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Comparative Analysis between Properties of Fly Ash Bricks and Normal Clay Bricks

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Abstract- This paper presents Fly Ash brick properties, manufacturing process material required for preparing the clay bricks and fly ash bricks as per Indian standard code provisions, inspection and quality control. The textures of the bricks with Fly Ash were very similar to that of clay bricks; the sample with the additive contains spherical Fly Ash particles. These particles of Fly Ash led to a reduction in the density of the bricks and a substantial improvement in their durability. Use of this additive could have practical implications as a means of recycling and for achieving cost savings in brick production. The absorption coefficient, shape and size, density, weight, porosity, thermal conductivity and compressive strength of Fly Ash bricks compare with normal clay bricks that delivered good results. From the present study, it can be concluded that Fly Ash bricks used as an alternative to clay bricks.
Keywords: Fly Ash Brick, Compressive Strength, Absorption Coefficient, Clay Bricks

1. INTRODUCTION

During the India day by days the growth of development is increased that requires of electricity generated from the thermal power plant and this plant gives residue in the form of Fly Ash in major quantity. The rate of generation of Fly Ash far exceeds the increasing growth rate of its user. In the next ten years, the target of 95 % use of Fly Ash likely bring into existence [1]. If one considers the expected generation of Fly Ash over the next two decades, the volume projected is gigantic and its use program will have to be far more challenging than what is perceived today. In construction industries clay bricks were used in 180 billion tons of common burnt clay bricks are consumed annually approximately 340 billion tons 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. Continuing use of clay bricks in the construction industry will lead to extensive loss of fertile top soil [2]. This could be a devastating environmental hazard. High demand for clay bricks would result in price hike of clay bricks. To keep the cost of building materials in a reasonable range, we should opt in for alternative building materials like fly ash bricks and hollow or solid blocks. The material required for the fly ash bricks as Fly ash, lime and gypsum are available in mutual proximity in many regions .Flyash can be used as an alternative material for burnt clay bricks, which is one of the important building materials, used for construction of housing and buildings. The Flyash used in concrete, can substitute the conventional building material like Cement and clay bricks in nearly all applications [3].

An economical alternative to conventional burnt clay bricks will be available if these materials can be used to make bricks and hollow blocks of adequate strength. Lime and gypsum are usually available either from mineral sources or may be procured from industrial wastes [4]. High fineness, low coal content, and rounded particle shape are, in general, favorable properties for use in cement and concrete. The amount of cement or lime or lime plus gypsum required to achieve a certain strength depends on the amount of free lime available in the fly ash [5].Fly ash does not modify the hydric properties of the bricks but it does make them lighter. In fact, all the bricks with fly ash have a lower density. Fly ash bricks show less damage than conventional bricks when exposed to salt crystallization cycles. This improvement is due to the reduction of the surface area of the bricks, i.e. the reduction of the volume of the smallest pores, the ones that cause the most damage to the bricks due to soluble salt crystallization. The addition of fly ash can enhance the quality of the brick, although for restoration purposes if too much fly ash (P10 wt. %) is added, this can spoil the

aesthetic appearance of the buildings being restored, due to excessive color differences. Bricks with larger amounts of fly ash could, however, be considered for use in the construction of new buildings [6].

2. ENVIRONMENTAL CONCERN

Climate change is considered as major environmental challenge for the world. Buildings have a significant and continuously increasing impact on the environment since they are responsible for a large portion of carbon emissions and also uses considerable number of resources. Buildings account for one-sixth of the world's fresh water withdrawals, one quarter of its wood harvest, and two-fifths of its material and energy flows. The construction sector consumes considerable amount of energy from the production of basic building materials, its transportation and assembling called embodied energy [7]. Brick and cement are one of the profuse pollutant industries with massive CO2 emissions. It is estimated that each million clay bricks cause to generate 300 tons of CO2 and each million tons of OPC cause to generate equal quantity of CO2 [8].

