FLY ASH BRICKS

A PROJECT REPORT

***Submitted by*: -**

Ravikumar Sukala (080430106050)

Dipti Singh (080430106051)

Pratik Solanki (080430106053)

Jigar Sutariya (080430106054)

Kuldeep Thakur (080430106058)

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CERTIFICATE

Date:

This is to certify that the dissertation entitled " ***FLY ASH BRICKS*** " has been carried out by ***Pratik Solanki, Dipti Singh, Jigar Sutariya, Kuldeep Thakur, Ravikumar Sukla*** under my guidance in fulfillment of the degree of Bachelor of Engineering in Civil (8^{th} Sem.) of Gujarat Technological University, Ahmedabad during the academic year 2011-2012.

Guide:

P. S. PAREKH

Applied Mechanics Department

SSEC, Bhavnagar

Head of Department

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SUBMITTERS

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.

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CHAPTER 1

INTRODUCTION

Fly Ash: An Overview

Amount of Fly Ash Generated in India

Present Utilization of Fly Ash in India

1.1 FLY ASH: AN OVERVIEW:

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.

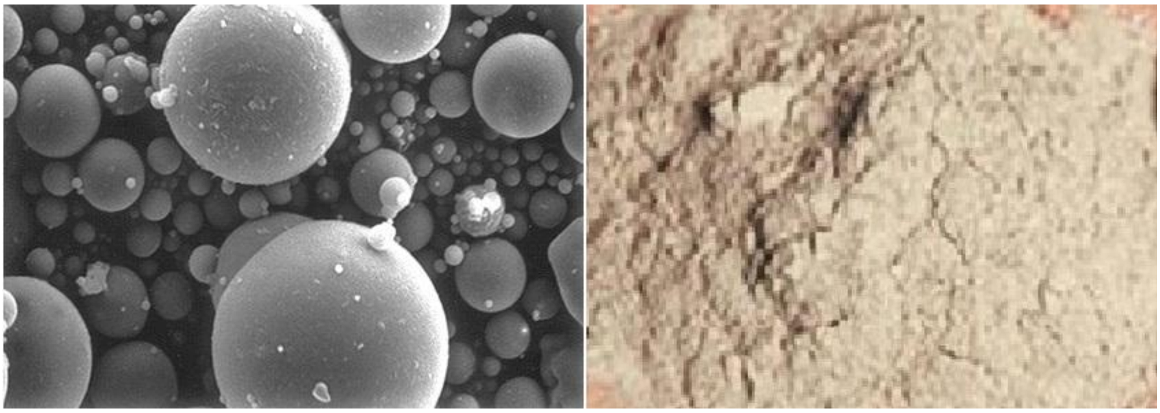

Fig.1 : Fly ash: the modern pozzolan

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.

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.

1.2 AMOUNT OF FLY ASH GENERATED IN INDIA:

The principle source of energy in India is the coal and it will remain the major source of thermal power for the next few decades. Nearly 65% power in India is generated through thermal power plants (TPP). The high ash content of Indian coals (30% to 40%) is contributing high volumes of fly ash. It is estimated at present nearly 160 million ton fly ash is produced every year.

The fly ash generation is increasing in such a proportion that it will not be possible for the cement industry alone to utilize the same. New avenues of gainful utilization of fly ash have to be found and promoted. The generation of fly ash in different five year plans is given in Table – 1.

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

1.3 PRESENT UTILIZATION OF FLY ASH IN INDIA:

The present utilization of fly ash in various sectors is shown in table – 2. Nearly 80 million tons of fly ash is reported being utilized out of 160 million tons generated during 2009 by Ministry of Science and Technology. Though percentage utilization has gone to nearly 50% but in absolute terms, very large quantity of fly ash still remains unutilized.

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)

