# Manufacturing Bricks using Black Cotton Soil

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***Abstract-*** *Due to the continuous rise in the construction industry, the demand for clay bricks is constantly increasing. Hence it is a necessity to find an appropriate alternative for a natural resource that is clay. Black cotton soil can act as an alternative for clay if it is stabilized using fly ash, which is a type of industrial waste. Use of fly ash as a stabilizer not only helps to enhance the properties of black cotton soil but also provide an efficient use of fly ash rather than disposing it and causing pollution. Experimental investigation was carried out on 5 types of mixtures of black cotton soil and fly ash. The percentages of fly ash added to the soil are 10%, 20%, 30%, 40% and 50%. Tests were carried out on soil containing fly ash like liquid limit test, plasticity test, plasticity index and standard proctor test. The bricks prepared from the mixtures were tested for water absorption and compression test respectively. The stabilized black soil bricks in some cases have shown compressive strength values higher than 3.5N/mm2 and water absorption values less than 20%. As these values satisfy the recommendations of IS 1077 code, stabilized black cotton soil bricks made by using fly ash can be used for construction activities.*

***Keywords***- Black Cotton Soil, Fly Ash, Water Absorption, Compression Test.

## I. INTRODUCTION

The common burnt clay brick is one of the oldest building materials, and is being extensively used even today as a leading construction material because of its strength, durability and low cost. Demand for this brick in our country is increasing day-by-day because of the brick's favourable characteristics and brisk construction activities increasing due to an increase in population. Clay that is the main ingredient in brick manufacturing is not readily available anywhere in our country. Hence it is transported to the places requiring its use to manufacture bricks. However, Black cotton soil is available in the Deccan Plateau in Maharashtra, Madhya Pradesh, Gujarat, Tamil Nadu, Andhra Pradesh and Karnataka. Black soil is one of the major soil deposits in India covering an area of about 5.4 lakh square kilometre i.e. 16.6% of the total land area of our country. There are two main drawbacks of the soil, first, it is highly expansive and sticky in nature when it comes in contact with water, and hence it is very difficult to mix and pug the soil, and second, the black soil shrinks heavily and develops large number of wide cracks when allowed to dry, and hence bricks made from black soil lose their dimensional stability and overall integrity. Therefore, in order to overcome the above two major problems, mineral admixtures are commonly added to stabilize the black soil to manufacture bricks. Various mineral admixtures available to stabilize and improve the engineering properties of black soil are: cement, lime, sand, micro silica, slag, fly ash, rice husk ash, groundnut shell ash, bagasse ash, granite waste, marble waste, crusher waste, cement kiln waste, carbide waste, tile waste, ceramic waste, polyvinyl waste, steel mill scale waste. In the present paper, the application of fly ash as an admixture for manufacturing bricks from black cotton soil is studied, by

## II. LITERATURE REVIEW

Patel Adit Kantibhai, Maguwala Shrey Dilipkumar, Patel Dhaval Pareshbhai, Ronak I. Khurana (2018) – They studied wide range of alternatives bricks available in the field of construction with the changing in the raw material for the product. They used black cotton soil as a raw material in bricks & also used some admixture to change the properties of the black cotton soil. This research study describes the feasibility of using black cotton soil as a raw material with some additional stabilizer in the brick production as partial replacement of clay in Indian context.

Dr. T. Sekar (2015)- An experimental investigation has been carried out by him to study the feasibility of producing bricks from locally available black cotton soil (also called black soil) using industrial waste materials such as fly ash and granite waste. A total of 594 numbers of brick specimens of 210x100x70mm size were prepared in three series by combining black soil, fly ash and granite waste in different proportions. The brick specimens were then air dried, baked in kiln and tested for compressive strength, water absorption, efflorescence and weight density as per IS 3495 code procedure. For comparison purpose, 18 numbers of conventional burnt clay bricks, and 18 numbers of pressed type water cured cement fly ash bricks were also tested for the aforesaid brick properties.

