STUDY ON STRENGTH BEHAVIOUR OF FLY ASH BRICKS

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ABSTRACT

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. Since fly ash is being accumulated as waste material in large quantity near thermal power plants and creating serious environmental pollution problems, its utilisation 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.

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 above problems can be reduced some extent by using fly ash bricks.

The object of this project is to represent the information regarding Fly Ash bricks and plant, properties and their uses in a most concise, compact and to the point manner. And also in this project various laboratory experiments were carried out on fly ash bricks samples. Some of them are Compressive strength study, water absorption study etc.

1. INTRODUCTION

Fly ash is the by-product of coal combustion collected by the mechanical or electrostatic precipitator (ESP) before the flue gases reach the chimneys of thermal power stations in very large volumes. All fly ash contain significant amounts of silicon dioxide (SiO_2), aluminium oxide (Al_2O_3), iron oxide (Fe_2O_3), calcium oxide (CaO), and magnesium oxide (MgO) however, the actual composition varies from plant to plant depending on the coal burned and the type of burner employed. Fly ash also contains trace elements such as mercury, arsenic, antimony, chromium, selenium, lead, cadmium, nickel, and zinc.

These particles solidify as microscopic, glassy spheres (see fig.1) that are collected from the power plant‘s exhaust before they can ―fly‖ away ― hence the product‘s name: Fly Ash. Chemically, fly ash is a pozzolan. When mixed with lime (calcium hydroxide), pozzolans combine to form cementitious compounds.

The power requirement of the country is rapidly increasing with increase in growth of the industrial sectors. India depends on Thermal power as its main source (around 65% of power produced is thermal power), as a result the quantity of Ash produced shall also increase. Indian coal on an average has 30% to 40% Ash and this is one of the prime factors which shall lead to increased ash production and hence, Ash utilization problems for the country.

Fly ash is one of the numerous substances that cause air, water and soil pollution, disrupt ecological cycles and set off environmental hazards. It's also contains trace amounts of toxic metals which may have negative effect on human health and on plants and the land where the fly ash decomposed not gets reused.

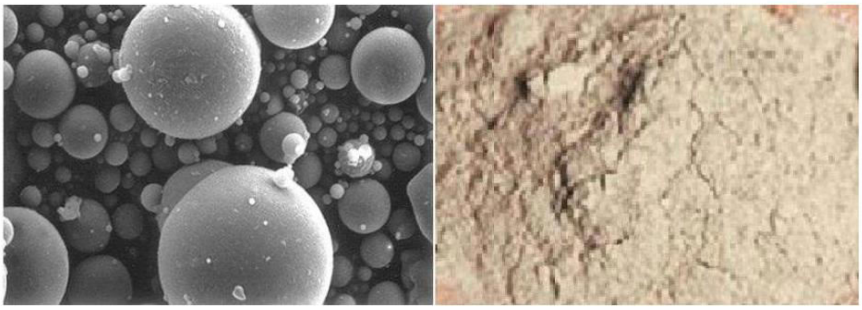

Fig.1 : Fly ash: the modern pozzolan

The disposal of this waste material is a matter of great concern from the environmental and ecological point of view. The safest and gainful utilisation of this material has been one of the topics of research over the last few decades.

The advantages of fly ash utilisation are:

- Saving of space for disposal and natural resources
- Energy saving and Protection of environment

The options of ash utilization including the ash based products are at development stage and need to be made more environments friendly by bringing ash revolution.

AMOUNT OF FLY ASH GENERATED IN INDIA:

Plan Period	Terminal Year	Power Generation, MW	Coal (million tons)	Fly ash (million tons)
8th Plan	1996 - 97	50,000	210	80
9th Plan	2001 - 02	87, 000	285	110
10th Plan	2006 - 07	1, 16, 400	400	140
11th Plan	2011-12	1, 38, 3000	500	175
Note: Fly ash Generation during 2009-2010 – 160MnT (source DST)				

Table 1: Generation of Fly ash during different Five Year Plans

PRESENT UTILIZATION OF FLY ASH IN INDIA:

Sector	MnT	% of utilization
In production of Portland Pozzolana Cement	32	40
Cement Replacement at Concrete batching Plants (RMC)	08	10
Filling in low lying areas	14	18
Roads and Embankments	12	17
Dyke Raising	4	5
Brick Manufacturing	3	2.5
Agriculture Sector	3	2.5
Other miscellaneous uses.	4	5
Total	**80**	**100**

Table – 2 Present Utilization of Fly ash(source - Fly ash utilization Unit – DST Govt. of India)

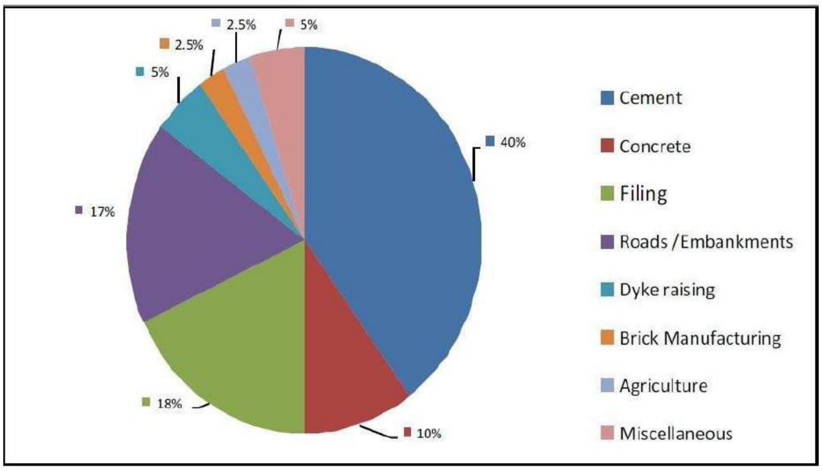

Fig. 2 Present Utilization of Fly ash in different segment

2. FLY ASH BRICK

Production of burnt clay bricks requires consumption of coal leading to green house gas emissions. The primary raw material used for bricks is the soil, which is often taken from prime agricultural land, causing land degradation as well as economic loss due to diversion of agricultural land. Use of traditional technologies in firing the bricks results in significant local air pollution. The burnt clay brick industry in India produces over 180 billion clay bricks annually with a strong impact on soil erosion and unprocessed emissions. At the same time, the thermal power plants in India continue to produce a huge amount of fly ash, disposal of which poses significant challenges for the power plants.

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. Although there exist several technologies for producing fly ash bricks, the one that is gaining popularity is the FaL-G technology. The FaL-G technology works with the strength of fly ash, lime and gypsum chemistry. The slow chemistry of fly ash and lime is manoeuvred by tapping ettringite phase to its threshold limits through sufficient input of gypsum. Therefore, FaL-G does not require heavy duty-press or autoclave, which is otherwise required in case of only fly ash and lime.

The FaL-G process completely eliminates the thermal treatment (except open air drying) and does not require combustion of any fossil fuel.

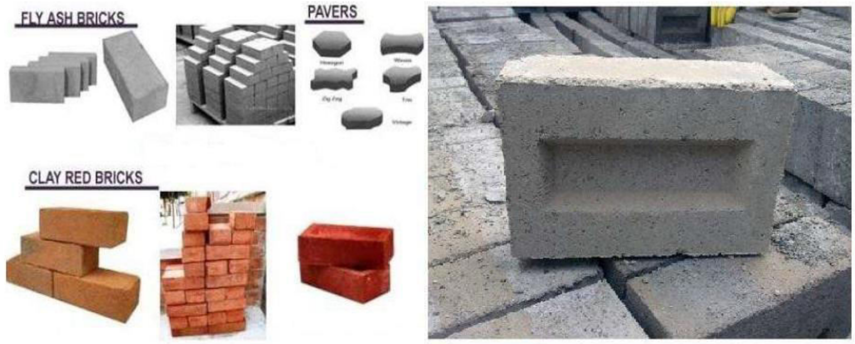

Fig. 3 – Fly ash bricks V/s Clay Bricks (Ordinary Bricks)

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. Since fly ash is being accumulated as waste material in large quantity near thermal power plants and creating serious environmental pollution problems, its utilisation 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.

