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# FLY ASH – AS A MAJOR CONSTITUENT OF BRICKS

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## ABSTRACT

In today fast growing world, it is needed to use waste material as a reuse. We know that recent technologies also used the waste material in a huge quantity day by day because of increasing demand of waste material. So for achieving maximum disposal of wastes and conservation of scarce resources and materials it is very important to use fly ash as a major constituent of bricks.

The fly ash bricks are about (28-29) % lighter than clay bricks. The compressive strength of bricks manufactured from fly ash possessed higher than 18 to 20MPa. Due to this the load carrying capacity of clay bricks available by more than 25% and is several times better than acceptable commercially available common clay bricks. This paper presents the results of testing and the advantages gained by this type of fly ash bricks over conventional clay bricks.

In the present study, the various properties of fly ash bricks with different materials were tested as material testing. The main properties which are studied is, water absorption, hardness, efflorescence, soundness, shape and size, crushing strength and basic compressive strength of the prism using different mortar mixes normally 1: 3, 1: 4 and 1: 5 cement-sand mortars.

In present study we did tests on the basis of using fly ash over conventional bricks, (28-29) percent of top fertile agricultural soil is saved. In many ways we used the fly ash as a beneficial way with its diversity. As compared to the conventional bricks we get more strength by fly ash bricks. Fly ash bricks are also more economical as compare to the conventional bricks. Also, the manufacturing of fly ash brick results in less pollution. Also fly ash bricks are less permeable as compared to clay bricks so the dampness related issues are less as compare to clay bricks.

***Keywords:*** *Fly Ash, Bricks, Properties, Mortar, Conventional*

## I. INTRODUCTION

Burnt clay bricks are being used on a large scale almost throughout India and. but the use of clay in high is harmful to society. The total clay taken out from the agricultural fields per day are over 10,000 Crore bricks works out to be over 300 million tones. So the use of waste products such as fly ash, for making bricks is ecologically and economically advantageous since apart from saving precious top agricultural soil, it meets the social objective of disposing industrial waste i.e. fly ash which otherwise is waste.

The increasing volume of fly ash quantities in the world has not been casually matched by its usage. Environmental perturb have been raised in every parts of the world where coal is the main power generating resource and where bricks are also the main building material. Such perturb have resulted in legislation to oblige the brick industry to incorporate at least 25% by weight of fly ash and or bottom or pond ash in the preparing the mix for brick if the industry is within 50 km from a coal power generation plant. Some successful researchers have been reported where fly ash was incorporated in the mixture at the rate of 20% to 50%.

The response of the ash to firing temperature at 1000 °c and beyond can be accurately controlled even in small factories. So far, few attempts at manufacturing bricks from more than 80 % fly ash have been made.The engineers now believe that fly ash on its own can be an excellent raw material for brick making. This has now been proven and a patent is taken for the manufacture of bricks from fly ash.

## II. LITERATURE REVIEW

There are no. of researchers has been yet on manufacturing of fly ash bricks some of the researches as discuses as.
In 2001,**S C RAGHAVENDRA, R L RAIBAGKAR et al**[20]"Dielectric Properties Of Fly Ash" This paper reports the dielectric properties of fly ash. The sample of fly ash is high value of dielectric constant(104),which can be a best suitable material for capacitor fabrication.

In 2002 **G. Sarangapani *, B. V.Venkatarama Reddy ET al**[4], Structural Characteristics Of Bricks, mortars and masonry Burnt clay bricks are widely used for load bearing masonry in India. This paper deals with the characterization of properties of local low modulus bricks, mortars and masonry using these materials. Bricks are tested to find out the properties such as compressive strength, flexure strength, water absorption, Initial Rate of Absorption (IRA), porosity and pore size and stress — strain relationships. Properties of two cement mortars (1:4 and 1: 6) and three composite mortars (cement soil and cement-lime mortars) were examined for their strength and elastic properties.

In 2006,**Dr. Mei-In (Melissa) Chou1, (Principal Investigator) Dr. Sheng-Fu et al**[3].Manufacturing fired bricks with class fly ash from Illinois basin coals The purpose of this project was to determine if Class F fly ash produced by one of the power generation batch of the Cinergy PSI is a viable raw material for brick production at a nearby brick plant. Also, the environmental feasibility study showed that, similar to the regular commercial brick, the fly ash containing bricks are environmentally safe construction products. Paving bricks with 20 vol% of fly ash and building bricks with up to 40 vol% (about 37wt%) of fly ash were successfully produced in commercial-scale production test runs.

In 2011,**N. Gamage1*, K. Liyanage et al**[16], **"**Overview Of Different categories Of Fly Ash And Their Use As A Building And Construction Material" Fly ash is produced, in massive amount, as a waste material of fossil fuel (coal Combustion) for the electricity generation. Currently about 901 million tones of fly ash produced, worldwide, annually and about 30-40% of this residue is being utilized for various purposes including in cement and concrete production. There are several types of fly ash, including Class F and Class C, generated by burning black coal and brown coal respectively.

