# ENGINEERING PROPERTIES OF CLAY BRICKS WITH USE OF FLY ASH

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## Abstract

*Mixing various properties of fly ash in clay material (5-50% by weight, in ratio of dry fly ash to wet clay, at a step of 5% each) this will from 16 bricks of each proportion have been manufactured. The manufacturing process uses techniques and equipment similar to those used in clay brick factories. The bricks produced were up to 10.60% lighter than clay bricks. The bricks manufactured from fly ash possessed compressive strength more than 5 N/mm2 which is more than normal clay bricks. This exceeds some of the best of load carrying clay bricks and is several times better than acceptable commercially available common clay bricks. Other important characteristics of the fly ash bricks have been evaluated. These included water absorption capacity, compressive strength and Efflorescence test. Fly ash bricks absorb less quantity of water which is under I.S. requirement. Fly ash-clay bricks give nil efflorescence. The values of these characteristics for fly ash bricks are excellent and have exceeded those pertaining to clay bricks. Moreover, fly ash bricks have been produced with a naturally occurring reddish colour similar to that of normal clay bricks. The new bricks and process have been given the name Fly ash Bricks. This work presents the results of testing and the advantages gained by this type of bricks over conventional clay bricks.*

***Keywords:*** *Clay bricks, Compressive strength, Fly ash*

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## 1. INTRODUCTION

### 1.1 Background

Fly ash is one of the numerous substances that cause air, water and soil pollution. It disrupts ecological cycles and set off environmental hazards. It also contains trace amounts of toxic metals which may have negative effect on human health, plants and the land where the fly ash decomposed and not reused. The disposal of this waste material is a matter of great concern from the environmental and ecological point of view. So, it is very necessary to utilize the huge quantity of fly ash.

The ever increasing volume of fly ash quantities in the world has not even remotely matched by its utilization. The most important and popular use of fly ash in India has been the partial replacement of Portland cement, Clay and manufacturing of building materials. India shares most of the Western countries in similar methods and traditions as far as residential buildings are concerned. These include bricks as the main constituent. Production of building materials, particularly bricks using fly ash is considered to be one of the solutions to the ever-increasing fly ash disposal problem in the country. It is therefore natural that the brick industry presents an opportunity for the efficient utilization of the vast quantities of fly ash. In this dissertation we made the bricks with use of fly ash and clay. Fly Ash bricks can be extensively used in all building constructional activities similar to that of common burnt clay bricks. The fly ash bricks are comparatively lighter in weight and stronger than common clay bricks. Fly ash is being accumulated as waste material in large quantity near thermal power plants and creating serious environmental pollution problems, its utilization as main raw material in the manufacture of bricks will not only create ample opportunities for its proper and useful disposal but also help in environmental pollution control to a greater extent in the surrounding areas of power plants.

In view of superior quality and eco-friendly nature, and government support the demand for Fly Ash Bricks has picked up. Also 180 billion tones of common burnt clay bricks are consumed annually approximately 340 billion tones of clay- about 5000 acres of top layer of soil dug out for bricks manufacture, soil erosion, emission from coal burning or fire woods which causes deforestation are the serious problems posed by brick industry. The all above problems can be reduced some extent by using fly ash bricks.

### 1.2 Scope and Objective of Dissertation

We believe that fly ash on its own can be an excellent raw material for brick making. This has now been proven so it is taken for the manufacture of bricks from fly ash. The response if the ash to firing temperature at 10000C and beyond can be accurately controlled even in small factories. The potential savings with this approach are many. These are illustrated in the following sections. Savings in production and transportation costs and producing bricks of superior qualities to those of standard clay bricks are in addition to the environmental solution that such venture may bring about. This may lead to save money which is needed to dispose the fly ash.

The objective of present work is to develop bricks with good strength as replacement of clay by fly ash in 5% to 50% to increase utilization of fly ash and to save environment. The objectives of this work are as follows

- The main objective of this project is to study the effect of addition of fly ash in bricks.
- To make the bricks without compromising its strength.
- To protect the environment by disposal of fly ash.