Laxmikant Yadu, Rajesh Kumar Tripathi, Dharamveer Singh (October2011)- The paper presented by them defined the laboratory study of black cotton (BC) soil stabilized with fly ash (FA) and rice husk ash (RHA). The soil was stabilized with different percentages of FA (i.e., 5, 8, 10,

12, and 15%) and RHA (i.e., 3, 6, 9 11, 13, and 15%). The Atterberg limits, specific gravity, California bearing ratio (CBR), and unconfined compressive strength (UCS) tests were performed on raw and stabilized soils. The addition of stabilizers (i.e., FA and RHA) increases UCS and CBR values, indicating the improvement in the strength properties of the soil. Based on the CBR and UCS tests, the optimum amount of FA and RHA was found to be as 12% and 9%, respectively.

Amu et al. (2005) -had used (Class- F) fly ash and cement for stabilization of expansive soil. It was found that stabilizing effect of 9% cement and 3% fly ash was better than the stabilizing effect 12% cement.

S. S. Kushwaha, D. Kishan, N. Dindorkar-The paper presented by them explored stabilization of Black cotton soil with Class F Fly Ash (FA) to verify its scope for use as soil sub-base construction material. In this research work, a Laboratory experimental program was planned with Fly ash, variation from 0% to 50% and humid curing period varies from 0 to 28 days. The Atterberg's limits, OMC, MDD, UCS, and CBR of Fly ash stabilized Black cotton found much satisfactory at 20% FA and 28 days curing period. CBR and UCS value get increments of 77.91% and 83.45% respectively. From the physicochemical analysis through X-Ray Diffraction (XRD) and Scanning of Electron Microscope (SEM), it was noticed That enhancement of strength is due to the pozzolanic reaction which causes the formation of new crystalline mineral of Alumino-Silicate-Hydrates (ASH) and Calcium- Alumino-Silicate-Hydrates(CASH) in void space of the matrix.

## III. OBJECTIVE OF THE WORK

1. To make use of industrial waste material like fly ash effectively.
2. To make use of locally available black cotton soil and make the brick manufacturing process economical and efficient.
3. To find a new alternative for clay bricks.
4. To decrease pollution by using fly ash and making the project environment friendly
5. To produce cost effective bricks.

## IV. METHODOLOGY

A literature survey was carried out to study the properties and availability of black cotton soil and fly ash. It is observed that fly ash is produced from the combustion of coal in electric utility or industrial boiler and can be used for stabilization of soil. Fly ash and black cotton soil are available in our country in abundance. We collected these materials required for the manufacturing of bricks and thoroughly researched their engineering properties. The definite proportions of soil and fly ash were selected. Firstly we carried the required soil tests on the selected proportions. Then we moulded bricks from the selected proportions and we carefully carried out the kneading and drying process. We strictly followed the standard drying process for bricks so that the required strength can be attained.

The testing process in our project was carried out in two parts. In the first portion, we performed different standardised tests on the specified samples of soil and fly ash, such as gradation test, liquid limit test, plastic limit test, plasticity index and standard proctor test as per IS 2720 (Part 5) 1985. And in the second portion, we carried out standardised tests on the bricks constructed from the chosen ratios which included water absorption test and compressive strength test as per IS 3495 (Part 1-2) 1992.

## V. MATERIALS TO BE USED

1. Black cotton soil
2. Fly ash
3. Water

**Black cotton soil**

Black cotton soils are inorganic clays of medium to high compressibility and form a major soil group in India. They are characterized by high shrinkage and swelling properties. These soils expand and become sticky during rainy season and contract during the dry season causing deep cracks into the soil. Chemically black soils consist of lime, iron, magnesium, alumina and potash but they lack in nitrogen, phosphorus and organic matter. Because of their capacity to hold water, they are suitable for the cultivation of cotton hence called as black cotton soil (Figure 1).