REQUIREMENTS OF FLY ASH LIME BRICKS AS PER IS 12894 : 2002 :

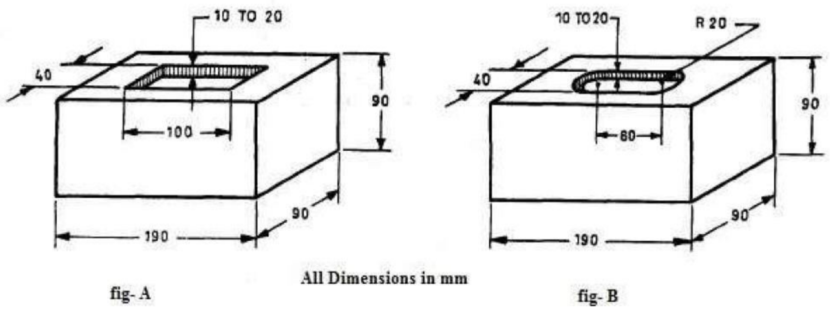

Fig. 4 Shape and size of frogs in brick

RAW MATERIALS :

The raw material that is used for fly ash brick are:

- FLY ASH : Pulverized fuel ash commonly known as fly ash shall conform to Grade 1 or Grade 2 of IS 3812. The proportion of the Fly ash is generally in the ratio 60-80%, depending upon the quality of raw materials.
- SAND/STONE DUST : Deleterious materials, such as clay and silt in sand, shall preferably be less than 5 percent. About 10 to 20% may used. Bottom ash used as replacement of sand shall not have more than 12 percent loss on ignition when tested according to IS 1727.
- LIME : Quick Lime or hydrated lime or both can be mixed in the composition. Lime should have minimum 40% CaO content.

- GYPSUM : Hydrated calcium sulphates are called gypsum. ($CaSO_4 \cdot 2H_2O$). Gypsum should have minimum 35% purity and 5 to 15% may be used.

MANUFACTURING PROCESS:

Fly ash, lime, sand and gypsum are manually fed into a pan mixer where water is added in the required proportion for intimate mixing. The proportion of the raw material is generally in the ratio 60-80% of fly ash 10-20% lime, 10% Gypsum and 10% sand, depending upon the quality of raw materials. The materials are mixed in pan mixture. After mixing, the mixture is conveyed through belt conveyor to the hydraulic/mechanical presses. The homogenised mortar taken out of roller mixer is put into the mould boxes. Depending on the type of machine, the product is compacted under vibration / hydraulic compression etc.

The green bricks are dried up under sun from 24 to 48 hours, depending whether lime route or cement route; the dried up bricks are stacked and subjected for water spray curing once or twice a day, for 7-21 days, depending on ambience. The bricks are tested and sorted before despatch.