Utilization of fly ash can result not only in reducing the magnitude of the environmental problems, but it is also to exploit fly ash as raw material for value added products (and conserve traditional materials), and for extraction of valuable materials. Use of fly ash in clay bricks saves the huge quantity of soil which is required for making clay bricks and also saves agricultural land.

## 2. EXPERIMENTAL WORK

So, far production of Flash Bricks has been performed in the laboratory. This has been repeated successfully many times and the testing has produced consistent results. But we tried to make bricks in the field where we can get water and clay easily. There are several techniques for manufacturing construction bricks from fly ash, producing a wide variety of products. One type of fly ash brick is manufactured by mixing fly ash with an equal amount of clay, then firing in a kiln at about 1000 degrees C. We had taken a frame of size 23 x 11 x 7 cm and casted bricks.

### 2.1 Casting of Bricks

In this dissertation, the bricks made with four different processes. These processes are as follows:

i. In first processes, the bricks made with Clay + Water
ii. In second processes, the bricks made with Clay + Fly ash + Water
iii. In third processes, the bricks made with Clay + Fly ash + Lime + Water
iv. In fourth processes, the bricks made with Clay + Fly ash +Sugarcane Pulp (BAKAS) + Water
   - In first process, made the bricks with 100% clay.
   - In second process, measure the weight of clay bricks and accordingly added 5-50% by weight, in ratio of dry fly ash to wet clay, at a step of 5% each.
   - Similarly, in third process we accordingly added 5-50% by weight, in ratio of dry fly ash + lime to wet clay, at a step of 5% each.
   - Similarly, in fourth process we accordingly added 5-25% by weight, in ratio of dry fly ash + Sugarcane Pulp (BAKAS) to wet clay, at a step of 5% each.

In this study compared the fly ash - clay bricks with normal Clay, Fly Ash-Lime, Fly Ash Bakas bricks

**Table -1:** Fly Ash-Clay Brick Samples

| Bricks Sample | No. of Bricks | % of Fly Ash by weight | Weight of Fly Ash (Kg) | % of Sand by weight | Weight of Sand (Kg) |
|---|---|---|---|---|---|
| A | 16 | 0 | 0 | 100 | 40 |
| B1 | 16 | 5 | 2 | 95 | 38 |
| B2 | 16 | 10 | 4 | 90 | 36 |
| B3 | 16 | 15 | 6 | 85 | 34 |
| B4 | 16 | 20 | 8 | 80 | 32 |
| B5 | 16 | 25 | 10 | 75 | 30 |
| B6 | 16 | 30 | 12 | 70 | 28 |
| B7 | 16 | 35 | 14 | 65 | 26 |
| B8 | 16 | 40 | 16 | 60 | 24 |
| B9 | 16 | 45 | 18 | 55 | 22 |
| B10 | 16 | 50 | 20 | 50 | 20 |

**Table -2:** Lime-Fly Ash-Clay Brick Samples

| Bricks Sample | No. of Bricks | % of Fly Ash by weight | Weight of Fly Ash (Kg) | % of Sand by weight | Weight of Sand (Kg) | % of Lime by weight | Weight of Lime (Kg) |
|---|---|---|---|---|---|---|---|
| C1 | 16 | 2.5 | 1 | 95 | 38 | 2.5 | 1 |
| C2 | 16 | 5.0 | 2 | 90 | 27.0 | 5.0 | 2 |
| C3 | 16 | 7.5 | 3 | 85 | 25.5 | 7.5 | 3 |
| C4 | 16 | 10.0 | 4 | 80 | 24.0 | 10.0 | 4 |
| C5 | 16 | 12.5 | 5 | 75 | 22.5 | 12.5 | 5 |
| C6 | 16 | 15.0 | 6 | 70 | 21.0 | 15.0 | 6 |
| C7 | 16 | 17.5 | 7 | 65 | 19.5 | 17.5 | 7 |
| C8 | 16 | 20.0 | 8 | 60 | 18.0 | 20.0 | 8 |
| C9 | 16 | 22.5 | 9 | 55 | 16.5 | 22.5 | 9 |
| C10 | 16 | 25.0 | 10 | 50 | 15.0 | 25.0 | 10 |