## III. MANUFACTURING OF FLY ASH BRICKS

Fly ash, Hydrated lime, Quarry dust and Gypsum are fed into a pan mixer manually where water is added in the required proportion for intimate mixing. The proportion of raw material is generally in the ratio depending upon the quality of raw materials.

| | |
|---|---|
| **62%** | **Fly ash** |
| **8%** | **Lime** |
| **5%** | **Gypsum** |
| **25%** | **Quarry Dust** |

***Components of fly ash bricks***

After mixing, the mix which is now ready is shifted to the hydraulic Brick Making machines. The bricks are carried on wooden pellets to the open area where they are dried and water cured for 14 days. The bricks are tested and sorted before dispatch.

Following are the phases for the making of fly ash bricks
1. Procurement of Raw Material
2. Storage of Raw Material

3. Batch Mining of Raw Material
4. Transferring from pan mixer to automatic brick making machine
5. Drying and Curing

**1. Procurement of Raw Material**
In Procedure of procurement of raw material, raw material is collected from different places like fly ash is taken form thermal plant, fly ash generated during the combustion of coal which is usedfor energy production is one of the industrial by products. Lime/Gypsum from chemical plants is collected. Stone dust from stone crusher. All the material needed for the making of fly ash bricks are procured.

**2. Storage of Raw Material**
Fly ash and stone dust are stored in open yards, duly wetted and covered by the plastic sheets. Lime sludge is dumped in open yards or stored in packets. Gypsum is stored in bags in godowns.

**3. Batch Mining of Raw Material**
In batch mining all the four elements used in making of fly ash bricks i.e sand, lime, gypsum and fly ash are transported to the roller mixture is required quantities were mixing of all the materials takes place is roller mixture.

**4. Mechanized Transfer From Pan Mixer To Automatic Brick Making Machine**
batch mixing of raw materials by mechanical system transfer is done from roller mixture to the vibropress and hydraulic compression as these plays role of automatic brick making machine .

**5. Drying and Curing**
After Bricks are prepared in automatic brick making machine the green bricks are dried up under sun from 24 to 48 hours. The dried up bricks are stacked and subjected for water spray curing once or twice a day for 7 to 21 days depending on ambience. After the procedure is complete brick are ready to dispatch in market.

## IV. EXPERIMENTAL PROGRAME

In the present study, fly ash bricks are subjected to the following tests to find out its suitability for the construction work:

1. Absorption Test
2. Hardness Test
3. Effloresсence Test
4. Soundness Test
5. Shape and Size Test
6. Crushing Strength Test
7. Prism Test

To compare the strength of fly ash bricks with congenital clay bricks, clay bricks are also listed for absorption, hardness, efflorescence and compressive strength.

**1. Absorption Test**
This test is carried out to determine the amount of water absorbed by the brick. When immersed in water for a period of 24 hours it should not, in any case, exceed 20% of weight of dry brick.

**Procedure For Absorption Test**
A brick was taken out it was weighed dry. It was then immersed in water for a period of 24 hours. It was weighed again. The difference in weight we recorded (Refer table 4 .1)

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*Table 4.1:AbsorptionTest*

| 1.**Normal Bricks**: | | | | |
|---|---|---|---|---|
| S.NO | Dry Weight (kg) | Wet weight (kg) | Water absorption (gm) | Water absorption (%) |
| 1. | 3.10 | 3.40 | 300 | 9.67 |
| 2. | 3.22 | 3.60 | 380 | 11.80 |
| 3. | 2.81 | 3.18 | 370 | 11.64 |
| Average | | | | 11.04 |

| 2. **Fly Ash Bricks**: | | | | |
|---|---|---|---|---|
| S.NO | Dry Weight (kg) | Wet weight (kg) | Water absorption (gm) | Water absorption (gm) |
| 1. | 3.20 | 3.49 | 290 | 9.28 |
| 2. | 3.10 | 3.40 | 300 | 9.30 |
| 3. | 3.15 | 3.41 | 260 | 8.19 |
| Average | | | | 8.92 |

## 2. Hardness Test

This test is carried out to see that the brick is sufficiently hard or not. We can judge hardness of the brick by making impression on the surface of the brick with the help of a finger nail.

**Procedure For Hardness Test**

A brick was taken and a scratch was made on bricks surface with the help of finger nail. The impression left on the surface of the brick was seen.

*Table 4.2: Hardness Test*

| Normal Bricks | Fly Ash Bricks |
|---|---|
| No impression after scratching with the help of a finger nail. | No impression after scratching on the surface of brick. |

## 3. Efflorescence Test

This test is conducted for finding out the presence of soluble salts in a brick when it is immersed in water for 24 hours and taken out and allowed to dry in shade. Absence of grey or white deposits on its surface indicates absence of soluble salts. If the white deposits cover about 10%surface, the efflorescence is said to be slight and it is considered as moderate, when the white deposits cover about 50% of surface. If grey or white deposits are found on more than 50% of surface, the efflorescence becomes heavy and it is treated as serious, when such deposits are converted into powdery mass.

**Procedure For Efflorescence Test**

A brick was immersed in water for 24 hours. It was then taken out and allowed to dry in shade. The grey or white deposits on the surface of the brick was seen and checked that efflorescence is slight, moderate or heavy, depending upon the percentage of the surface it covers.

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*Table 4.3: Efflorescence Test*

| Normal Bricks | Fly Ash Bricks |
|---|---|
| Slight to moderate | The grey deposits are less than 10 %. |

**4. Soundness Test**

This sound is carried out to find out that a clear ringing sound is produced or not when the two bricks are struck with each other without breaking any of the two bricks. The procedure of this test is self explanatory.