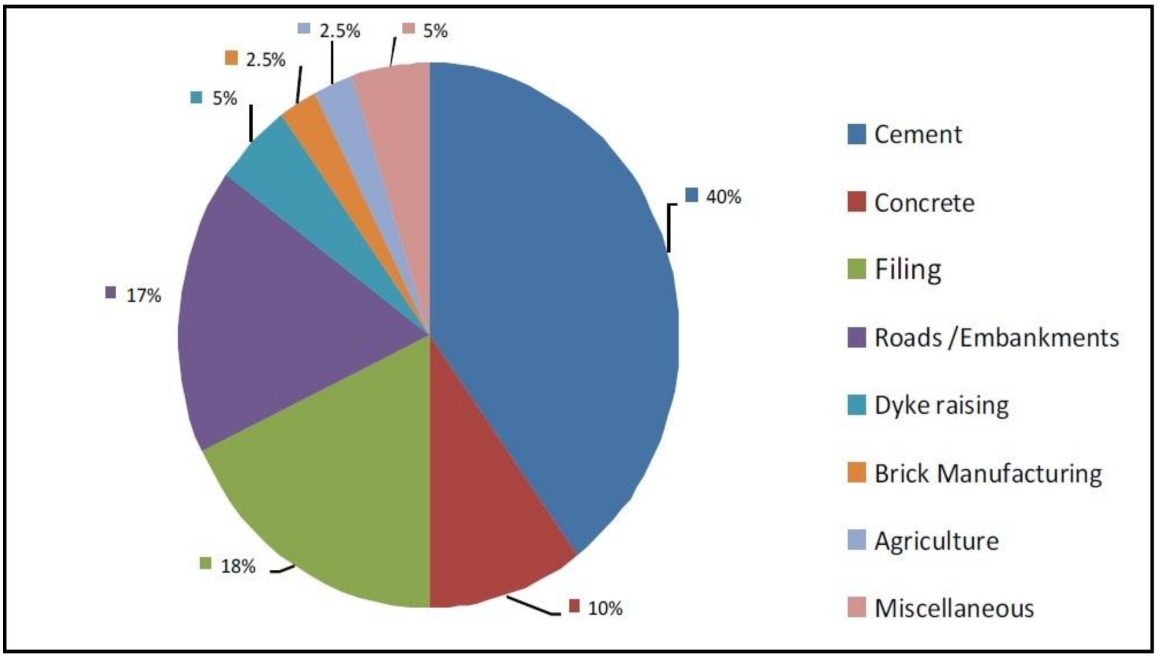

Fig. 2 Present Utilization of Fly ash in different segments

CHAPTER 2

FLY ASH BRICK

Introduction

Requirements Of Fly Ash Lime Bricks As Per IS 12894 : 2002

Clay Fly Ash Bricks

Fly Ash Lime Bricks

Fal-G Technology

Manufacturing Process

Advantages of Fly Ash Bricks

2.1 INTRODUCTION:

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.

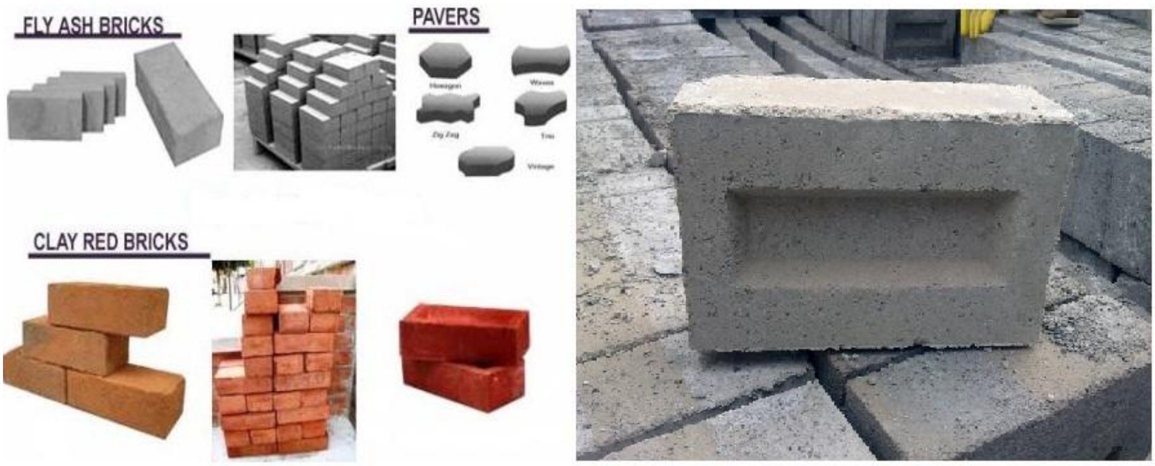

Fig. 3 – Fly ash bricks V/s Clay Bricks (Ordinary Bricks)

The ingredients of the FaL-G bricks and blocks, fly ash, lime, and gypsum, are well-known minerals that are widely used in industries. All these materials are available in form of wastes and bi-products from industrial activities and are available in adequate quantities in the areas, where the project activities are located. In certain cases, where by-product lime is not available in adequate quantity, ordinary Portland cement (OPC) is used as the source of lime, producing the same quality of bricks and blocks. The technology is proved to be environmentally safe and sound.

Fly ash- lime-gypsum (FAL-G) is not a brand name but it is duct name, christened to the mix for easy identification of its ingredients.

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.

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.

Bricks made of fly ash can be broadly classified into following groups –

- Clay Fly ash bricks
- Fly ash lime bricks
- Mud Fly ash bricks

2.1.1 CLAY FLY ASH BRICKS:

Brick industry is large field in which fly ash can be utilised as a major raw materials because both clay and fly ash are of not much differences in respect of their chemical composition. Further more, the residual carbon content in fly ashes bring about an economy in fuel consumption during firing of bricks.

In the process of bricks manufacturing from fly ash, about 25 to 80 % of clay can be replaced by fly ash and the bricks are produced by conventional or mechanised processes.

The green bricks after drying in open air or drying shed are fired in conventional or high draught kiln to obtain finished red clay fly ash bricks. The bricks thus produced are lighter as the bulk density of fly ash is about one half of the clay.

Logistic problem of getting fly ash at the brick kiln or getting land near power stations to make bricks there have prevented large scale commercialisation of technology.

2.1.2 FLY ASH LIME BRICKS:

In presence of moisture, fly ash reacts with lime at ordinary temperature and forms a compound possessing cementitious properties. After reactions between lime and fly ash, calcium silicate hydrates (C-S-H) are produced which are responsible for the high strength of the compound.

This process involves homogeneous mixing of raw materials (generally fly ash, sand and lime), moulding of bricks and then curing of the green bricks. Some technologies call for usage of chemical accelerator like gypsum. These processes are almost similar and vary slightly from water curing to steam curing at low pressure or autoclaving at 10-14 kg/cm^2.