***Fig. 1:*** *Black cotton soil*

**Fly ash**

Fly ash is a by product from burning pulverized coal in electric power generating plants. During combustion, mineral impurities in the coal (clay, feldspar, quartz, and shale) fuse in suspension and float out of the combustion chamber with the exhaust gases. As the fused material rises, it cools and solidifies into spherical glassy particles called fly ash. The fine powder does resemble Portland cement but it is chemically different. Fly ash chemically reacts with the by-product calcium hydroxide released by the chemical reaction between cement and water to form additional cementitious products that improve many desirable properties of concrete. All fly ashes exhibit cementitious properties to varying degrees depending on the chemical and physical properties of both the fly ash and cement (Figure 2).

***Fig. 2:*** *Fly ash*

**MIX DESIGN**

The mix design was made with different proportions of fly ash and black cotton soil as shown in the Table 1. We took five samples with varying proportions of fly ash. This mix design will give the percentage of fly ash in bricks and then the engineering properties of the bricks will be checked with each proportion of materials (Table 1).

***Table 1:*** *Mix design of fly ash in black cotton soil*

| Sr. No. | Samples | Fly ash (%) |
|---|---|---|
| 1 | S1 | 10 |
| 2 | S2 | 20 |
| 3 | S3 | 30 |
| 4 | S4 | 40 |
| 5 | S5 | 50 |

**VI. TESTS TO BE PERFORMED**

**TESTS ON SOIL**

**1. Gradation Test**

From the gradation curve, the uniformity coefficient (Cu) and coefficient of curvature (Cc) was calculated as follows.
(Cu) :- D60/D10=1.8/0.2= 9

From the graph and IS code soil was concluded as Medium graded soil
Coefficient of curvature (Cc):- [(D30)*2]/ (D10*D60) = [(0.55)*2]/ (0.2*1.8) = 0.84
From the graph and IS code the soil was concluded as poorly graded soil.

**2. Liquid Limit Test**

The liquid limit of raw expansive soil was found 62.55%. Addition of 10% fly ash to expansive soil liquid limit reduces to 58.23% on immediate testing.

Liquid limit reduces further with the increase in the rate of fly ash up to 50% and it was noted to be 44.73% on immediate testing.

***Table 2:*** *Liquid limit result*

| Sr. No. | Mixtures | Liquid Limit (%) | | |
|---|---|---|---|---|
| | | Curing period in days | | |
| | | 0 | 7 | 14 |
| 1 | C alone | 62.55 | - | - |
| 2 | C+10FA | 58.23 | 58.45 | 58.65 |
| 3 | C+20FA | 54.47 | 54.61 | 54.96 |
| 4 | C+30FA | 51.28 | 51.39 | 51.48 |
| 5 | C+40FA | 47.47 | 47.62 | 47.75 |
| 6 | C+50FA | 44.73 | 44.85 | 44.97 |

**3. Plastic Limit Test**

Soil alone - The plastic limit of raw black cotton soil was reported as 32.33%.

Soil with fly-ash - With the addition of 10% fly ash to black cotton soil, the plastic limit reduces to 29.64% on immediate testing. Further plastic limit of expansive soil continuously decreases with an increase in the portion of fly ash up to 50%.

***Table 3:*** *Plastic limit test result*

| Sr. No. | Mixtures | Plastic limit % | | |
|---|---|---|---|---|
| | | Curing period in days | | |
| | | 0 | 7 | 14 |
| 1 | C alone | 32.33 | - | - |
| 2 | C+10FA | 33.64 | 33.73 | 33.87 |
| 3 | C+20FA | 35.54 | 35.78 | 35.93 |
| 4 | C+30FA | 36.57 | 36.65 | 36.85 |
| 5 | C+40FA | 35.93 | 36.24 | 36.53 |
| 6 | C+50FA | 34.34 | 34.56 | 34.75 |

**4. Plasticity Index Test**

Soil alone - Plastic limit of raw black cotton soil was reported as 30.4%.