*Table 4.4: Soundness Test*

| Normal Bricks | Fly Ash Bricks |
|---|---|
| Good | A clear ringing sound produced. |

**5. Shape and Size Test**

This test is done to examine the structure of the brick when the brick is broken. It is seen that the structure of the brick is homogeneous, compact and free from any defects such as holes, lumps etc. or not. Mainly the defects such as holes, lumps should not be there.

*Table 4.5: Shape and Size Test*

| Normal Bricks | Fly Ash Bricks |
|---|---|
| Free from any defects such as holes. | Free from any defects such as hole etc. lumps etc. |

**6. Crushing Strength Test**

This is the main test conducted to test the suitability of the brick for construction work. This test is executed with the help of compression testing machine. A brick is placed in a compression testing machine. It is pressed till it breaks. Then the compression strength of the brick is recorded from meter of the compression testing machine.

**ProcedureFor Crushing Strength Test**

A brick sample in compression testing machine is tested after frog of brick is filled with 1:3 cement sand mortar, after 7 days of curing brick sample is tested. Sample is kept in machine and load is applied till the sample of brick breaks. By calculation the crushing strength was found.

*Table 4.6: Crushing Strength Test Results*

| **Normal Bricks**: | | | | | |
|---|---|---|---|---|---|
| S. No. | Length (mm) | Breadth (mm) | Depth(mm) | Load KN | Crushing Strength ($N/mm^2$) |
| 1. | 230 | 109 | 71 | 219 | 8.74 |
| 2. | 224 | 109 | 70 | 165 | 6.76 |
| 3. | 222 | 107 | 69 | 170 | 7.16 |
| 4. | 219 | 106 | 72 | 220 | 9.48 |
| 5. | 225 | 108 | 74 | 210 | 8.64 |
| 6. | 226 | 107 | 73 | 195 | 8.29 |
| | | | | Average | 8.18 |

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| **Fly Ash Bricks:** | | | | | |
|---|---|---|---|---|---|
| S. No. | Length (mm) | Breadth (mm) | Depth(mm) | Load KN | Crushing Strength ($N/mm^2$) |
| 1. | 225 | 116 | 75 | 395 | 15.31 |
| 2. | 229 | 115 | 74 | 522 | 19.82 |
| 3. | 228 | 114 | 75 | 398 | 15.31 |
| 4. | 226 | 115 | 74 | 609 | 23.43 |
| 5. | 227 | 116 | 75 | 460 | 17.46 |
| 6. | 225 | 115 | 74 | 515 | 19.90 |
| | | | | Average | 18.53 |

## 7. Prism Test:

**Determination Of Compressive Strength Of Masonry By Prism Test:**
When compressive strength of masonry(f'm) is to be established by tests, it shall be done in advance of the construction, using prisms built of similar materials under the same bonding arrangement as for the structure. In building the prisms, moisture content of the units at the time of laying, the consistency of the mortar, the thickness of mortar joints and workmanship shall be the same will be used in the structures. Assembled specimen shall be at least 40 cm height and shall have a height to thickness ratio (h/t) of at least 2 but not more than 5. If the h/t ratio of the prism tested is less then 5 and more then 2, compressive strength values indicated by the tests shall be corrected by multiplying with the factor indicated by Table.

***Table .7: Correction factors for different h/t ratios***

| Ratio of height to thickness (h/t) | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 5.0 |
|---|---|---|---|---|---|---|
| Correction factors for brickwork* | 0.73 | 0.80 | 0.86 | 0.91 | 0.95 | 1.00 |
| Correction factors for blockwork* | 1.00 | ------- | 1.20 | ------- | 1.30 | 1.37 |

*Interpolation is valid for intermediate values.
Prisms are tested after 28 days between sheets of nominal 4 mm plywood, slightly longer than the bed area of the prism, in a testing machine, the upper platform of which is spherically seated. The load shall be evenly distributed over the whole top and bottom surfaces of the specimen and shall be applied at the rate of 350 to 700 kN/m. The load at failure should be recorded.

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**Calculation Of Basic Compressive Stress**

Basic compressive stress of masonry shall be taken to be equal to 0.25 f'm where f'm is the value of compressive strength of masonry as obtained from prism test.

**Procedure For Basic Compressive Stress**

The bricks had approximate length, width and height as 230, 110 and 75 mm respectively. Different grades of mortar (cement sand by volume) used in the study were: 1 : 6(weak), 1 : 4 (medium) and 1 : 3 (strong). Compressive load was applied in displacement control on three brick high masonry prisms using servo-hydraulic actuator. Approximate height of thee-brick high masonry prism with 10 mm thick mortar joints was about 400–410 mm. To record the displacement response acrossmortar joints Epsilon extensometers were used. For the Load and displacement measurements a computer-based data acquisition system is used. IS 1905 – 1987 is used for The compression testing. The Indian masonry code gives some factors to be used in correcting the prism strength of masonry for height-thickness ratio of prism lower than 5.0. For different type of tests, this correction factor comes out to be about 0.95. Generally, three-brick high masonry prisms are tested to obtain the prism strength of masonry, and the correction factors are then used to arrive at compressive strength of masonry (or design strength of masonry) from Indian masonry code (IS: 1905–1987). But here, this factor has not been used, and the results presented here represent the true values as obtained in the tests. Masonry with weak mortar was found to be less stiff than that constructed with the other two grades of mortar.