Bricks made by mixing lime and fly ash are, therefore, chemically bonded bricks. These bricks are suitable for use in masonry just like common burnt clay bricks. These bricks possess adequate crushing strength as a load-bearing member and are lighter in weight than ordinary clay bricks.

Generally, dry fly ash available from power plants meets the properties specified in IS: 3812 and is suitable for manufacture of Fly Ash – lime bricks in accordance with the requirements of IS: 12894.

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

2.2.1 GENERAL REQUIREMENT:

- Visually the bricks shall be sound, compact and uniform in shape. The bricks shall be free from visible cracks, war-page and organic matters.

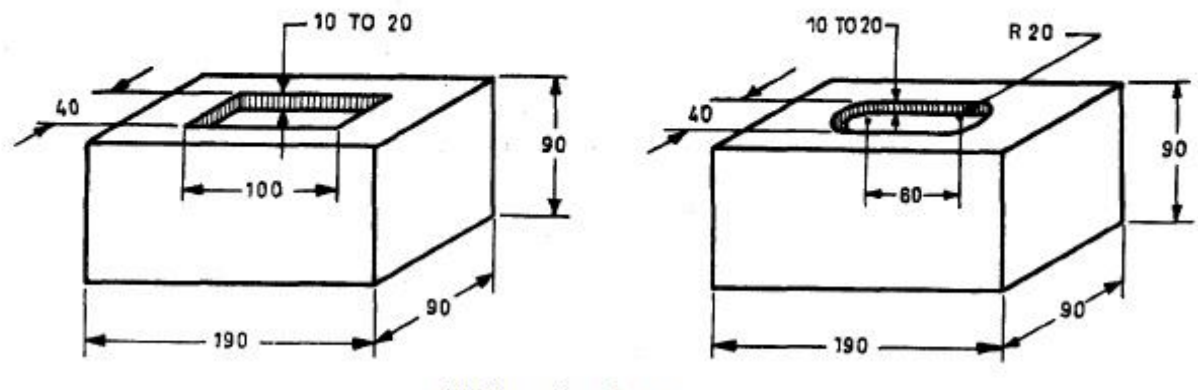

Fig. 4 Shape and size of frogs in brick

- Hand-moulded bricks of 90 mm or 70 mm height shall be moulded with a frog 10 to 20 mm deep on one of its flat sides; the shape and size of the frog shall conform to either Fig. 3A or Fig. 3B. Bricks of 40 or 30 mm height as well as those made by extrusion process may not be provided with frogs.

- The bricks shall be solid and with or without frog 10 to 20 mm deep on one of its flat side. The shape and size of the frog shall conform to either Fig. 3A or Fig. 3B.

- The bricks shall have smooth rectangular faces with sharp corners and shall be uniform in shape and colour.

2.2.2 DIMENSIONS AND TOLERANCES:

The standard ***modular sizes*** of pulverized fuel ash-lime bricks shall be as following table - 3 (see Fig. 3A and 3B) :

Length (L) mm	Width (W) mm	Height (H) mm
190	90	90
190	90	40

The following ***non-modular sizes*** of the bricks may also be used (see Fig.3A and Fig. 3B):

Length (L) mm	Width (W) mm	Height (H) mm
230	110	70
230	110	30

For obtaining proper bond arrangement and modular dimensions for the brickwork, with the non-modular sizes, the following sizes of the bricks may also be used:

Length (L) mm	Width (W) mm	Height (H) mm
70	110	70 1/3 length brick
230	50	70 1/2 width brick

Tolerances

The dimensions of bricks when tested in accordance with **5.1.1** shall be within the following limits per 20 bricks:

For Modular Size

Length 3720 to 3880 mm (3800 ± 80 mm)

Width 1760 to 1840 mm (1800 ± 40 mm)

Height 1760 to 1840 mm (1800 ± 40 mm) *(For 90 mm high bricks)*

760 to 840 mm (800 ± 40 mm) *(For 40 mm high bricks)*

For Non-moduIar Size

Length 4520 to 4680 mm (4600 ± 80mm)

Width 2160 to 2240 mm (2200 ± 40mtn)

Height 1360 to 1440 mm (1400 ± 40mm) *(For 70 mm high bricks)*

560 to 640 mm (600 ± 40mm) *(For 30 mm high bricks)*

2.2.3 CLASSIFICATION:

The fly ash-lime bricks shall be classified on the basis of average wet compressive strength as given in Table-3.

Class Designation	Average Wet Compressive Strength not less than	
	N/mm^2	$kg\ f/cm^2$ (Approx)
30	30	300
25	25	250
20	20	200
17.5	17.5	175
15	15	150
12.5	12.5	125
10	10	100
7.5	7.5	75
5	5	50
3.5	3.5	35

Table – 4 classes of fly ash lime bricks

2.2.4 COMPRESSIVE STRENGH:

The minimum average wet compressive strength of fly ash-lime bricks shall not be less than the one specified for each class in **2.3.1.** When tested as described in IS 3495 (Part 1). The wet compressive strength of any individual brick shall not fall below the minimum average wet compressive strength specified for the corresponding class of bricks by more than 20 percent.

