2: Compressive strength of bricks

% of Sludge	Avg. compressive strength, N/mm^2
0 %	3.82
10 %	3.58
20 %	3.39
30 %	2.77
40 %	1.76
50 %	1.48

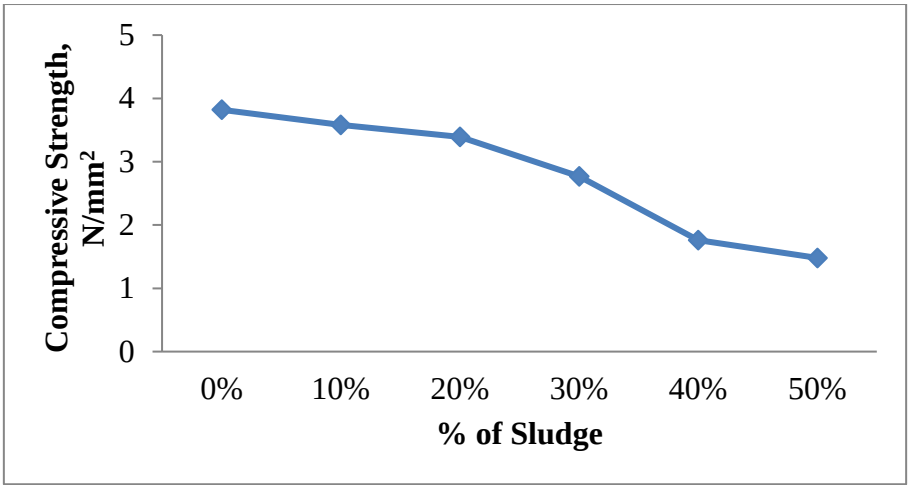

Fig. 7 Variation of compressive strength with % of sludge

Above fig. illustrates the compressive strength of the bricks tested. The addition of sludge is in less amount to the other constituents increased the compressive strength of bricks. Even so, the addition of sludge is more in percentage resulted in a reduction of compressive strength. However, sludge being finer than soils itself, it also may fill the voids within the soil causing a reduction in void space thereby making bricks denser. Hence, the filler action of sludge should increase the compressive strength of bricks. The observed changes in strength should obviously be the sum total of these two effects. Filler action is dominant when percentage sludge added is less than 5%. Further addition of sludge occupies the space only by pushing the coarse sand particles in the soil apart. This will result in a reduction in the friction between sand particles which contribute significantly to the compressive strength of bricks. Therefore, reduction in compressive strength is expected at higher percentages of sludge.

6.2 WATER ABSORPTION TEST OF BRICK

The amount of water absorption is calculated from the following equation.
Amount of water absorbed (%) = (W2-W1)/W1
Where W2 = weight of wet brick in gm,
The W1= weight of dry brick in gm,

Table 3: Results of water absorption test

% of Sludge	Avg. the weight of dry bricks(W_1) (gm)	Avg. the weight of wet bricks(W_2) (gm)	Amount of Water Absorbed (%)
0 %	2766.33	3256.00	17.70
10 %	2509.67	2965.00	18.14
20 %	2130.33	2559.33	20.14
30 %	1854.67	2246.67	21.14
40 %	1575.00	1931.00	22.60
50 %	1291.00	1612.33	24.89

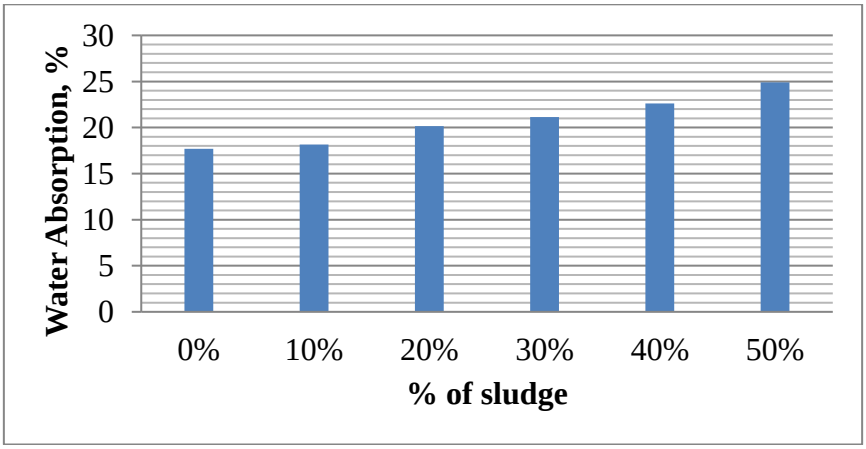

Fig. 8: Water absorption.

6.3 EFFLORESCENCE TEST

The efflorescence test of the brick is conducted by placing the end of the brick in the dish and the distilled water is filled up to the depth of 25mm. The whole arrangement is made at the room temperature with the well-ventilated room until all water in the dish is absorbed by the brick and the surface water evaporate. The dish is covered in order to reduce excess evaporation. When the water is absorbed the bricks appeared to be dry, place a similar quantity in the dish allows it to evaporate as made before.

Table 4: Results of efflorescence test

% of Sludge	Status
0 %	Nil
10 %	Slight
20 %	Moderate
30 %	Moderate
40 %	Heavy
50 %	Serious

6.4 SOUNDNESS TEST

In this test, we have checked the bricks to check its hardness in case of the sudden impact. The two bricks are taken and made struck with each other. Brick of good quality should not break and produce a ringing sound. The ringing sound of brick goes on decreasing with increase in the amount of sludge content. Ringing sound is excellent for original bricks with 0% sludge. Ringing sound is least for 20% of sludge addition bricks. This may be because of increased porosity of the bricks. For bricks, up to 20% sludge addition has good ringing sound is heard.