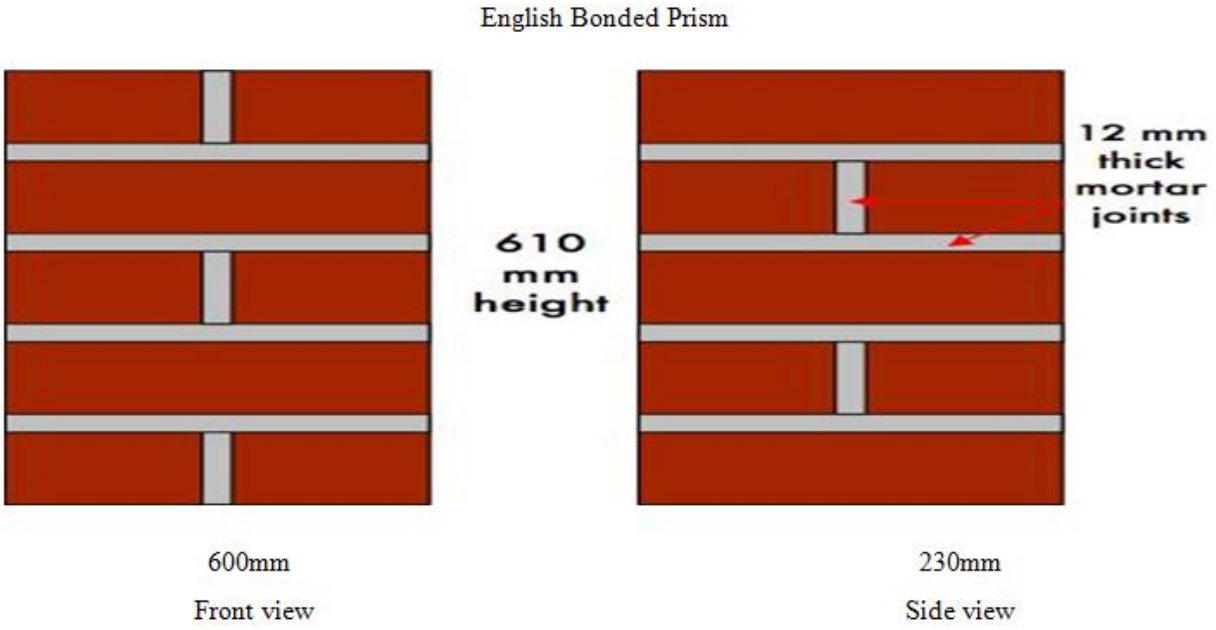


***Figure 4 .1: Typical Size Of Prisms For Compressive Strength Test***

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*4.1 Prism Test for Fly Ash Bricks*

*Table 4.8:Crushing Strength by Prism Test*

| Mortar Type | Prism Size (mm) (width×thick× hight) | h/t | Correction Factor | Failure Load (KN) | Basic Compressive Stress of Fly Ash Bricks MPa | Basic Compressive Stress of Class A Bricks As Per IS: 1905-1987 MPa |
|---|---|---|---|---|---|---|
| 1:3 | 600×230×685 | 3 | 0.86 | 290 | 1.8 | 1.31 |
| 1:4 | 600×230×610 | 2.65 | 0.82 | 264 | 1.56 | 1.19 |
| 1:5 | 600×230×610 | 2.65 | 0.82 | 240 | 1.42 | 1.13 |

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Sample Calculation for basic compressive stress of fly ash bricks:-
Basic Compressive Stress of Prism of Fly Ash Brick masonry
$= (290 \times 10^3 \times 0.86) / (600 \times 230) = 1.8\ N/mm^2$

**Width Of Cracks In Fly Ash Bricks Prisms**

The crack widths were measured at different stages of loading.

***Table 4.9: The maximum crack widths are located in table***

| C : S Mortar | Load (KN) | Max. Crack Width |
|---|---|---|
| 1 : 5 | 60 | 3.5 mm |
| | 180 | 6 mm |
| 1 : 4 | 140 | 1.5 mm |
| | 190 | 2.5 mm |
| 1 : 3 | 180 | 1.5 mm |
| | 210 | 4 mm |

As per the above table 1:5 cement sand mortar prism was tested, It was examined that on applying low load more cracks appeared. With mortar 1:4 Ratio prism load was increased (60 KN - 140 KN) cracks appeared were less as compared with the last one. When using mortar 1:3 Prism load was again increased (140- 180 KN) and cracks were again examined on the increase of high load so at last it can be set that as cement sand mortar ratio increases, prism strength increases, cracks probability decreases.

## V. ANALYSIS OF RESULTS

All these bricks were treated to be sufficiently hard as no impression was left on the surface when a scratch was made on brick surface with the help of finger nail. Absence of grey or white deposits on brick surface indicates absence of soluble salts so efflorescence is said to be slight. These bricks when tested for soundness test were found sufficiently sound because on striking with each other, these brick did not break and a clear ringing sound was produced. When structure of fly ash bricks were examined these are found to be homogeneous and compact.