2.3.5 WATER ABSORPTION:

The bricks, when tested in accordance with the procedure laid down in IS 3495 (Part 2), after immersion in cold water for 24 hr, shall have average water absorption not more than 20 percent by mass up to class 12.5 and 15 percent by mass for higher classes.

2.3 FaL-G TECHNOLOGY:

Fly ash- lime-gypsum (FaL-G) is not a brand name but it is duct name, christened to the mix for easy identification of its ingredients.

FaL-G technology is based on the principles namely, that fly ash lime pozzolanic reaction does not need external heat under tropical temperature condition, and strength of fly ash-lime mixtures can be greatly augmented in the presence of gypsum.

FaL-G technology was developed by institute of solid waste research and ecological balance, Vishakhapatnam. Fly ash lime mix in different proportions, is mixed in pre-determined proportions with calcined gypsum which produces FaL-G having strong binding properties and can be used as cement. It can be mixed with sand and/or aggregate to produce building blocks of any desired strength.

2.4 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.

2.5 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.

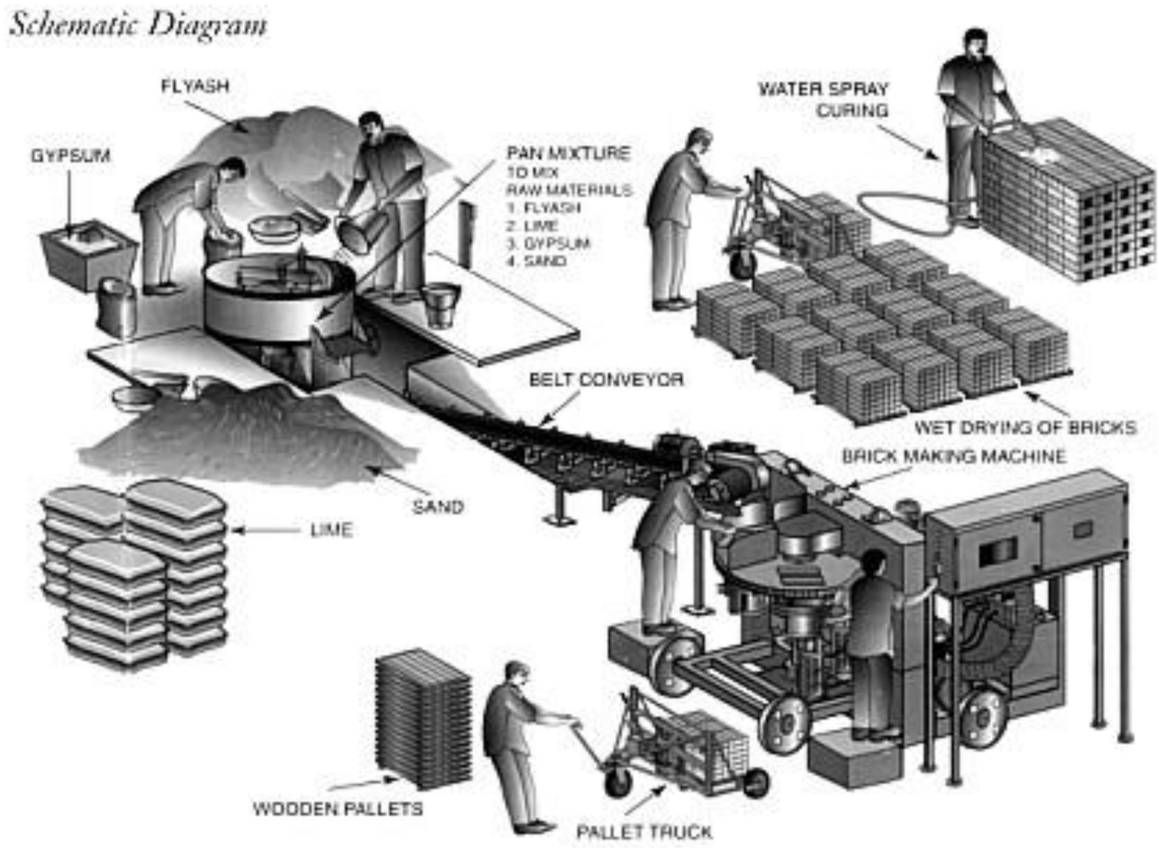

Fig. 5 Schematic Diagram of manufacturing of fly ash bricks (FaL-G Bricks)