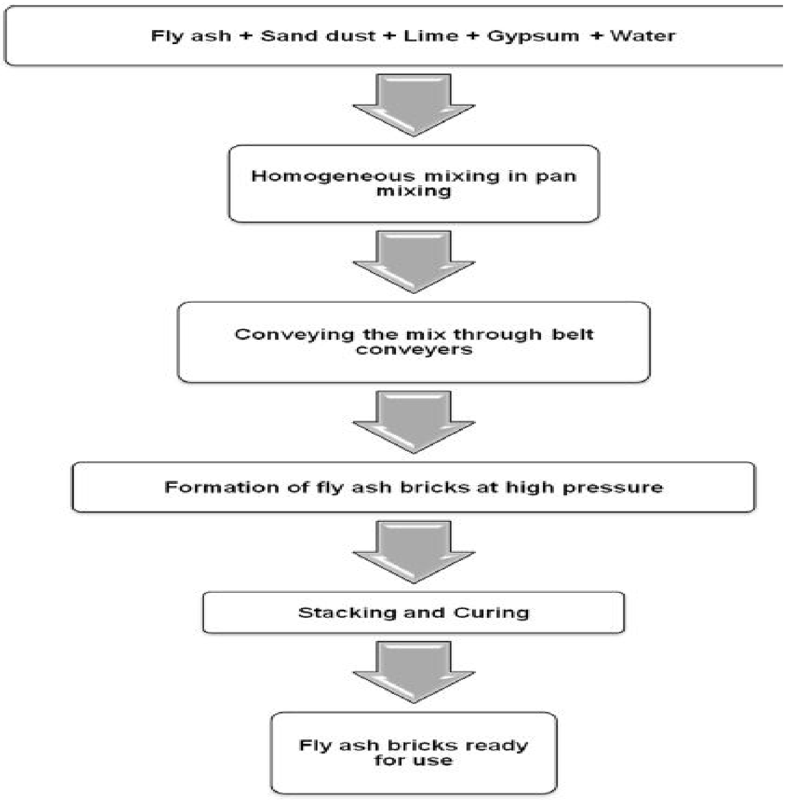

Fig. 6 Flow Sheet for the manufacture of FaL- G bricks

FLY ASH BRICKS PLANT:

The raw materials used for manufacturing of bricks by using FaL-G technology are:

- Fly ash – produced as waste material from coal based thermal power plant;
- Lime – Produced as waste material from paper and other industries; •

- Gypsum – produced as by product from fertilizers and aluminium plant; •
- Sand – sourced from riverbed; •
- Stone dust – produced as rejects from stone crushers; and •
- OPC – product from cement plant, which is used as a substitute of lime. •

ADVANTAGES OF FLY ASH BRICKS:

- Appearance: These bricks have a pleasing colour like cement, are uniform in shape and smooth in finish, also, they require no plastering for building work. The bricks are of dense composition, uniformly shaped with/without a frog, free from visible cracks, warpage, organic matter, pebbles and nodules of free lime. They are lighter in weight than ordinary clay bricks and less porous too. The colour of fly ash bricks can be altered with the addition of admixtures during the process of brick making. They come invarious sizes, but generally are similar to the sizes of clay bricks.
- Structural Capability: These bricks can provide advantages being available in several load-bearing grades, savings in mortar plastering, and giving smart looking brickwork. High compressive strength eliminates breakages/wastages during transport and handling, the 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. Due to its comparable density the bricks do not cause any extra load for design of structures and provides better resistance for earthquake loads due to panel action with high strength bricks.
- Thermal properties: Thermal conductivity is 0.90-1.05 W/m_2 ºC (20-30% less than those of concrete blocks). These bricks do not absorb heat; they reflect heat and gives maximum light reflection without glare.
- Sound insulation: It provides an acceptable degree of sound insulation.
- Durability and moisture resistance: These blocks are highly durable, after proper pointing of joints, the bricks can be directly painted in dry distemper and cement paints, without the backing coating of plaster. Rectangular faced with sharp corners, solid, compact and uniformly Water absorption is 6-12% as against 20-25% for handmade clay bricks, reducing dampness of the walls.
- Toxicity and Breath-ability: There are no definite studies on the toxic fume emissions or the indoor air quality of structures built with fly ash bricks, though claims of radioactive emissions by these blocs have been made at some scientific forums. Fly ash as a raw material is very fine and care has to be taken to prevent from being air-borne and causing serious air pollution as it can remain airborne for long periods of time, causing serious health problems relating to the respiratory system. Though block manufactured from fly ash has no such problems.
- Fire and vermin resistance: Fly ash bricks have a good fire rating. It has no problems of vermin attacks or infestation.
- Sustainability:(Environmental impacts) Fly ash is one of the numerous substances that cause air, water and soil pollution, disrupt ecological cycles and set off environmental hazards. It's also contains trace amounts of toxic metals – silica, aluminium, iron oxides, calcium, magnesium, arsenic, mercury, and cadmium, which may have negative effect on human health and plants. But the brick is better off, for fly ash changes into

a non-toxic product when mixed with lime at ordinary temperature as the calcium silicate hydrates and forms a dense composite inert block. Thus having the potential as a good building material, while offsetting about 100million tonne‘s of fly ash annually produced in India by the numerous thermal power plants, which could cause serious contamination of land, groundwater and air.