**1. Absorption Test**
Water absorption test for clay bricks and fly ash bricks was conducted and the result are compared in Table: 4.1

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*Table: 5.1*

| Type of Bricks | % Average Water Absorption | % Decrease Water Absorption |
|---|---|---|
| Clay Bricks | 11.04 | --- |
| Fly Ash Bricks | 8.92 | 18.90 |

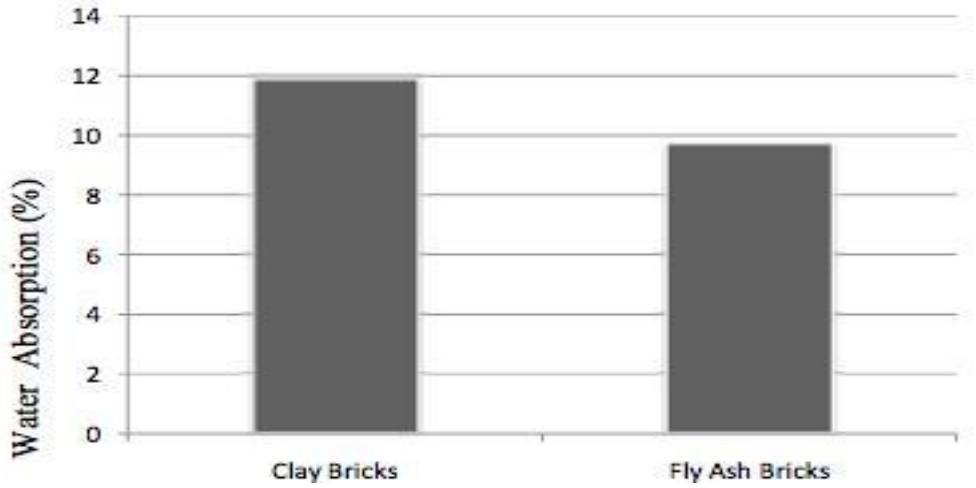


*Figure: 5.1. Water Absorption (%)*

As per the above table, the average absorbed moisture content of clay bricks is found to be 11.93% and for fly ash bricks is found to be 9.77%. Thus there is net 18.10% decrease in moisture absorbed for fly ash bricks as a part to clay bricks.

**2. Hardness Test**

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

**3. Efflorescence Test**

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

**4. Soundness Test**

The Soundness test for clay bricks and fly ash bricks was conducted and the results were compared in which two bricks are struck with each other, It was found that a normal brick shows good results when struck with each other but fly ash bricks show clear ringing sound.

**5. Shape and Size Test**

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

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**6. Crushing Strength Test**

Crushing strength test for clay bricks and fly ash bricks was conducted and the result are compared in Table: 5.2

***Table: 5.2***

| Type of Bricks | Average Crushing Strength ($N/mm^2$) | % Increase Average Crushing Strength |
|---|---|---|
| Class A Clay Bricks | 8.14 | --- |
| Fly Ash Bricks | 18.81 | 56.72 |

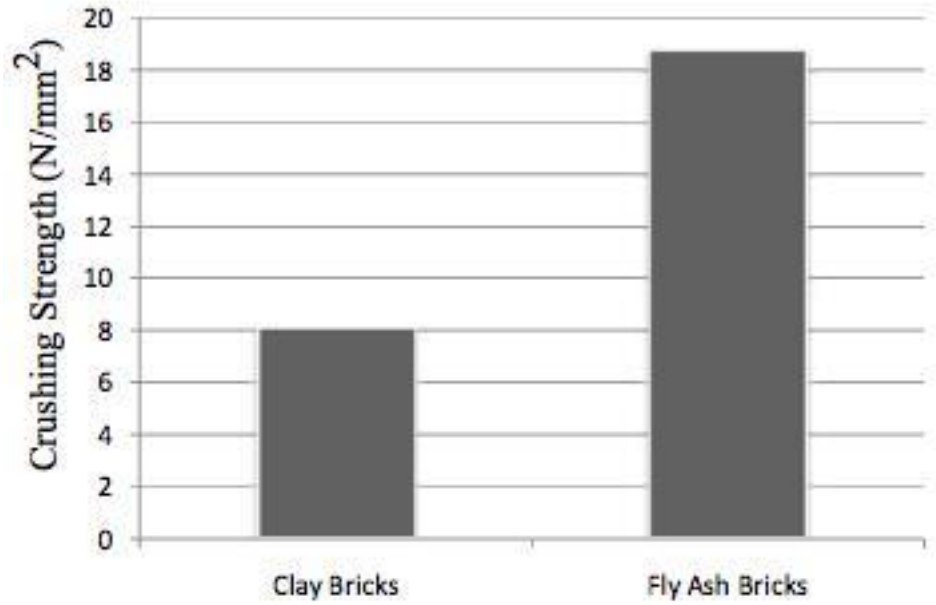


***Figure: 5.2. Crushing Strength ($N/mm^2$)***

As per the above table, the crushing strength of clay bricks is found to be 8.14$N/mm^2$ and for fly ash bricks it is found to be 18.81 $N/mm^2$. Thus there is net 56.71% increment in crushing strength for fly ash bricks as a part to clay bricks.