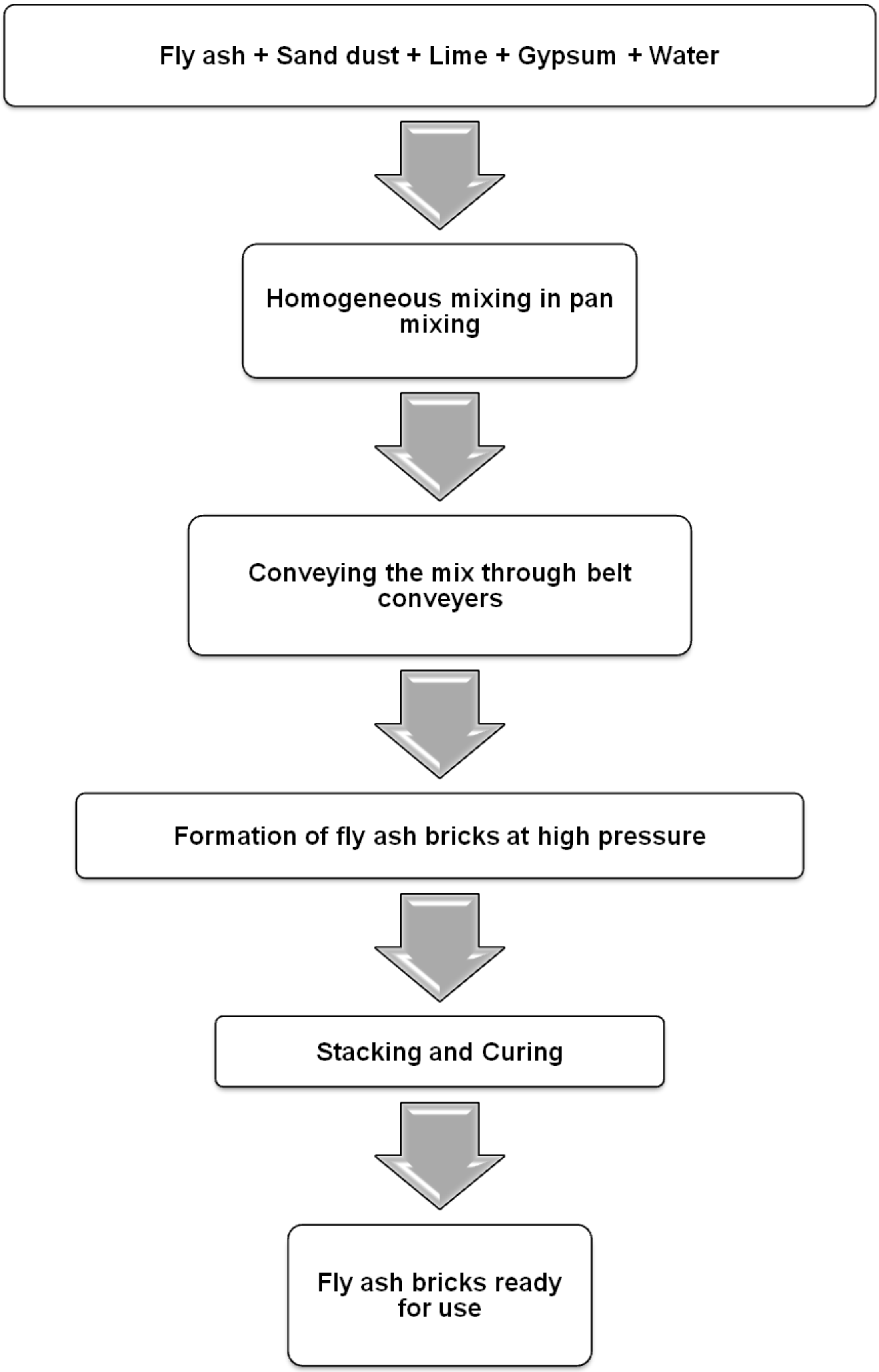

Fig. 6 Flow Sheet for the manufacture of FaL- G bricks

2.6 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, warp-age, 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 in various 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.

CHAPTER 3

FLY ASH BRICKS PLANT

(FaL-G UNIT)

Environmental Aspects and Potential Impacts

Comparison of FaL-G and Burnt Clay Brick Units

3.1 ENVIRONMENTAL ASPECTS AND POTENTIAL IMPACTS:

3.1.1 LAND USE:

Land requirement for FaL-G unit is varied from 0.5 to 1.0 hectare and confined to one place mainly, unlike red brick unit. As such FaL-G units could be operational on wide type of land, preferably flat. It should be ideal if FaL-G unit is located at notified industrial areas.

3.1.2 RAW MATERIALS:

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.

It is evident that about 85–100% of the total raw materials are either waste material or by-product, barring sand. Only OPC is used in case of non-availability/non-suitability of Lime.

Hence, there is lot of saving of natural resources like fertile soil and coal, if compared with red bricks activity.

3.1.3 WASTE MATERIALS/BY-PRODUCTS:

The main advantage of FaL-G technology is the use of waste materials/by-products produced elsewhere. Disposal of fly ash in thermal power plant and lime from paper and other industry is a potential problem of disposal. No waste material is generated from the FaL-G activity. Waste materials arising from breakage of bricks are recycled in the process itself.

3.1.4 LOCAL ASSETS:

The project development is entirely within the premises. Except for groundwater, there are no local claimants or competing users of natural resources. Land may also be considered to have competing users. However the FaL-G entrepreneurs either own the land or purchase the same through private negotiations. Therefore impact on local assets is not considered to be a significant issue.

3.1.5 NOISE:

The noise level in units operated based on grid power is negligible. Both stationary and mobile noise generating sources can adversely affect the ambient noise levels. Since the noise from mobile sources shall be intermittent as well as transient, most of the potential impacts shall be due to the continuous and stationary sources such as diesel generators & engines, pumps, motors and other rotating equipment. As per the estimation, the resultant noise level emitted from the operation of FaL-G unit is about 90-100 dB(A) which shall be attenuated and mingled with ambient noise level within 200-300 m from the source.