3. RESEARCH SIGNIFICANCE

Continuing use of clay bricks in the construction industry will lead to extensive loss of fertile top soil. This could be a devastating environmental hazard. High demand for clay bricks would result in price hike of clay bricks. To keep the cost of building materials in a reasonable range, we should option for alternative building materials like fly ash bricks and hollow or solid blocks. Modern Fly ash bricks are manufactured using high end pre-programmed hydraulic machines. Bricks from these machines are tested for its quality and durability and strength.

4. LABBORATORY TESTS TO DETERMINE THE QUALITY OF BRICKS

A. Experimental Procedure

(A) Clay Bricks

Brick is a building material used to make walls, pavements and other elements in masonry construction. Modern, fired, clay bricks are formed in one of the three processes – Soft mud, Dry press (Dust Press) and Extruded. Normally, bricks contain the following ingredients: Silica (Sand) – 50% to 60% by weight. Clay bricks made of fired clay. The composition of clay varies over a wide range. Usually, clays are composed mainly of Silica (grains of sand), Alumina, Lime, Iron, Manganese, Sulphur, and Phosphates, in different proportions. Bricks are manufactured by grinding or crushing the clay in mills and mixing it with water to make it plastic. Brick is made from clay, shale and then fired in a Kiln at up to 2,000° F having the standard size and weight. There are various types of bricks used in masonry.

The process of making a brick has not changed much over the centuries or across geographies. The clay is mined and stored in the open. This makes the clay soft and removes unwanted oxides then mixed with water to get the right consistency for Moulding. Mixing is done manually with hands and feet. A lump of the mix is taken, rolled in sand and slapped into the mould. Initially, moulds were made of wood of size 22 X 10 X 7.5 mm (8.66 X 3.93 X 2.95 inch), now metal moulds are used. Sand is used so the brick does not stick to the mould. The mould is emptied onto the drying area, where the bricks are arranged in a herringbone pattern to dry in the sun.

Every two days they are turned over to facilitate uniform drying and prevent warping. After two weeks they are ready to be burnt. The green bricks are arranged in a kiln and insulation is provided with a mud pack. Fire holes left to ignite the kiln are later sealed to keep the heat inside. This is maintained for a week. Firing like other operations also depends on the knowledge and experience of the brick maker. After the kiln is disassembled, the bricks are sorted according to color. Colour is an indication of the level of burning. Over burnt bricks are used for paving or covering the kiln while slightly under burnt bricks are used for building inner walls or burnt once again in the next kiln.

Figure 1: Clay Bricks

(b) Fly Ash Bricks

Fly ash, cement, and sand are manually fed into a pan mixer where water is added to the required proportion for homogeneous mixing. The proportion of raw material may vary depending

upon the quality of raw materials. After mixing, the mixture is allowed to belt conveyor through feed into automatic brick making machine where the bricks are pressed automatically. Then the bricks are placed on wooden pallets and kept as it is for two days thereafter transported to open area where they are water cured for 10 -15 days. The bricks are sorted and tested before dispatch.

Figure 2: Fly Ash Brick

B. Materials

(a) Fly Ash

What is Fly ash?

Pulverized fuel ash commonly known as Fly ash, is comprised of the non-combustible mineral portion of coal. When coal is consumed in a power plant, it is first ground to the fineness of powder. Blown into the power plant‘s boiler, the carbon is consumed — leaving molten particles rich in silica, alumina and calcium. These particles solidify as microscopic, glassy spheres that are collected from the power plant‘s exhaust before they can “fly” away — hence the product‘s name: Fly ash. Fly ash is a pozzolanic when mixed with lime (calcium hydroxide), pozzolanic combine to form cementitious compounds. Concrete containing Fly ash becomes stronger, more durable, and more resistant to chemical attack [9].

There are about 40 major thermal power plants in India, which produces about 15 million tons of Fly ash every year. Such enormous quantities need huge dumping grounds and create pollution problems.