**7. Prism Test**

Crushing strength test for clay bricks and fly ash bricks was conducted and the result are compared in Table: 5.3, 5.4 and 5.5

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*Table: 5.3 Cement Sand Mortar 1:3*

| Type of Bricks | Average Crushing Strength ($N/mm^2$) | % Increase Average Crushing Strength |
|---|---|---|
| Clay Bricks | 1.31 | --- |
| Fly Ash Bricks | 1.8 | 27.22 |

As per the above table, the crushing strength by prism of clay bricks is foundto be 1.31 $N/mm^2$ and for fly ash bricks is found to be 1.8 $N/mm^2$. Thus there is net 27.22% increase is crushing strength by prism for fly ash bricks as compared to clay bricks.

**Table: 5.4 Cement Sand Mortar 1:4**

| Type of Bricks | Crushing Strength ($N/mm^2$) | % Increase Crushing Strength |
|---|---|---|
| Clay Bricks | 1.19 | --- |
| Fly Ash Bricks | 1.56 | 23.71 |

As per the above table, the crushing strength by prism of clay bricks is found to be 1.19 $N/mm^2$ and for fly ash bricks is found to be 1.56 $N/mm^2$. Thus there is net 23.71% increase is crushing strength by prism for fly ash bricks as compared to clay bricks

*Table: 5.5 Cement Sand Mortar 1:5*

| Type of Bricks | Crushing Strength ($N/mm^2$) | % Increase Crushing Strength |
|---|---|---|
| Clay Bricks | 1.21 | --- |
| Fly Ash Bricks | 1.59 | 23.90 |

As per the above table, the crushing strength by prism of clay bricks is foundto be 1.21 $N/mm^2$ and for fly ash bricks is found to be 1.59 $N/mm^2$. Thus there is net 23.90% increase is crushing strength by prism for fly ash bricks as compared to clay bricks.

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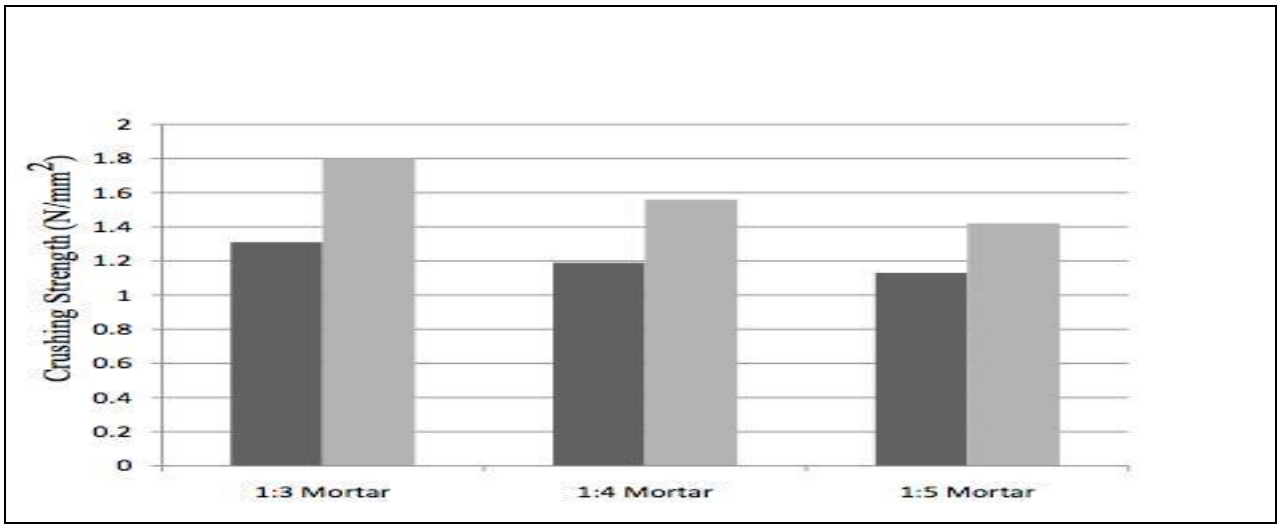
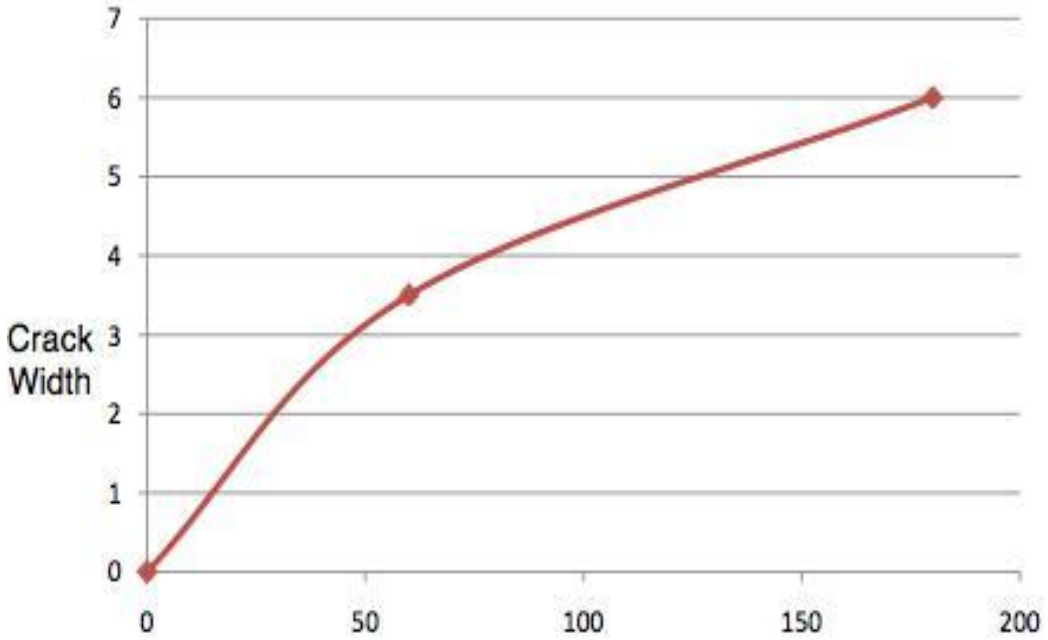