3.1.6 WATER RESOURCES:

Water requirement is about 500 – 1000 m^3 per million of bricks in case of using FaL-G unit. In most of the cases, the source is ground water. The magnitude of the impact depends on the water balance on the region.

3.1.7 AIR POLLUTION:

Emission of Green House Gases:

In a FaL-G unit the anticipated main green house gas is CO_2 emanating from:

- Operation of Diesel Generators in case of non-availability of grid power;
- Operation of diesel driven machinery,
- Vehicular movement.

Emissions of Other Pollutants:

The other sources of the air emission from the operation of FaL-G unit are:

- Transportation, Handling and storage of raw materials;
- Operation of Diesel Generators in case of non-availability of power;
- Operation of diesel driven machinery, if any;
- Vehicular movement.

Considerable numbers of presently operated units are taking adequate precaution during transportation. However, some more precautions need to be taken during handling and storage of raw materials in order to contain dispersion of fine dust in the atmosphere. Though impacted area is very small as quantity involved is small and height of release is almost ground level.

3.1.8 TERRESTRIAL ECOLOGY:

During operation of a FaL-G unit, the terrestrial ecology may be affected due to settlement of suspended dust carried by air as:

- ❖ Impact on fertility of soil due to settlement of dust; and
- ❖ Impact on growth of plants.

It is proved by study that the fly ash can be used as fertilizer to increase the production of crops particularly rice, wheat and cereals. But it cannot be used in any quantity for better production.

Depending on the type of crops, an optimum amount of fly ash can be used for better production.

3.2 COMPARISON OF *FAL-G* AND BURNT *CLAY BRICK UNITS:*

ISSUE	FAL-G UNIT	BURNT CLAY BRICK UNIT
1. Air Emission	**Source of Emission:** – Transportation and unloading of raw materials; – Storage and handling of raw materials; – Operation of diesel engines – Transportation of bricks	**Source of Emission:** – Handling of sand and soil; – Handling of coal; – Combustion of coal; – Removal of bricks from kiln; – Removal and handling of ash from kiln;

		– Transportation and storage of coal; and – Transportation of bricks
2. Loss of soil / Agriculture land	Nil	For brick size of 9”x4”x3” : – Loss of Soil – 1770 m^3 per million of bricks per annum; and – Loss of Land – 0.116 hectare per million of bricks per annum.
3. Waste Water Discharge	**Sources** storm water **Management** – It is possible to provide separate drainage system for storm water; and – Septic tank	**Sources** storm water **Management** – It is not possible to provide separate drainage system for storm water; because the soil is excavated from the same place for making bricks thus making that piece of land them low-lying compared to nearby land – Only soak pits could be the better & cost effective option.

4. Heat Emission	Nil	Brick firing is carried out at 1000ºC. Residual heat of the process is partly used to raise the temperature of bricks waiting for firing and: – Loss of heat through radiation; – Loss of heat through convection; and – Emission into atmosphere along with gases through stack.
5. Solid Waste Generation and its disposal	Negligible	– Ash and unburnt coal from kiln which varies from 25%-40% as per ash content in the coal; – Some of this coal-ash is used for covering the bricks in kiln for thermal insulation; and – Excess ash is disposed off haphazardly.

Table 5 Comparison of FaL-G and burnt clay brick units

CHAPTER 4

FLY ASH BRICKS PLANT VISIT

4.1 FLY ASH BRICKS PLANT VISIT:

We have visited fly ash bricks plant which is located at Swaminarayan Temple (BAPS), aksharvadi, Bhavnagar.

PLANT LOCATION:

Shri Swaminarayan Mandir,

Aksharvadi,

Vaghavadi Road,

Bhavnagar,

Gujarat - 364002

Fig. 7 Fly ash bricks plant location

Shri Swaminarayan Mandir, Aksharvadi is a good example of use of fly ash bricks in Bhavnagar. We also visited the construction of hostel (Aksharpurshotam Chhatralay) made for students beside the temple, where these bricks are being used.

On site, the engineer told the process of making the fly ash bricks. The material required for making of fly ash bricks are used in this plant are fly ash taken from Nirma Chemical Complex (Bhavnagar), Lime taken from Exel Crop. Ltd. (Bhavnagar), Gypsum purchased from Baroda and Sand dust. The proportion of these raw materials is generally in the ratio 50-60% of fly ash 10-20% lime, 05-10% Gypsum and 15-20% sand, depending upon the quality of raw materials are used in this plant.

In this plant, Fly ash bricks are made by mixing the ingredients (Fly ash + lime + gypsum + sand dust) in the appropriate proportion using mechanical mixer with the addition of water. After mixing, the mixture is conveyed through belt conveyor to the mechanical presses, in this paste has been moulded to shape of brick by applying 70-80 tons load over the dye. The green bricks are dried up under sun from 24 hours and 7 days curing for creating a good quality of fly ash bricks.

In this plant 8 to 10 workers work for one day produce around 6000 to 7000 bricks. The bricks are environment friendly. And also it is cheaper than conventional clay bricks comparatively.

PROPERTIES OF THIS BRICKS:

- Size: 9” x 4” x 3” inch.
- Colour: Reddish gray
- Compressive strength of bricks is 55 to 100 kgf/cm^2.
- Water Absorption: 10 to 15 %
- Light weight

This fly ash bricks are used in dome of Shri Swainarayan Temple, Aksharpurshotam Hostel, Sabha Hall etc. Below pictures shows structure in which fly ash bricks are used.

