

## **Critical Review on Fly Ash Bricks**

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**Abstract** ---In India, bricks are mainly composed up of clay, and are generally produced in traditional, unorganized small scale industries. Bricks are important building material and about 250 billion bricks are annually produced by the brick industries. Red clay bricks making consumes larger amount of clay which leads to top soil removal and land degradation. Large areas of lands are destroyed every year especially in developing countries due to collection of soil from a depth of about 1 to 2 m from agricultural land. An important step in brick making is firing of bricks in brick kilns which cause serious environmental pollution and health problems. Brick burning largely influence the concentrations of greenhouse gases in the atmosphere. This causes serious air pollution and also workers in brick industries are prone to respiratory diseases, to avoid all this environmental threats brick made of waste that is originated from the waste as a residue from the different industries and factories, this types of bricks is termed as fly ash bricks which is composed by the different materials such as lime, gypsum, sand, fly ash etc. The objective of this paper is to explain about manufacturing of fly ash bricks in present era and advantages of using it as a construction material. In this paper author explain about advantages of fly ash bricks over burnt clay bricks or red bricks and manufacturing process of fly ash brick.

**Keywords:** Fly ash bricks, Manufacturing & Material selection.

### **I. INTRODUCTION**

The requirement of energy for the developing countries in particular area is fulfilled from the combustion of coal. The disposal of the increasing amounts of thermal waste from coal-fired thermal power plants is increasing day by day, this disposal of the thermal waste is termed as *fly ash*, which is composed of the non-combustible mineral portion of coal consumed in a coal fuelled power plant and the powdery waste remained as residue from the various plants and factories. Fly ash is a powdery substance obtained from the dust collectors in the electrical power plants that use coal as fuel. Fly ash bricks is the composition of gypsum, lime, sand, bed waste, fly ash (with composition of silica 40%, alumina 7.8%, magnesium and some amount of mercury) [21]. There are two basic type of fly ash Class C and Class F [1]. Where it is the fine powder formed from the mineral matter in coal, consisting of the non-combustible matter in coal plus a small amount of carbon that remains from incomplete combustion. Due to rise in demands and industries, fly ash is being accumulated as waste material in large quantities near thermal power plants. As the power requirements of the country goes up, the amount of waste produced will also increase enormously creating problems for its safe disposal due to lack of adequate disposal facilities. Its use in the construction industry i.e. (in manufacturing of bricks) will be helpful in its disposal and also help in controlling pollution. Fly ash is supplied free of cost to entrepreneurs. The raw materials are composed in desired proportions in a Pan mixer for 4-5 minutes and compressed. The bricks undergo curing for a minimum of 14 days and are then air dried for 7 days. Strength of these bricks can be engineered by varying the compositions. These 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 as compared to common clay bricks. As an industrial waste, fly ash presents some environmental and storage problems of our country needs approximately 250 billion bricks per year for all kind of construction works, to make 60 billion bricks, 185 million tons of top soil is needed. Ultimately near about 7500 hectares of very fertile land is deliberately eroded to meet the demand of clay bricks for construction every year. This devastating act is slowly killing our environment and we will be left with no fertile land for agriculture in near future, deforestation also occurs in search of soil source for clay brick manufacturing [21]. However, it has been used widely as an excellent mineral additive in the construction industry [2, 3]. The use of fly ash prevents different environmental pollution, and it contributes in reducing need for natural resources. Fly ash is available in different types, such as C and F. The F type has a low Calcium content, and its content of  $\text{SiO}_2 + \text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$  is greater than 70 (ASTM C 618) [4]. It is a finely divided residue resulting from the combustion of powdered coal and collected by electronic precipitators in thermal power plants. Presently in India, approximately 160 million tons of fly ash is produced by thermal power plants every year. The estimation for generation of fly ash as a residue during the year 2031-32 would be expected to be around 900 million tons [5]. Since fly ash is being accumulated as waste material in large quantity near thermal power plants and creating different serious environmental pollution problems, its utilization as main raw material in the manufacture of bricks will not only create sample opportunities for its proper and useful disposal but also help in reduction of environmental pollution control to a greater extent in the surrounding areas of power plants. In view of superior quality and eco-friendly nature the government support the fly Ash Bricks, as in 2014 according to order of 'The Supreme Court Of INDIA' it is illegal to use red burnt clay bricks in the construction activities. About 150 million ash bricks have been manufactured and used in house consumption. All the fly ash bricks manufacturing plant use similar processes called FAL-G Technology by using fly ash, cement/lime and gypsum to