*Figure: 5.3. Crushing Strength By Prisms (N/mm$^2$)*

**Clay Bricks**

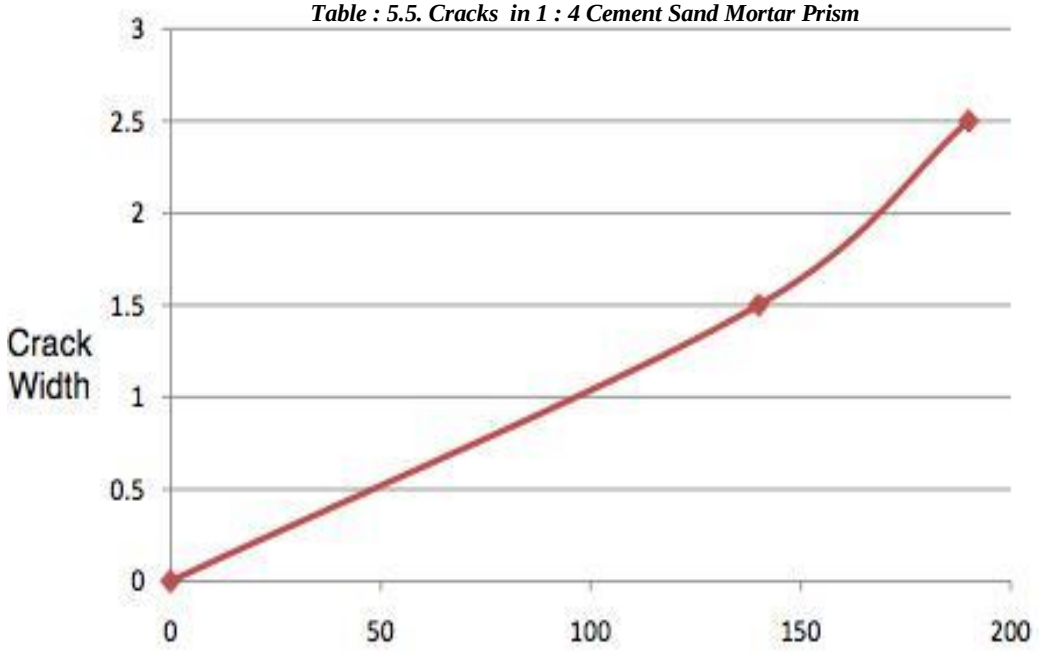
**Fly Ash Bricks**

*Table : 5.4 Cracks in 1 : 5 Cement Sand Mortar Prism*



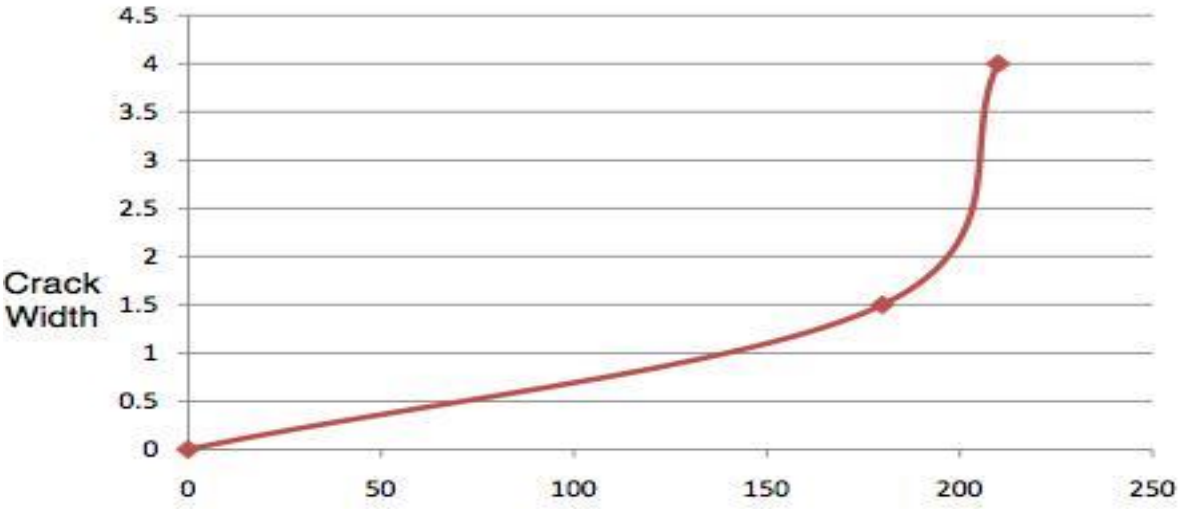
In prism testing of 1:5 cement sand mortar maximum width of crack appeared to be 3.5 mm and average width of crack was 1 mm on applying load of 60 KN . On again applying load crack were measured with the maximum width of 6 mm and average crack width of 2 mm by applying load of 180 KN.Prism of 1:5 cement sand mortar failed on applying load of 240 KN.