**Table -3:** Fly Ash-Bakas-Clay Brick Samples

| Bricks Sample | No. of Bricks | % of Fly Ash by weight | Weight of Fly Ash (Kg) | % of Sand by weight | Weight of Sand (Kg) | % of Bakas by weight | Weight of Bakas (Kg) |
|---|---|---|---|---|---|---|---|
| D1 | 16 | 2.5 | 1 | 95 | 38 | 2.5 | 1 |
| D2 | 16 | 5.0 | 2 | 90 | 27.0 | 5.0 | 2 |
| D3 | 16 | 7.5 | 3 | 85 | 25.5 | 7.5 | 3 |
| D4 | 16 | 10.0 | 4 | 80 | 24.0 | 10.0 | 4 |
| D5 | 16 | 12.5 | 5 | 75 | 22.5 | 12.5 | 5 |

### 2.2 Testing of Bricks

A series of test were performed on Flash Bricks in order to compare their qualities as load bearing bricks with those made from clay. The Bureau of Indian Standards 12894 & 13757 – 1993 were applied in all the tests reported here. Commercially available bricks were tested and compared to the results from Fly ash Bricks.

i. Compressive Strength
   - Dry Compressive Strength of Bricks.
   - Wet Compressive Strength of Bricks.

ii. Water Absorption
   - 24-Hour Immersion Cold Water Test
   - 5-Hour Boiling Water Test

iii. Efflorescence Test

## 3. RESULTS AND DISCUSSION

### 3.1 Compressive Strength

**Table -3:** Testing Dry Compressive Strength of Fly Ash-Clay Bricks

| Bricks Sample | Average Compressive Strength (N/mm2) |
|---|---|
| A | 4.348 |
| B1 | 4.150 |
| B2 | 4.427 |
| B3 | 5.020 |
| B4 | 3.874 |
| B5 | 3.083 |
| B6 | 2.213 |
| B7 | 1.858 |
| B8 | 1.304 |
| B9 | 0.949 |
| B10 | 0.830 |

**Table -4:** Testing Wet Compressive Strength of Fly Ash-Lime-Clay Bricks

| Bricks Sample | Average Compressive Strength (N/mm2) |
|---|---|
| A | 3.162 |
| B1 | 3.281 |
| B2 | 3.597 |
| B3 | 5.099 |
| B4 | 3.123 |
| B5 | 2.490 |
| B6 | 2.292 |
| B7 | 2.095 |
| B8 | 1.739 |
| B9 | 1.067 |
| B10 | 0.711 |

**Table -5:** Testing Dry Compressive Strength of Fly Ash-Lime-Clay Bricks

| Bricks Sample | Average Compressive Strength (N/mm2) |
|---|---|
| C1 | 3.123 |
| C2 | 3.202 |
| C3 | 3.241 |
| C4 | 2.253 |
| C5 | 1.700 |
| C6 | 1.423 |
| C7 | 1.265 |
| C8 | 0.870 |
| C9 | 0.632 |
| C10 | 0.395 |

**Table -6:** Testing Wet Compressive Strength of Fly Ash-Lime-Clay Bricks

| Bricks Sample | Average Compressive Strength (N/mm2) |
|---|---|
| C1 | 3.162 |
| C2 | 3.2O2 |
| C3 | 3.083 |
| C4 | 2.055 |
| C5 | 1.779 |
| C6 | 1.225 |
| C7 | 0.790 |
| C8 | 0.514 |
| C9 | 0.395 |
| C10 | 0.277 |