Figure 3: Fly Ash

Classification of Fly Ash:

ASTM C618 classifies the Fly ash into two classes:

(a) Class F

(b) Class C

Class F Fly ash: Fly ash normally produced from burning anthracite or bituminous coal falls in this category. Class F ashes bituminous or anthracite coals. Class F are generally low-calcium fly ashes with carbon contents less than 5% but sometimes as high as 10%. Class F fly ash possess only pozzolanic properties. This class of Fly ash exhibits pozzolanic property but rarely if any, self-hardening property. In Class F Fly ash, total calcium typically ranges from 1 to 12 percent, mostly in the form of calcium hydroxide, calcium sulphate, and glassy components in combination with silica and alumina.

Class C Fly ash: Fly ash normally produced from lignite or sub- bituminous coal is the only material included in this category. This class of Fly ash has both pozzolanic and varying degree of self cementitious properties. Most class C Fly ashes Class C ashes are produced from burning sub bituminous or lignite coals. Class C are often high calcium fly ashes with carbon content less than 2% class C fly ash possess both cementations and pozzolanic properties.

Figure 4: Compressive Strength of fly ash Brick

Figure 5: Test for compressive strength of Brick

(b) Cement

Portland cement is the basic ingredient of concrete. Concrete is formed when portland cement creates a paste with water that binds with sand and rock to harden. Cement is manufactured through a closely controlled chemical combination of calcium, silicon, aluminum, iron and other ingredients. Ordinary Portland cement of 43 grades was used for the entire work.

Figure 6: Cement & Fly Ash

(c) Crush Sand

In a replacement of fine aggregate (sand) in fly ash bricks, crush sand there used its cost effective than the fine aggregate. There no specific grade for the crushed sand to maintain the quality of bricks.

Figure 7: Crushed Stone/ Sand

(d) Fly Ash Concrete

Effect of Fly Ash on Properties of Concrete:

(i) Fresh Concrete

- Improved workability
- Reduced water demand for most Fly ashes.
- Produced concrete with more cohesive and segregates
- Less-improved pump ability.
- Reduced bleeding especially at high replacement level.

(ii) Set Time Extended

- Extended-especially in cold water.
- Can increased or retarded the setting time for certain combinations of Fly ash, cement and chemical admixtures. .

(iii) Heat of Hydration

- Reduced for Class F Fly ash at normal levels of replacement, Class C Fly ashes have to be used at higher levels of replacement to reduce heat (for example ≥ 50%).
- Increased in reduction by using high levels of replacement, low total cementitious contents, and low concrete placing temperature.

(iv) Early Age Strength

- Reduced the early strength of concrete especially at first day.
- Class F will have a greater reduction and for higher replacement levels of Fly ash.

(v) Long Term Strength

- Improved long term strength
- Strength improved with the increment of replacement level of Fly ash.

(vi) Permeability and Chloride Resistance

- Reduced by time.

(vii) Expansion (alkali-silica reaction)

- Reduced.
- Sufficient levels of replacement can completely suppress deleterious.

(viii) Sulfate resistance

- Increased for class F Fly ash
- Resistance to cyclic immersion in sodium sulphate solution and drying has been shown to be relatively unaffected by up to 40% Fly ash.

(ix) Resistance to Carbonation

- Decreased.
- Significant decreases when high levels of Fly ash are used in poorly- cured, low-strength (high w/cm) concrete.

(x) Inspection and Quality Control

The Bureau of Indian Standards has formulated and published the specifications for maintaining the quality of product and testing purpose in IS: 12894:2002.Compressive strength achievable 870-3626 psi (6-25N/mm2).

(xi) Water absorption

5 – 12 %; Density is 12.5 lb/gal (1.5 gm./cc) Coefficient of softening (depending upon water consistency factor), Unlike conventional clay bricks Fly Ash bricks have high affinity to cement mortar though it has a smooth surface, due to the crystal growth between brick and the cement mortar.