***Table : 5.5. Cracks in 1 : 4 Cement Sand Mortar Prism***




In prism testing of 1:4 cement sand mortar maximum width of crack appeared to be 1.5 mm and average width of crack was 1 mm on applying load of 140 KN . On again applying load crack were measured with the maximum width of 2.5 mm and average crack width of 1.5 mm by applying load of 190 KN.Prism of 1:4 cement sand mortar failed on applying load of 264 KN.

**Table : 5.6. Cracks in 1 : 3 Cement Sand Mortar Prism**



In prism testing of 1:3 cement sand mortar maximum width of crack appeared to be 3.5 mm and average width of crack was 1.5 mm on applying load of 180 KN. On again applying load crack were measured with the maximum width of 6 mm and average crack width of 2 mm by applying load of 210 KN.Prism of 1:3 cement sand mortar failed on applying load of 290 KN.

## VI. CONCLUSIONS

In order to know the effect of fly ash on the properties of bricks, the following studies were carried out :
The total number of fly ash bricks tested was more than one hundred fifty. Tests were also conducted on the Clay Bricks in order to compare these bricks with the experimental bricks. And the following properties were studies for fly ash

1. The results are indicative of the satisfactory performance of fly ash Bricks as load bearing elements. These of bricks use 100% fly ash without mixing with clay and shale. It is therefore provides a large venue for the disposal of fly ash in a very efficient, useful and profitable way.
2. Fly Ash Bricks were found to be sufficiently hard as scratching by the finger nail on the surface left no impression on it as compared to normal bricks.
3. The Efflorescence of all bricks tested were found to be slight as while or grey deposits were less than 10% on surface of the bricks which is almost same as that inthe normal bricks.
4. A ringing sound in the Fly ash Bricks was observed to be far better than that in normal bricks.
5. Structure of the bricks was found to be compact, homogeneous and free from any defects like holes, lumps etc as compared to normal bricks.
6. The average absorbed moisture content of clay bricks is found to be 11.93% and for fly ash bricks is found to be 9.77%. Thus there is net 18.10% decrease in moisture absorbed for fly ash bricks as a part to clay bricks.
7. The crushing strength of clay bricks is found to be 8.14 $N/mm^2$ and for fly ash bricks is found to be 18.81 $N/mm^2$. Thus there is net 56.71% increment in crushing strength for fly ash bricks as a part to clay bricks.
8. The crushing strength by prism of clay bricks is found to be 1.31 $N/mm^2$ and for fly ash bricks is found to be 1.8 $N/mm^2$. Thus there is net 27.22% increase is crushing strength by prism for fly ash bricks as compared to clay bricks.
9. The crushing strength by prism of clay bricks is found to be 1.19 $N/mm^2$ and For fly ash bricks is found to be 1.56 $N/mm^2$. Thus there is net 23.71% increase is crushing strength by prism for fly ash bricks as compared to clay bricks.
10. The crushing strength by prism of clay bricks is found to be 1.21 $N/mm^2$ and for fly ash bricks is found to be 1.59 $N/mm^2$. Thus there is net 23.90% increase is crushing strength by prism for fly ash bricks as compared to clay bricks.

## VII. FUTURE SCOPE

Instead of Fly Ash, investigations can be done on waste material such as saw dust, lime sludge, rice husk etc. Thermal conductivity can also be investigated for such type of brick. Work can be extended by using Fly Ash. Fly ash bricks can be used partially with clay so that economically fly ash bricks can be better used. Fly ash bricks can be used partially with rice husk so that bonding with mortar will be stronger. Industrial wastes should be better used in brick making for strengthening purpose and also profitable for cleaning society.

## REFERENCES

1. *Dass. Mohan, "New Substitutes of Bricks", Civil Engineering and Construction, June 1992, PP22.*
2. *Dr. Durgesh C Rail, "Review of design Codes for Masonry Buildings", Department of Civil Engineering, Indian Institute of Technology, Kanpur.*
3. *Dr. Mei-In (Melissa) Chou and Mr. Vinod Patel, "Manufacturing Fired Bricks With Class F Fly Ash From Illinois Basin Coals", Dept. of Natural Resources and Environmental Sciences, University of Illinois Urbana-Champaign IL 61820*
4. *G. Sarangapani*, B. V. Venkatarama Reddy et al, Structural characteristics of bricks, mortars and masonry Journal of Structural Engineering No.29-11 Vol. 29. pp. 101-107*

5. Gupta P. C. and Ray S. C. , "Commercialization of Fly ash", The Indian Concrete Journal vol- 167, Now. 1993, PP 554-560.
6. IS: 101153 - 1982 Guidelines for Utilization and Disposal of Fly ash.
7. IS : 1905-1987 Code of Practice for Structural use of Unreinforced Masonry (Third revision)
8. IS: 2117-1975 Guide for Manufacture of Hand- Made Common Burnt Clay Building Bricks (Second Revision).
9. IS: 3495 (P-I) -1976 Determination of Compressive Strength (Second Revision).
10. IS: 3495 (P-II) -1976 Determination of Water Absorption (Second Revision).