manufacture bricks. These bricks are water cured, thus avoiding the need of firing or steam curing of the bricks [6]. The consumption of earth-based materials as clay, shale and sand in brick production resulted in resource depletion, environmental degradation, and energy consumption. Virgin resources are mined from riverbeds and hillsides to service brick industry leaving mines areas un-reclaimed. Environmental degradation accompanies such mining activities with air pollution and remains after the mines cease operations, leaves scars on the landscape [22].

## **II. JOURNEY FROM BURNT CLAY BRICKS TO ASH BRICKS**

The brick was traditionally produced by mixing the virgin resources, forming the bricks, drying them and then firing them [7]-[8]. The current trend in bricks manufacturing has major emphasis on the use of post-consumer wastes and industrial by-products in the production process. Most of the researches went through enhancing the clay brick quality and properties by mixing the clay with various recycled wastes as foundry sand, granite sawing waste, harbour sediments, sugarcane baggase ash, clay waste and fine waste of boron, sewage sludge, waste glass from structural wall and other different wastes [9]-[10]. Furthermore researches were held in developing bricks from wholly waste materials without exploiting any sort of natural resources, in order to achieve sustainability. They used entirely wastes in bricks making like waste treatment residual, granite waste, paper sludge, straw fibres, waste treatment sludge, fly ash and few other wastes[11]-[12]. The conventional method of bricks making has caused serious environmental contamination represented by the enormous emissions of green house gases (GHG) resulted in unusual climate changes as smog, acid rain and global warming. Furthermore, energy as fuel and electricity showed a drastic consumption during the traditional manufacturing of bricks led to highly economical expenditures. As a result, vast forests are in current deforestation in order to utilize their woods and trees as source of energy in the firing stage of bricks production. Hence, recycling the wastes in the bricks production appears to be viable solution not only to environmental pollution but also economical option to design of green building. However, the chronicle problem of (GHG) and energy consumption has not yet been tackled properly as most of the previous works were mainly focused on recycling the wastes traditionally in the bricks. Several researches addressed the amount of (GHG) emission and their impacts on the context as well as the energy consumption [12]-[13]. Few researches took the initiative in developing eco- friendly bricks in an economical environmental concern [14]-[15].

## **III. METHOD OF MANUFACTURING**

Ash bricks can be prepared by the use of different semi automatic and automatic machines with the use of moulds pre attached in machines, where using of manual moulds in the manufacturing method leads to frequent change in the size of the bricks and may results in the poor exterior quality of the bricks. Approximately every ash bricks manufacturing plant uses machines to produce ash bricks, which led to the use of less labours and makes the cost less of per ash bricks which can be easily afforded by low to high class families. There are 3 different proportion by which fly ash bricks can be prepared which depends on the materials available.

## **IV. PROCESS OF MANUFACTURING**

The bricks produced according to the use of waste material originated from different factories as a residue have been named as Fly Ash Bricks. Essentially the only solid ingredient of the brick is the powdered ash and the main liquid ingredient is water. Other ingredients that so far are commercially protected are only minor in quantities. The process of manufacturing fly ash bricks is based on the reaction of lime with silica of fly ash to form calcium silicate hydrates (C-S-H) which binds the ingredients to form a brick and acts as a bounding material. The quality of bricks obtained is highly dependent on the quality of fly ash [18]. Its process of manufacturing is as follows –

- a) The manufacturing process of brick requires fly ash, sand/stone dust, lime and gypsum to be mixed in appropriate proportion.
- b) Lime and gypsum are first added to the hydraulic mixer machine where it is grinded finely as a dry mixture.
- c) While the mixture is mixed thoroughly and uniformly the grinding of the machine is stopped.
- d) After the above process, the fly ash and the sand stone are taken in the required quantity.
- e) Ash and sand /stone dust are then added into the pan –mixture to form uniform mixture.
- f) When cement is used in place of lime, first fly ash and sand/stone dust is mixed in pan-mixture and then cement is added into pan-mixture to have uniform dry mixture.
- g) Now the mixer machine is made in ON condition and the above mixture is ground uniformly in the dry condition.
- h) After this Water is added into the pan-mixture once the uniform dry mixture of fly ash, sand/stone dust and cement is achieved.
- i) The water content must be added in a required quantity as the mixture must be in a concentration that they should be capable of moulded into the brick.