- Buildability, availability and cost: The blocks have an easy workability and high compressive strength eliminates breakages/wastage during handling giving a neat finish, with lower thickness of joints and plaster. The construction technique remains the same as regular bricks ensuring easy change of material, without requiring additional training for the masons. Though these bricks are abundantly 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.

Applicability:

- The blocks being available in several load bearing grades are suitable for use: -
- Load bearing external walls, in low and medium size structures.
- Non - load bearing internal walls in low and medium size structures.
- Non - load bearing internal or external walls in high-rise buildings.

RESULTS AND ANALYSIS:

The results of the measurement should comply with the limits stated in IS 12894:2002. Table 8 below shows the results obtained from the measurement of 10 bricks.

Dimensions	Total Measurement for 10 Bricks (mm)	Mean Measurement for Single Brick (mm)
Length, L	2370	237
Width, W	1150	115
Height, H	790	79

Immerse completely dried specimen in clean water at a temperature of 27 ± 2 °C for 24 hours. Remove the specimen and wipe out any traces of water with a damp cloth and weigh the specimen. Complete the weighing 3 minutes after the specimen has been removed from water (M2). Water absorption, percent by mass, after 24-hour immersion in cold water is given by the following formula:

$$\frac{M_2 - M_1}{M_1} \times 100$$

Sample	Weight (dry) gm	Weight (wet, after 24 hr) gm	% of water absorption
A	2679	3202	19.53
B	2666	3218	20.07
C	2675	3182	18.95
D	2683	3187	18.78
E	2672	3179	18.97
		Average	**19.26 %**

Preparation of Sample :-

- Remove unevenness observed in the bed faces to provide two smooth and parallel faces by grinding.
- Immerse the sample in water at room temperature for 24 hours.
- Prepare cement mortar (1:1) and fill the frog and all void in bed faces with it.
- Store the sample prepared in (iii) under damp jute bag for 3 days in clean water.
- Remove and wipe out a trace of moisture.
- Measure the area of two horizontal faces.

Testing :-

i. Place the specimen with flat faces horizontal and mortar filled facing upwards between two plywood sheets and centre carefully between plates of testing machine.

ii. Load is applied axially at a uniform rate 14 N/mm2 per minute till failure occurs; Note the maximum load at failure

CALCULATION:

$$\text{Compressive Strength } (N/mm^2) = \frac{\text{Max.Load at Failure in N}}{\text{Avg.Area of Bed face in mm2}}$$

Sample	Dimension of Fly ash Bricks			Avg. Area of bed surface (mm^2)	Max load at failure (KN)	Compressive strength (N/mm^2)
	Length (mm)	Width (mm)	Height (mm)			
A	230	100	78	23000	118	5.153
B	228	100	80	22800	104	4.582
C	228	100	76	22800	132	5.815
D	230	102	78	23000	127	5.546
E	230	100	80	23000	138	6.026
					AVERAGE	**5.425** (approx 54.25 kgf/cm^2)

CONCLUSION:

Fly ash utilization in the country has remained less than 30% during the past 5 years and it might take several years to reach the final goal of cent percent utilization. It is estimated at present nearly 160 million ton fly ash is produced every year, out of which hardly 40- 50 % is used in all possible applications.

To utilize such a huge quantity of ash, we have to take necessary actions from government side and from nongovernment side for utilisation point of view. Based on the results for the experiments done on Fly ash lime brick,

Compressive strength = 54.25 kg/cm2

% Water absorption = 19.26 %

Properties	Red Bricks	Fly Ash Bricks	Remarks
Colour	Very	Uniform	Good Appearance
Density	1600 – 1750 kg/m^3	1700 – 1850 kg/m^3	Higher Load Bearing
Compressive Strength	30 – 35 kg/cm^2	55 – 100 kg/cm^2	Higher Load Bearing
Water Absorption	15 – 25 %	10 – 14 %	Less Dampness
Dimensional Stability	Very Low Tolerance	High Tolerance	Saving in Mortar Up to 25 %
Wastage During Transit	Up to 10 %	Less than 2 %	Saving in Cost Up to 8 %
Plastering	Thickness Vary on the Both Sides of Walls	Even on Both Sides of Walls	Saving in Plaster Up to 15 %

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