6.5 HARDNESS TEST

Scratch is made on the brick surface with the help of finger nail. If no impression on the surface, the brick is sufficiently hard. First three sample shows good results and last three samples does not show good results.

6.6 DIMENSIONS TOLERANCE TEST (IS 1077-1970)

The test is performed to check whether the bricks are of required dimensions or not. The results are as follows

Table 5 Dimensions tolerance test

S. No	Trial	Dimensions, cm
1	1	395 X 196 X 191
2	2	392 X 195 X 192
3	3	396 X 195 X 192

7. COST ESTIMATION

After all the tests over the dry sludge bricks, we did an analysis to the cost of the bricks. The analysis of the cost of the brick is done on the basis of the four factors

- Price of clay soil
- Price of sludge
- Price of fly ash
- Labor cost

According to the mix design calculation, we achieved the weight of water, sludge and fly ash for bricks. As the water is largely available in India, its costs can, therefore, be neglected. The current study shows that replacement of soil using sludge can be made as much as 20% (by weight). After the Analysis, we come to know that as the percentage of the sludge in the brick is increasing, the cost of the brick is decreasing in the same way.

Table 6: Cost analysis of brick

% of Sludge	Weight of bricks (gm)	Cost per Brick, Rs
0 %	2766	5.58
10 %	2500	4.52
20 %	2130	4.17
30 %	1850	3.78
40 %	1570	3.45
50 %	1290	3.14

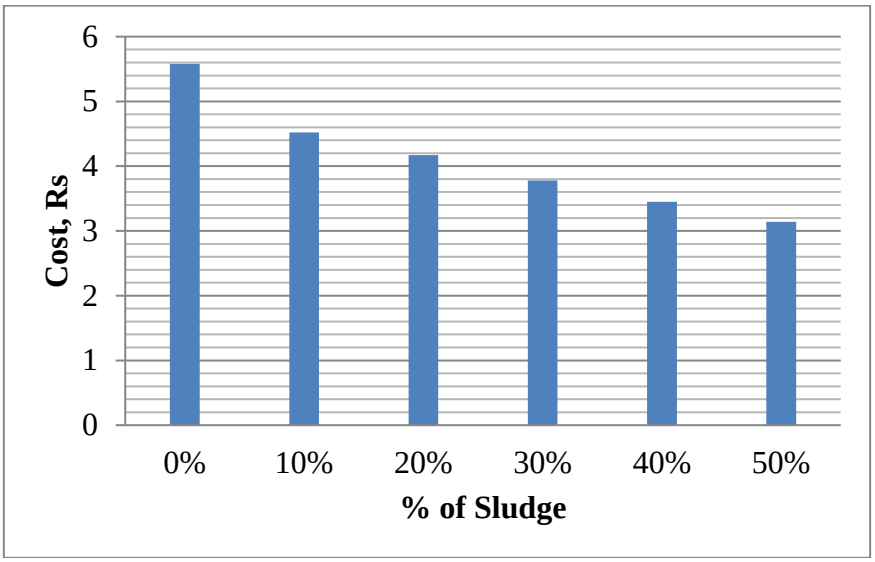

Fig. 9: Variation of cost analysis of brick with % of sludge

On the basis of the analysis done, it comes to know that the cost of the brick is reducing the use of dry sludge in it. According to the Government norms, the sludge can be avail at free of cost including transport charges. Hence the cost of the brick is decreasing with the increase in the quantity of dry sludge in the brick.

8. CONCLUSION

From the study of this work, it has been concluded that dry sludge can be used for the manufacturing of the brick. Hence it is the good alternate to the disposal of the dry sludge.

- After the testing of all the brick samples for the compressive strength it comes to know that bricks made up of sludge up to 10 percent can be used for the construction of all the structures as it has the satisfactory results in the form of the hardness. Compressive strength decreases with the replacement of dry Sludge with ordinary soil as compare to traditional Brick.
- All the samples of the sludge bricks were tested for the Water Absorption test and after the study of observations, it comes to know that the samples have good results. The water absorption increases with the replacement of soil by dry Sludge. A good correlation between all properties tested was observed.
- Ringing sound is excellent for original bricks with 0% sludge. Ringing sound is least for 20% of sludge addition bricks. This may be because of increased porosity of the bricks. For bricks, up to 20% sludge addition has good ringing sound is heard.
- Scratch is made on the brick surface with the help of finger nail. If no impression on the surface, the brick is sufficiently hard. It shows within the limit.
- The efflorescence test of the brick is conducted by placing the end of the brick in the dish and the distilled water is filled up to the depth of 25mm.The whole arrangement is made at the room temperature with the well-ventilated room until all water in the dish is absorbed by the brick and the surface water evaporate. The dish is covered in order to reduce excess evaporation. When the water is absorbed the bricks appeared to be dry, place a similar quantity in the dish allows it to evaporate as made before.
- The test is performed to check whether the bricks are of required dimensions or not. It shows within the limit.
- It utilizes waste material such as sludge & fly ash whose management leads to the expenditure of millions of fund by the Indian government. Hence it is economically feasible.

- Sludge and Fly ash both pollute the environment in a number of ways. Because fly ash and sludge cause several diseases. Since our work utilizes the use of both wastes in making of Brick which is non-harmful in nature. Hence it is environmentally feasible.
- Finally, we recommended with this study sewage-fly ash bricks are not much useful. Because it causes harmful diseases to the labor.

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