Fig. 8 Structures in which fly ash bricks are used

This Fly ash bricks have many advantages like:

- Due to high strength, practically no breakage during transport & use.

- Due to uniform size of bricks mortar required for joints & plaster reduces almost by 50%.
- Due to lower water penetration seepage of water through bricks is considerably reduced.
- The buildings using fly ash bricks are cool in summers and warm in winters. The high insulating property, with low embodied energy, of our products reduces the energy consumption of the buildings significantly by as much as 40-50%.
- Fly ash bricks are sound absorbent and restrict sound transmission keeping the interiors very pleasant and quiet.
- Fly ash bricks resist salt and other sulphates attack, ensuring no efflorescence in the structure.

We also have taken the bricks to conduct few experiments on it to justify the quality of fly ash bricks. Experiments which we performed are visual analysis, measurement of dimension, determination of water absorption and compressive strength of fly ash bricks.

In visual analysis and measurement of dimension we measured the length, depth and height of given fly ash bricks as per clause 5.2.1, IS 12894:2002. Dimension of these FA bricks are compared to normal bricks is more.

In water absorption test (as per IS 3495 (Part 2) : 1992) we compared the change in weight of given FA bricks before and after soaking of brick in water for 24 hours.

In compressive strength test (as per IS 3495 (Part 1) : 1992) we determine compressive strength of given FA bricks. Compressive strength of these bricks are around 55-60 kg/cm^2 which is higher than normal clay bricks.

These experiment and result are described in chapter 5 - Testing of fly ash bricks.

CHAPTER 5

TESTING OF FLY ASH BRICKS

Measurement of Dimensions of Brick

Determination of Water Absorption

Determination of Compressive Strength

5.1 TESTING OF FLY ASH BRICKS:

We have taken some bricks from fly ash bricks plant located at shri swaminarayan temple to conduct few experiments on it to justify the quality of fly ash bricks. The experiments and result are explained below:

5.1.1 MEASUREMENT OF DIMENSIONS OF BRICK:

For the bricks' dimensions measurement, the procedures were based on Clause 5.2.1, IS 12894:2002. The required apparatus in this test was measuring tape.

In this test, a total of 20 (or more according to the size of stack) bricks were selected randomly from the bricks stack. Any blister, small projections or loose particles of clay that adhered to each brick had to be removed. The bricks were then placed in contact with each other in a straight line upon a level surface. The method of arranging the bricks depended on which dimension to be measured; length, width or height. The Figures 8 shows the arrangement of bricks respect to the dimension measured.

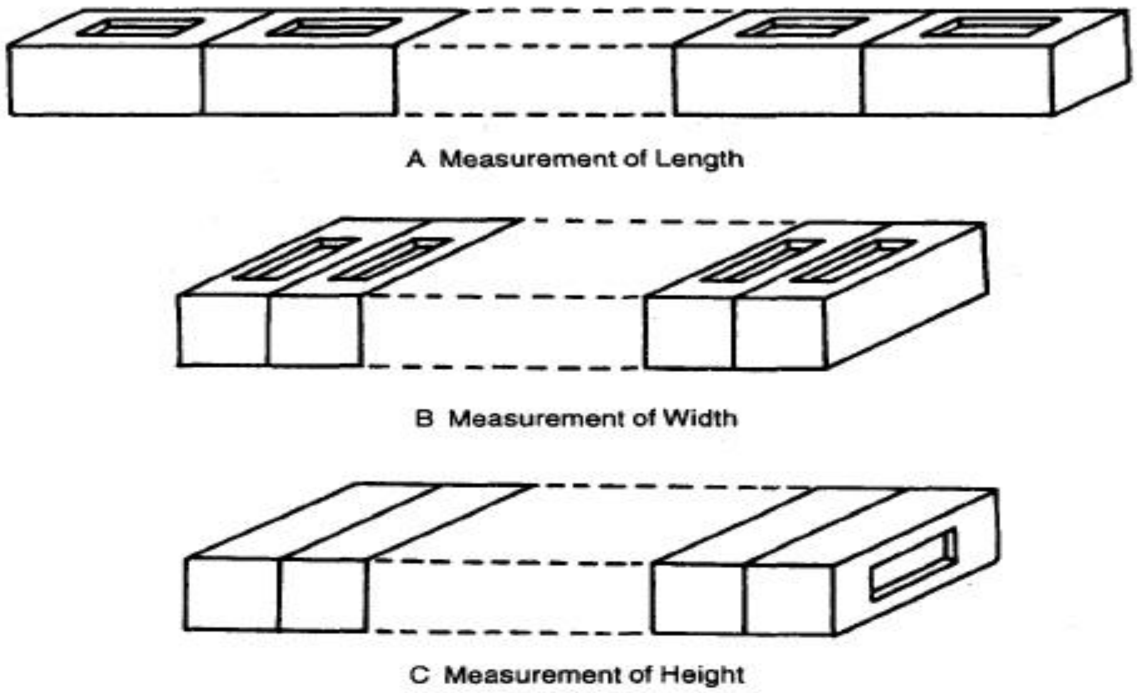

Fig.9 Arrangement of bricks for measurement of (a) length, (b) width, and (c) height

The overall length of the assembled bricks shall be measured with a steel tape or other suitable inextensible measure sufficiently long to measure the whole row at one stretch. Measurement by repeated application of short rule or measure shall not be permitted.