- j) It is to be carefully noted that the quantity of water must not be more and for per Kg of cement the water content ratio must not exceed 0.6%.
- k) When the quantity of the materials are less they are needed to be transferred through the labours.
- l) When the quantity of the mixture is more, then the process of transferring to the mould could be done by a conveyor belt.
- m) Hydraulic machine consists of three pairs of brick moulds.
- n) Moulds can differ according to the machines available.
- o) After the quantity of the mixture content is transferred to the place of the location of brick mould, it is needed to be filled into the holes provided in the machine which represents the brick mould.
- p) The mould is mostly provided at the circular table which is capable of rotating in clockwise direction.
- q) After the mould is filled with the materials, the table is allowed to rotate in clockwise direction and then it remains under the part of closed portion of the machine.
- r) At that portion the mixture is hydraulically pressed to obtain bricks and then the pressed bricks are pushed outside the brick mould automatically.
- s) Once bricks are taken out from the mould, they are transferred to the Planck
- t) The transferring of the bricks must be carried out carefully as it is possible to get broken due to the pressure applied over it.
- u) When the certain ratios of the bricks are completed for the purpose of reference they are to be noted over the brick.
- v) When the Planck is filled by the bricks then they are to be taken by the Planck lifter for the purpose of air drying process where the bricks are air dried for 2 to 3 days.
- w) Water curing is done for required days and to achieve the required strength [6].

## **V. MATERIALS SELECTION OF INGREDIENTS**

Fly Ash bricks are made of fly ash, lime, gypsum and sand. These can be extensively used in all building constructional activities, the materials that are used in the composition of fly ash bricks along with its sources are as follows :-

### **5.1. Fly Ash**

Fly ash samples are directly collected from Electrostatic Precipitators (ESPs)/chemical industry in gunny bags and transported to the place of manufacturing. Minimum requirement of fly ash for brick manufacturing are

- Loss of ignition should be more Availability of MgO should not be greater than 15%.
- SiO<sub>2</sub> content should not be more Source of ash.
- Ash from thermal power station.
- Ash from coal boiler used in industry for generation for energy.
- Ash from Bagasse boiler used in mostly sugar industry and many other industries which are using Bagasse boiler.

Source of fly ash

In present approx. more than 72% of electricity demand is fulfilled by coal based thermal power plants. These power stations generate nearly 40 million tons of fly ash annually. Fly ash contains Carbon di oxide emitted from thermal power plants, industries using coal as a fuel emits unwanted ash and smoke from which fly ash is produced. In all the power plants and industries, they separate the fly ash by using the cyclone converter. This fly ash is then used as a raw material for manufacturing of bricks.

### **5.2. Lime**

Commercially available chemically pure lime (CaCO<sub>3</sub>) obtained from industry. Lime is important ingredient for manufacturing of fly ash brick, which acts as a binding material; lime should be satisfying the following requirement.

- During lime slaking, it should not attain less than 600°C temperatures and slaking time should not be more than 15 min.
- Availability of CaO should be minimum of 60%.
- MgO content should be maximum of 5%.
- Should be in fine powdered form.

Source of Lime

- It can be obtained from different industry in the form of calcium hydroxide sludge.

### **5.3. Quarry Dust**

It referred to a waste material obtained from pulverizing coarse aggregate which are abundantly available.

Source of quarry dust

- Quarry sand can be collected from any construction site for manufacturing of fly ash bricks.

#### **5.4. Polymer**

TBA (tertiary butyl acrylate)

Polymer used as adhesive material for the manufacturing of fly ash brick. Polymer is one of the wastes generated from the chemical industry.

#### **5.5. Cement**

Cement is constructing material it used as binder in the manufacturing of Brick. Cement can be easily available at construction place.

#### **5.6. Mould**

9"×4"×3" blocks: iron blocks are used for the manufacturing of fly ash cubes.

#### **5.7. Thapi**

Mostly used at construction site but hear this used for the mixing of ingredient in equal manner [18].