Soil with fly ash – With the addition of 10% fly ash to black cotton soil the plasticity index obtained 24.59%.

***Table 4:*** *Plasticity index*

| Sr. No. | Mixtures | Plastic limit % | | |
|---|---|---|---|---|
| | | Curing period in days | | |
| | | 0 | 7 | 14 |
| 1 | C alone | 30.4 | - | - |
| 2 | C+10FA | 24.59 | 24.72 | 24.78 |
| 3 | C+20FA | 18.93 | 18.83 | 19.03 |
| 4 | C+30FA | 14.71 | 14.74 | 14.63 |
| 5 | C+40FA | 11.54 | 11.38 | 11.22 |
| 6 | C+50FA | 10.39 | 10.29 | 10.22 |

**5. Standard Proctor Test**

Soil alone - The Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of black cotton soil, reported were 15.50kN/m3 and 23.50% respectively.

Soil with fly ash - Addition of 10% to 20% fly ash to black cotton soil MDD marginally increases from 15.84 to 16.45kN/m3 and OMC decreases 21.25% to 17.60% respectively. Further it was noticed that increasing of fly ash to black cotton soil MDD decreases and OMC increases.

***Table 5:*** *Standard proctor test result*

| Sr. No. | Mixtures | Standard Proctor Test | |
|---|---|---|---|
| | | Optimum Moisture Content (%) | Maximum Dry Density ($Kn/m^3$) |
| 1 | C alone | 23.50 | 15.52 |
| 2 | C+10FA | 21.25 | 15.84 |
| 3 | C+20FA | 17.60 | 16.90 |
| 4 | C+30FA | 18.33 | 16.27 |
| 5 | C+40FA | 20.05 | 16.00 |
| 6 | C+50FA | 20.51 | 15.75 |

**TESTS ON MANUFACTURED BRICKS**

**1. Compressive strength test**

Compression testing machine was used for this test. The bricks were placed between the plates of the testing machines and load was applied axially at a uniform rate of 14 N/mm2 per minute till failure occurred. The stabilized black soil bricks in some cases showed compressive strength values higher than 3.5N/mm2.

***Table 6:*** *Compressive strength result*

| Sr. No. | Mixtures | Compressive strength (N/mm2) |
|---|---|---|
| 1 | C+10FA | - |
| 2 | C+20FA | 3.2 |
| 3 | C+30FA | 3.77 |
| 4 | C+40FA | 4.71 |
| 5 | C+50FA | 5.48 |

**2. Water absorption test**

The bricks were dried in a ventilated oven at a temperature of 105 °C to 115°C till it attained substantially constant mass and later cooled. Further, the dried bricks were immersed completely in clean water at a temperature of 27+2°C for 24 hours. All stabilized bricks showed water absorption values of less than 20%.

***Table 7:*** *Water absorption*

| Sr. No. | Mixtures | Water absorption (%) |
|---|---|---|
| 1 | C+10FA | - |
| 2 | C+20FA | 16 |
| 3 | C+30FA | 14 |
| 4 | C+40FA | 13 |
| 5 | C+50FA | 13 |

**VII. CONCLUSION**

Black cotton soil bricks stabilized using fly ash is a green alternative to normal clay bricks having high compressive strength and low water absorption. Fly ash is an industrial waste material and effective utilization of this waste converts it into a useful product besides saving natural resources. Hence, fly ash waste stabilized black soil bricks stand as a promising alternative to conventional clay and can be manufactured on large-scale wherever black soil and fly ash are available in plenty.

It also helps make use of locally available black cotton soil which is only used for farming purposes. It makes an optimum use of black cotton soil as well as fly ash. It is a very economical and environmental process

In short, the paper shows that it is possible to manufacture good quality bricks from locally available black soil using industrial waste material either fly ash.

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