If, for any reason it is found impracticable to measure bricks in one row, the sample may be divided into rows of 10 bricks each which shall be measured separately to the nearest millimetre. All these dimensions shall be added together.

RESULTS AND ANALYSIS:

Measurement of the bricks' dimensions was done based on the procedures given above. 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

Table 6 the results obtained from the measurement of 10 bricks

From the measurement done on 10 bricks, the total length, width and height obtained were 2370 mm, 1150 mm and 790 mm.

By taking the mean for the dimensions of a single brick, a brick was 237 mm in length, 115 mm in width and 79 mm in height.

5.1.2 DETERMINATION OF WATER ABSORPTION:

(24-hour Immersion Cold Water Test)

- **APPARATUS:**

A sensitive balance capable of weighing within 0.1 percent of the mass of the specimen and a ventilated oven.

- **PRECONDITIONING:**

Dry the specimen in a ventilated oven at a temperature of 105 to 115 °C till it attains substantially constant mass. Cool the specimen to room temperature and obtain its weight (M_1). Specimen warm to touch shall not be used for the purpose.

- **PROCEDURE:**

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 (M_2). 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 %**

From the result average % of water absorption is 19.26 %.

5.1.3 DETERMINATION OF COMPRESSIVE STRENGTH OF FLY ASH BRICKS:

- **APPARATUS:**

  Compression testing machine, measuring tape or scale, surface grinder, plywood sheets.

- **PROCEDURE:**

  - **Preparation of Sample :-**

    i. Remove unevenness observed in the bed faces to provide two smooth and parallel faces by grinding.
    ii. Immerse the sample in water at room temperature for 24 hours.
    iii. Prepare cement mortar (1:1) and fill the frog and all void in bed faces with it.
    iv. Store the sample prepared in (iii) under damp jute bag for 3 days in clean water.
    v. Remove and wipe out a trace of moisture.
    vi. 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/mm^2 per minute till failure occurs; Note the maximum load at failure

- **CALCULATION:**

Compressive Strength (N/mm^2) =

$$\frac{\text{Max.Load at Failure in N}}{\text{Avg.Area of Bed face in mm2}}$$

❖ OBSERVATION TABLE:

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)**

From the result average compressive strength is 5.425 N/mm^2 (approx 54.25 kg/cm^2) which is higher than normal clay bricks.

CHAPTER 6

CONCLUSION &

REFERENCES

6.1 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/cm^2

% Water absorption = 19.26 %

The results shows the FaL-G bricks are more safe, economical and having higher strength compare to conventional bricks. Comparison of Fly ash bricks and ordinary red clay bricks are shown in below table.

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 %

Table 9. Comparison of Fly ash bricks and ordinary red clay bricks

Further Fly ash bricks have many advantages like -

- Light weight
- Economical
- Environmental friendly
- Saving of fertile land, pure water
- More compressive strength
- Use of wastage etc.

Thus, Fly ash brick is one of the best uses of fly ash. It may be concluded that the use of fly ash in brick manufacturing industry is techno-economically viable, if utilized by application of optimum technologies, which are available with commensurate levels of automation and capacity generation. Fly ash brick manufacturing is a potential field of application wherein large-scale utilisation of fly ash is possible.

From the previous chapters it can be understood that fly ash bricks are better alternative to conventional burnt clay bricks in structural, functional and economic aspects. This industry has the potential to consume at least 50% of the ash production in India. By use of this aspect we can convert waste into wealth.

After looking into all the facets of fly ash brick industry and its different applications in the previous chapters, in the end it is a request to all the government and nongovernment organizations involved in generation, research and development and utilisation of fly ash, to extend all possible help in terms of technology, resources or finance to the entrepreneurs who are trying to come forward to set their plants in spite of tough competition and numerous set back in marketing. If this much could be done, it will prove to be a big stepping stone towards the present need of sustainable development.

6.2 INDIAN STANDARD REFERRED:

1.	IS 12894 : 2002	Pulverised Fuel Ash-Lime Bricks – Specification (first Revision)
2.	IS 3812	Pulverised Fuel Ash – Specification
	(Part 1) : 2003	For use as Pozzolana in Cement, Cement Mortar and Concrete
	(Part 2) : 2003	For use as Admixture in Cement Mortar and Concrete
3.	IS 456 : 2000	Plain And Reinforced Concrete - Code Of Practice (Fourth Revision)
4.	IS 3495	Method of Testing of Burnt Clay Building Bricks
	(Part 1) : 1992	Determination of Compressive Strength
	(Part 2) : 1992	Determination of Water Absorption
	(Part 3) : 1992	Determination of Effloration

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4. Environmental and Social Review (ESR) for FaL-G Bricks/Blocks Project prepared by Eco Carbon Private Limited, Visakhapatnam.

5. S. K. Malaviya, B. Chatterjee And K. K. Singh, 'Fly Ash - An Emerging Alternative Building Material', National Metallurgical Laboratory, Jamshedpur, PP. 59-67.

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