Figure 8: Bricks Water Absorption Test

Fly Ash Bricks: Bricks may be made from a number of different kinds of material, but they must usually possess (can be capable of developing) a certain amount of plasticity. Fly ash is one of them. Use of Fly ash with soil and firing the bricks with agricultural waste will reduce the cost of the building material i.e. Clay bricks. Fly ash is an industrial waste, which is just a burden for the industry we can take it free of cost from the industries and can utilize it for the manufacturing of fly ash bricks[8].

Clay-Flyash bricks: Flyash generally contains 5 to 6% of unburnt carbon, incorporation of Flyash, therefore, results into a better-burnt product together with an economy in fuel consumption. It has been experimentally verified that saving of about five tons of coal per Lac bricks could be achieved by mixing 40% flash ash by volume with the clay for making bricks

Advantages of Clay Fly ash Bricks:

a) Reduction in drying shrinkage and about 15 to 25% of the weight of the bricks with better thermal insulation.

b) The properties of bricks are not affected by mixing Fly ash with the clay [11].

Various special features of Fly ash bricks are as follows:

A. Being machine finished these are uniform in size and shape.
B. Consumes 20-25 percent less cement mortar.
C. Stronger than Class-I, burnt clay-building bricks.
D. Outside wall plastering is not essential as these bricks have cement gray colour, smooth surface and low water absorption capacity.
E. Being lighter in weight in comparison to the conventional red bricks, the dead building load and the transportation cost will be less.
F. Adoption of this process helps to conserve invaluable topsoil of agricultural land.
G. By consuming 80-82% Fly ash, the cause of environmental pollution and hazards due to disposal is minimized.

5. RESULTS AND ANALYSIS

A comparison between the bricks that conducted from experimental work. The fly ash bricks and clay bricks are tested on universal testing machine (UTM). Fly ash bricks crevice fall out less than that of clay bricks show the Table 1. The experimental effect or response of bricks remark in Table 1. (See. Set A, B, C). On study of fly ash bricks benefits as given bellow.

Table 1: Compressive Strength for trial mix

Experimental Set – A				
Parameter	Compressive Strength psi (N/mm^2)			
Sample No.	**1**	**2**	**3**	**4**
Normal Clay Bricks	584.19(4.08)	519.15(3.8)	578.20(4.09)	1205.91(8.5)
Fly – Ash Bricks	578.40(4.03)	825.70(5.7)	1546.28(10.75)	645.08(4.42)

Experimental Set – B				
Parameter	Compressive Strength psi (N/mm^2)			
Sample No.	**1**	**2**	**3**	**4**
Normal Clay Bricks	658.77(4.8)	545.28(3.81)	658.5(4.51)	799(5.9)
Fly - Ash Bricks	1135(7.75)	1148 (7.95)	1105.3(7.8)	1160(9)
Experimental Set – C				
Parameter	Compressive Strength psi (N/mm^2)			
Sample No.	**1**	**2**	**3**	**4**
Normal Clay Bricks	888.7(7.12)	625.68(4.51)	844.38(5.67)	677.35(4.68)
Fly – Ash Bricks	1115.45(7.65)	1135.28(7.9)	1167(8)	1190.30(8.24)

Appearance: The bricks have the appearance which is very pleasant like cement; Due to smoothness and finish on their surface they require no plastering for building work. These are compact, uniformly shaped and free from visible cracks. They are lighter in weight than ordinary clay bricks and are less porous. The color of these bricks can be altered by the addition of admixtures during the process of brick making. The size of these bricks can vary but they are generally available in the same sizes of the normal clay bricks.