### **VI. DRYING AND CURING OF BRICKS**

After making of block, it was kept for sun drying for 24hrs then block is removed and kept for further drying process. Curing means watering the bricks. This process is done after 48 hours of manufacturing of bricks after the process of air and sun drying.

### **VII. TESTING OF BRICKS**

Bricks should be passes through the following tests after 7, 14 & 28 days from curing

#### **7.1. Weight of Dry Block**

Weight of the block has to taken to calculate the moisture content. As per the construction norms the brick should show the 10% moisture content of its weight. If the moisture content satisfies this test it will undergoes the next test.

#### **7.2. Size of Block**

Sizes of brick were checked for the slump test & to calculate the compressive strength of brick. Also through this test the uniformity of the brick was checked in six samples.

#### **7.3. Compressive strength**

Compressive strength of the specimen brick was calculated after 7, 14 & 28 days of curing using the formula as follows,

Compressive strength = Applied Max load x 1000 (N)/Cross sectional Area (mm<sup>2</sup>) [18].

The compressive strength of fly ash brick is three times greater than the normal clay brick. The minimum compressive strength of clay brick is 3.5 N/mm<sup>2</sup>. So as the fly ash brick has compressive strength of 10-12 N/mm<sup>2</sup>. 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 (Kilo Newton) and applied a load uniform at the rate of 2.9 kN/min. The load at failure is the maximum load at which specimen fails to produce any further increase in the indicator reading on the testing machine [19].

#### **7.4. Water absorption**

Fly ash Bricks should not absorb water more than 12% by its weight. The bricks to be tested should be dried in an oven at a temperature of 105°C to 115° C till attains constant weight cool the bricks to room temperature and weight ( $W_1$ ). Immerse completely dried and weighed ( $W_1$ ) brick in clean water for 24 hrs at a temperature of 27±20°C. Remove the bricks and wipe out any traces of water and weigh immediately ( $W_2$ ). Water absorption in % by weight =  $(W_2 - W_1/W_1) \times 100$  [19].

#### **7.5. Efflorescence test**

For this test, brick has to be placed vertically in water with one end immersed. The depth of immersion in water being 2.5 cm, then the whole arrangement should be kept in a warm-well-ventilated room temperature of 20-30° C until all evaporates. When the water in the dish is absorbed by the brick and surplus water evaporates. When the water is completely absorbed and evaporated place similar quantity of water in dish and allows it to absorb and evaporate as before. Examine the brick after this and find out the percentage of white spots to the surface area of brick. If any

difference is observed because of presence of any salt deposit, then the rating is reported as ‘effloresced’. If no difference is noted, the rating is reported as ‘not effloresced’ [19].

**7.6. 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. If the two bricks are not broken after striking with each other and a clear ringing sound is produced, then it means that the bricks are sufficiently sound [20].

**7.7. 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. A brick after undergoing compression test, this test is carried out for both fly ash bricks and as well as burnt clay bricks [20].

**VIII. CONCLUSION**

Fly ash bricks use 50% of fly ash but without using of clay. The mechanical properties of the fly ash bricks have exceeded that those of conventional brick. The study suggests that the fly ash from chemical industry ash/ Electrostatic Precipitators (ESPs) can be effectively used for manufacturing of bricks. Using of fly ash in to manufacturing of brick, helps in minimization of the waste also this method will help to conserve natural resource like air, water, soil. Fly ash is not only to enhance the mechanical properties of brick but the addition of polymer and lime correlate their gape of strength and their use in helping to reduce environmental pollution and save energy. Because of uniformity of the fly ash bricks the quality of construction is improved surface of wall is unique, it can reduced the cost of the plastering after the brick work, layers of the each brick shows the straight line.[18].It is highly fire insulation, due to high strength, practically no breakage during transportation and use, due to its uniform size of bricks mortar required for joints and plaster reduced almost by 50%, it has lower water penetration seepage of water through bricks is considerably reduced. These bricks do not require soaking in water for 24 hours, sprinkling of water before use is enough and on the other side red bricks has many disadvantages such as it has high water absorbing capacity, good conductor of heat and has less compressive strength [21].