**Table -7:** Testing Dry Compressive Strength of Fly Ash-Bakas-Clay Bricks

| Bricks Sample | Average Compressive Strength (N/mm2) |
|---|---|
| D1 | 3.320 |
| D2 | 2.885 |
| D3 | 2.411 |
| D4 | 1.937 |
| D5 | 1.344 |

**Table -8:** Testing Wet Compressive Strength of Fly Ash-Bakas-Clay Bricks

| Bricks Sample | Average Compressive Strength (N/mm2) |
|---|---|
| D1 | 3.399 |
| D2 | 3.004 |
| D3 | 2.292 |
| D4 | 1.660 |
| D5 | 1.146 |

## 3.2 Water Absorption Test

### 3.2.1 24-Hour Immersion Cold Water Test

**Table -9:** Water Absorption Capacity of Fly Ash-Clay Bricks

| Bricks Sample | Percentage of water absorbed (%) | Class of bricks |
|---|---|---|
| A | 21.67 | II$^{nd}$ |
| B1 | 21.02 | II$^{nd}$ |
| B2 | 20.11 | II$^{nd}$ |
| B3 | 19.53 | I$^{st}$ |
| B4 | 22.10 | III$^{rd}$ |
| B5 | 24.75 | III$^{rd}$ |
| B6 | 25.73 | |
| B7 | 26.22 | |
| B8 | 28.21 | |
| B9 | 27.47 | |
| B10 | 26.51 | |

**Table -10:** Water Absorption Capacity of Lime-Fly Ash-Clay Bricks

| Bricks Sample | Percentage of water absorbed (%) | Class of bricks |
|---|---|---|
| C1 | 20.25 | II$^{nd}$ |
| C2 | 20.95 | II$^{nd}$ |
| C3 | 22.17 | III$^{rd}$ |
| C4 | 21.51 | II$^{nd}$ |
| C5 | 22.56 | III$^{rd}$ |
| C6 | 23.18 | III$^{rd}$ |
| C7 | 24.49 | III$^{rd}$ |
| C8 | 24.84 | III$^{rd}$ |
| C9 | 25.34 | |
| C10 | 22.35 | III$^{rd}$ |

**Table -11:** Water Absorption Capacity of Fly Ash-Bakas-Clay Bricks

| Bricks Sample | Percentage of water absorbed (%) | Class of bricks |
|---|---|---|
| D1 | 20.31 | II$^{nd}$ |
| D2 | 21.04 | II$^{nd}$ |
| D3 | 22.02 | III$^{rd}$ |
| D4 | 22.30 | III$^{rd}$ |
| D5 | 22.69 | III$^{rd}$ |

### 3.2.2 5-Hour Boiling Water Test

**Table -12:** Water Absorption Capacity of Fly Ash-Clay Brick

| Bricks Sample | Percentage of water absorbed (%) | Class of bricks |
|---|---|---|
| A | 23.43 | III$^{rd}$ |
| B1 | 22.92 | III$^{rd}$ |
| B2 | 23.33 | III$^{rd}$ |
| B3 | 21.21 | II$^{nd}$ |
| B4 | 23.52 | III$^{rd}$ |
| B5 | 25.87 | |
| B6 | 27.61 | |
| B7 | 28.34 | |
| B8 | 29.33 | |
| B9 | 28.05 | |
| B10 | 29.22 | |

**Table -13:** Water Absorption Capacity of Fly Ash-Bakas-Clay Bricks

| Bricks Sample | Percentage of water absorbed (%) | Class of bricks |
|---|---|---|
| D1 | 21.43 | II$^{nd}$ |
| D2 | 22.52 | III$^{rd}$ |
| D3 | 23.71 | III$^{rd}$ |
| D4 | 24.08 | III$^{rd}$ |
| D5 | 23.95 | III$^{rd}$ |