Structural Capability: These bricks do not cause any extra load on the design of structures due to its comparable density and thus provide better resistance to earthquakes and other natural calamities. The compressive strength of Fly Ash and lime bricks is average 1305 psi (9.00 N/mm2) (as against 507 psi [3.50 N/mm2] for handmade clay bricks). The bricks possess high compressive strength which eliminates breakages/wastages during transport and handling. When a structure is formed using Fly Ash bricks the possibility of cracking of plaster is reduced due to lower thickness of joints and plaster and basic material of the bricks, which is more compatible with cement mortar.

Thermal Properties: These bricks have got thermal conductivity around 0.90-1.05 Webster/m2 (20-30% less than those of concrete blocks). These bricks do not absorb heat; they reflect heat and gives maximum light reflection which causes less heating of huge structures.

Sound Insulation of Fly Ash Bricks: It provides an acceptable degree of sound insulation. The sound produced at one side of a wall made using Fly Ash bricks do not let the sound waves pass easily to the other side of the wall due to its compactness. Hence they may be considered for the abatement of the noise pollution.

Durability and Moisture Resistance: Fly Ash blocks are highly durable. When their joints are properly joined, the bricks are ready to be directly painted with the paints available in the market or with the cement paint without plaster. The bricks, usually, are rectangular faced having sharp corners, solid, compact and uniformly shaped. The bricks are said to absorb the moisture approximately 6-12% than that of 20-25% for handmade clay bricks thus they help reducing dampness of the walls.

Toxicity and Breath-ability: There are no positive evidence and studies that suggest about toxic fume emissions or the indoor air quality of structures built with Fly Ash bricks. Fly Ash as a raw material is very fine so care has to be taken while its handling and transport to avoid any kind of air pollution in the view of occupational safety. Once it is flue, it can remain airborne for long periods of time, causing serious health problems relating to the respiratory system. But block manufactured from Fly Ash has no such problems.

Sustainability: We can conclude that Fly Ash is a cocktail of unhealthy and hazardous elements like silica, mercury, iron oxides, calcium, aluminum, magnesium, arsenic, and cadmium. It poses serious environment and health hazards for a large population who live in the nearby area of the plants. But the brick is better off, during the process of brick making the toxins associated with Fly Ash gets changed into a non-toxic product. The mixing of with lime at ordinary temperature leads to the hydration of calcium silicate and formation of a dense composite insert block. Thus it has the potential of being a good building material. In India about 100 million tons of Fly Ash is produced annually by the numerous thermal power plants,

which could cause serious contamination of land, groundwater, and air but due to the practice of Fly Ash bricks now it is safe and sound.

Build Ability, Availability, and Cost: The compressive strength of Fly Ash blocks is so high that it eliminates breakages/wastage during handling and gives a neat finish, with a lower thickness of joints and plaster. The construction technique does not change in the case of Fly Ash bricks and remains as same as in the case of regular bricks which ensures an easy change of material. Masons do not require additional training while construction. Though these bricks are abundantly and widely available closer to thermal power plants all over the country for obvious reasons, finding dealers in all major cities and towns wouldn't be a problem.

Comparison between Clay Brick and Fly Ash Brick:

- Normal clay bricks have varying color as per soil whereas Fly Ash bricks have a uniform pleasing color like cement.
- As normal clay bricks are handmade they have an uneven shape, on the other hand, Fly Ash bricks are uniform in shape and smooth in the finish.
- Normal clay bricks are lightly bonded whereas there is a dense composition in the case of Fly Ash bricks.
- Plastering is required in case of normal clay bricks whereas no plastering is required in case of Fly Ash bricks.
- Fly Ash bricks are lighter than clay bricks.
- The compressive strength of Fly Ash bricks is more than that of clay bricks
- Fly Ash bricks are less porous than that of clay bricks

Environmental benefits of Fly ash:

1. Fly ash utilization reduces the requirement of clay, sand, lime stone in cement manufacturing and hence conserves natural resources.
2. Fly ash utilization reduces the cement requirement and hence carbon-di- oxide liberation during cement manufacturing is reduced.
3. Fly ash utilization reduces the topsoil requirement for land filling / brick manufacturing and saves agricultural land.
4. Fly ash utilization achieves increased strength of the finished concrete product without increasing the cement content.