**IX. ADVANTAGE OF FLY ASH BRICKS OVER RED BRICKS**

Ash bricks are manufactured by the use of semi auto and automatic machines, in these types of machines there is an arrangement of hydro pressing with a pre attached mould. Approx 10 labours are required to use this machine and the machines outputs 10000 bricks in 8-9 hours. Approx. (depends on the type mould attached in the machine) after the formation 2 curing is done till 15 days to provide strength to bricks. Whereas on the other side, the formation of red clay bricks mould of dimension 20x10x10cm are used. After moulding clay bricks are dried under the sunlight than it is ovened in kilns by the use of cow dung, coal and wood at 1100°C.Than the bricks are left undisturbed for 30 days [21].

**Comparison table between red bricks and fly ash bricks based on the local survey [21]**

*Table 1. Materials used for preparing*

<b>Red bricks</b>	<b>Fly ash bricks</b>
<ul style="list-style-type: none"> <li>• Coal powder</li> <li>• Field soil</li> <li>• Coal factory waste (powder)</li> <li>• Rice husk</li> <li>• Sand</li> </ul>	<ul style="list-style-type: none"> <li>• Gravels</li> <li>• Gypsum</li> <li>• Lime</li> <li>• Sand</li> <li>• Bed waste</li> <li>• Fly ash (with composition of silica 40%, alumina 7.8%, magnesium and some amount of mercury)</li> </ul>

**Table 2. Technique and machine used**

<b>Red bricks</b>	<b>Fly ash bricks</b>
<ul style="list-style-type: none"> <li>In the formation of these bricks mould of dimension 20x10x10cm are used. After moulding clay bricks are dried under the sunlight than it is ovened in kilns by the use of cow dung, coal and wood at 1100C. Than the bricks are left undisturbed for 30 days.</li> </ul>	<ul style="list-style-type: none"> <li>By the use of semi auto and automatic machines, in these types of machines there is an arrangement of hydro pressing with a pre attached mould. Approx 10 labours are required to use this machine and the machines outputs 10000 bricks in 8-9 hours. After the formation 3 curing is done till 15 days to provide strength to bricks.</li> </ul>

**Table 3. Drying of bricks**

<b>Red bricks</b>	<b>Fly ash bricks</b>
<ul style="list-style-type: none"> <li>They are left undisturbed in kilns at high temperature for 20 days and are cured 2 times in 7 days under sunlight.</li> </ul>	<ul style="list-style-type: none"> <li>They are dried in sun light for 3 days and are cured 3 times till 15 days as more the curing more the strength.</li> </ul>

**Table 4. Market of bricks**

<b>Red bricks</b>	<b>Fly ash bricks</b>
<ul style="list-style-type: none"> <li>This type of brick is mostly used in rural areas, due to its less per brick cost and it is easily affordable by low to high class family.</li> </ul>	<ul style="list-style-type: none"> <li>Due to its eco-friendly nature it has a very good value in market but due to its high price it can't be afforded by low class family.</li> </ul>

**Table 5. Demand of bricks**

<b>Red bricks</b>	<b>Fly ash bricks</b>
<ul style="list-style-type: none"> <li>These bricks had decreasing demand nowadays because of its poor compressive strength and high water absorbing capacity and may conduct good amount of electricity while seepage on rainy season.</li> </ul>	<ul style="list-style-type: none"> <li>These bricks have huge demand throughout the India because of its high compressive strength and low water absorption property and are highly fire resistant.</li> </ul>

**Table 6. Types of labour in bricks manufacturing unit**

<b>Red bricks</b>	<b>Fly ash bricks</b>
<ul style="list-style-type: none"> <li>In this unit unskilled labours are required who work on the daily wages. Production depends upon the number of labour (approx. 20-25 labours).</li> </ul>	<ul style="list-style-type: none"> <li>In this unit a skill operator is required to operate the machine and rest for the transportation of bricks tray from one sector to another (approx 12 labours).</li> </ul>

**Table 7. Effect of bricks in environment**

<b>Red bricks</b>	<b>Fly ash bricks</b>
<ul style="list-style-type: none"> <li>Red bricks are composed by dumping mixture of materials in mould which is a manual process and it requires a high temperature for baking which is processed by the use of wood, coal and dry grass. The soil required units formation may result in the removal of top layer of soil.</li> </ul>	<ul style="list-style-type: none"> <li>Ash bricks are composed by applying high pressure on the pre attached mould which does not require usage of coal and wood for baking .Thus it is eco-friendly in nature.</li> </ul>

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