**Table -14:** Water Absorption Capacity of Fly Ash-Lime-Clay Bricks

| Bricks Sample | Percentage of water absorbed (%) | Class of bricks |
|---|---|---|
| C1 | 21.34 | II$^{nd}$ |
| C2 | 21.88 | II$^{nd}$ |
| C3 | 23.16 | III$^{rd}$ |
| C4 | 23.85 | III$^{rd}$ |
| C5 | 23.88 | III$^{rd}$ |
| C6 | 24.28 | III$^{rd}$ |
| C7 | 25 | III$^{rd}$ |
| C8 | 26.67 | |
| C9 | 28.29 | |
| C10 | 27.04 | |

## 3.3 Efflorescence Test

**Table -15:** Efflorescence for Fly Ash-Clay Brick

| Bricks Sample | Efflorescence (%) |
|---|---|
| A | NIL |
| B1 | NIL |
| B2 | NIL |
| B3 | NIL |
| B4 | NIL |
| B5 | NIL |
| B6 | NIL |
| B7 | NIL |
| B8 | NIL |
| B9 | NIL |
| B10 | NIL |

**Table -16:** Efflorescence for Fly Ash-Lime-Clay Bricks

| Bricks Sample | Efflorescence (%) |
|---|---|
| C1 | SLIGHT |
| C2 | SLIGHT |
| C3 | SLIGHT |
| C4 | SLIGHT |
| C5 | SLIGHT |
| C6 | SLIGHT |
| C7 | SLIGHT |
| C8 | MODERATE |
| C9 | MODERATE |
| C10 | SLIGHT |

**Table -17:** Efflorescence for Fly Ash-Bakas-Clay Bricks

| Bricks Sample | Efflorescence (%) |
|---|---|
| D1 | NIL |
| D2 | NIL |
| D3 | NIL |
| D4 | NIL |
| D5 | NIL |

## 4. CONCLUSIONS

i. The results are indicative of the satisfactory performance of Fly ash Bricks as load bearing elements. This type of bricks uses 15% fly ash mixing with 85% clay. It therefore provides a large venue for the disposal of fly ash in a very efficient, useful and profitable way. This result is better compared to lime bricks and clay bricks.

ii. The mechanical property of Fly ash Bricks has exceeded those of the standard load bearing clay bricks. Notable among these properties are the compressive strength. The wet compressive strength was 40% better than good quality clay bricks and lime bricks.

iii. The water absorption in cold water of fly ash-clay brick of sample B3 which contain 15% fly ash and 85% clay absorb 19.53% of water about its weight which is desirable.

iv. There is evidence that the micro-structural features of the surface of Fly ash Bricks is characterized by a rougher texture than that of clay bricks. This characteristic is believed to be responsible for the increased bond strength with mortar.

v. The edges of Fly ash Bricks are good compared to lime bricks and clay bricks.

vi. The resistance of the bricks to repeated cycles of salt exposure showed zero loss of mass and indicated excellent resistance to sulphate attack. It means nil Efflorescence.

vii. The Fly ash bricks produced were about 10.60% lighter than clay bricks.

viii. The reduction in the weight of bricks results in a great deal of savings to the consumer that results from increased number of units and reduction in the loads on structural elements.

ix. The process of manufacture of Fly ash Bricks indicates clearly that there is much savings to be done during the making of the bricks. These savings arise mainly from the uniformity of the raw material and the reduction in firing time as well as from doing away with whole processes of mining, transporting, mixing and grinding, that are necessary in the case of the clay and shale based bricks.

x. From all the above results it is seen that the sample B3 of fly ash- clay brick is more beneficial than normal clay bricks, fly ash-lime bricks and fly ash-bakas bricks.

### 4.1 Future Scope

i. The use of 100% fly ash can be more economical and may play an important role in light weight structure so, it may be investigated.

ii. Further study can be done on fly ash + cement and compared with fly ash - clay bricks.

iii. The similar work may be done by taking different proportions of ingredients.

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## BIOGRAPHIES

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