6. CONCLUSIONS AND FUTURE ENHANCEMENT

Coal is the main energy source in India and Fly ash results as a by-product of coal combustion. Dumping of Fly ash poses environmental problems. It has been proved that the basic properties of Fly ash if used consciously and precisely it can be turned out to be a successful material. Replacing Cement by Fly ash in concrete mix will minimize environmental impact. This recycling of waste material like Fly ash as replacement for cement , provides a large setting for the disposal of Fly ash in a very efficient, useful and profitable way.

In this study, Fly ash as a sustainable alternate building material is studied and the potential of this material to be used as alternate building materials is brought out. Proper awareness needs to be created in the housing sector for the use of Fly ash as an Alternate building material for the low cost housing. This material if studied and developed properly holds the key to address the current housing needs. Mass housing targets can be achieved by replacing the conventional materials and more than that, the process of making use of industrial waste material like Fly ash in large quantities, is more environmentally acceptable.

Fly ash used as wasted product and environment is directly protected by reducing solid waste disposal. The average compressive strength of fly ash brick is 1305 psi (9 N/mm2).In clay bricks, fly ash can also be used for the manufacturing process. The result of 40% fly ash with 60% Clay will be the good combination. Fly ash used as raw material replacing of clay to make fired bricks is an effective measure of saving land and decreasing pollution. The properties of the bricks improved with the firing temperature. Fly ash does not modify the hydric properties of the bricks but it does make them lighter. In fact, all the bricks with fly ash have a lower density. Fly ash bricks show less damage than conventional bricks when exposed to salt crystallization cycles. This improvement is due to the reduction of the surface area of the bricks.

REFERENCES

[1] Ujjwal Bhattacharjee, Tara Chandra Kandpal "Potential of fly ash utilization in India" Energy 27, 2002, pp. 151-166.

[2] Samitinjay Sadashivrao Bansode "Comparative Analysis between Properties of Steel Slag, Fly Ash, and Clay Bricks" Geo-Congress(ASCE) 2012 pp. 3816-3825.

[3] Techno Economic Feasibility Report on Flyash Bricks', BMPTC-Building Materials & Technology Promotion Council Ministry of Housing & Urban Poverty Alleviation Government of India, New Delhi.

[4] Sunil Kumar "A perspective study on fly ash–lime– gypsum bricks and hollow blocks For low-cost housing development" Construction and Building Materials 16, 2002 pp. 519–525.

[5] K. Wesche "Fly Ash in Concrete" edition published in the Taylor & Francis e-Library, ISBN 0-203-62641-9 Master e-book ISBN, 2005. pp. 168.

[6] Giuseppe Cultrone, Eduardo Sebastian "Fly ash addition in clayey materials to improve the quality of solid bricks" published in Journal of Construction and Building Material 23, (2009) pp.1178-1184.

[7] Shruti Mutkekar and Shweta Patil, _Flyash as an Alternative Energy Efficient Building Material for Cement', International Journal of Current Engineering and Technology, E-ISSN 2277-4106, P- ISSN 2347- 5161, ©2015 INPRESSCO®, Available at http://inpressco.com/category/ijcet, Vol.5, No.2 (April 2015) [3] Techno Econ.

[8] Environment Friendly Indian Building Material Technologies for Cost Effective Housing'– Society for Excellence in Habitat Development, Environment Protection and Employment generation [SHEE], New Delhi.

[9] Swaptik Chowdhury and Sangeeta Roy, Prospects of Low Cost Housing in India', published in Scientific Research, Geomaterials, 2013, 3, 60-65.

[10] Xu Lingling.Guo Wei.Wang Tao.Yang Nanru, - Study on fired bricks with replacing clay by fly ash in high volume ratio', published in Construction and Building Materials, Volume 19, Issue 3, April 2005, Pages 243- 247.