Study on Innovative Building Materials Used in Fly Ash Bricks Manufacturing with Various Mix Proportion

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Abstract -- The cost-effective building materials otherwise known as low cost building materials are the materials used in building construction with appropriate technology to reduce overall constriction cost compared to conventional types of building. This is possible by using locally available materials with appropriate technology. These techniques are developed by various agencies like HUDCO, Auroville Building Center and practically tested at Department of Civil, Civil & Structural Engineering, Annamalai University. In construction industry low cost building materials which reduces the construction costs. The technology and materials are may not be the same to all areas. It depends upon the availability of suitable material, labour etc., because transporting materials will increase the construction costs. The process of reduction in the construction cost starts from the planning itself. Planning the building to the various requirements and cutting down the unnecessary cost definitely result in cost reduction. The major cost in the construction is on the cement, steel, bricks and timber. Use of alternate building materials will reduce the quantity of the above said materials which results in cost reduction. The quality of the materials used in the conventional type are not now a days in the desired standards. But the alternate building materials or otherwise known as cost effective building materials used in this technique are manufactured by the constructor himself and at the site itself which ensures good quality and reliable. Now various Government and non-Government agencies are employing these materials which appropriate technology for group housing schemes and other related projects

Indexed Terms: Low cost, building materials, Fly ash bricks, appropriate technology

I. INTRODUCTION

Fly ash is a waste arising due to various Industrial activities. The annual production and availability of Industrial waste like fly ash is about 30 million tons per annum thrown a challenging task to make use of such materials which otherwise are creating environmental problem. At the same time there is growing global consciousness in the past two to three decades to utilize fly ash in various form in the construction activities.

The reason for this awareness is mainly by the threat due to accumulation of millions of tons of fly ash every year in all countries.

Dumping of dry fly ash on land devours large areas of fertile land and also flies of in the air to places near the dumping ground making the atmosphere dusty and unhealthy. Wet dumping with water creates problems like polluting the ground water in addition to dewatering the land where this fly ash slurry is disposed off in ponds.

To overcome these problems many new uses for fly ash have been found out thorough research one of such is in making building bricks in conjunction with clay or other soils and sand. The use of fly ash has the added advantage of conserving fertile top soil in brick manufacturing areas as 50,000 acres of fertile top soil destroyed every year for the brick production.

In view above mentioned facts the need for scientific and pollution free disposal of fly ash has become compelling necessity. Being pozzolonic material rich in silica content, fly ash an important building material has been accepted as Eng. reality in the Industrially; advanced countries are utilizing 70 % of fly ash production in various application whereas the Indian level of utilization is up to only 5 % In this study possibilities for the bricks manufactured with fly ash and practices so far adopted are explored and presented.

II. NEED AND OBJECTIVES OF THE STUDY

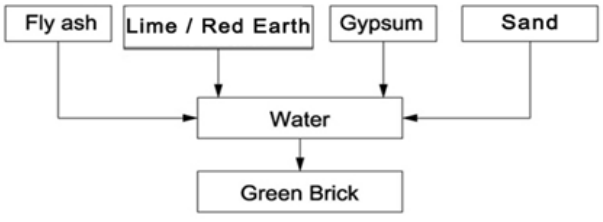
Next only to food and clothing the third world has on in as major problem, massive and gigantic deficit in housing. Coupled with this are the limited resources of land, finance, building materials and a time has come to ensure optimum utilization of these resources.

Building materials and construction technology requires environment friendly and affordable development by utilizing local and appropriate resources. The most important resources required are finance, materials, manpower, machinery, technology transfer mechanism and its management. The main objectives of the study are,

- To investigate the compressive strength of fly ash bricks using red earth,
- To determine the water absorption capacity of fly ash bricks

Huge quantities of Fly ash are being generated daily from various Industrial activities. One such fly ash contribution being the Thermal power plants. The disposal of the huge mass of Fly ash has been a problem all along and researches have been carried out continuously to determine alternative uses of Fly ash. In this paper, an attempt has been made to stand by the possible use of fly ash as a building material.

III. MATERIALS AND METHODS



Flow Chart for Preparation of Bricks

Properties of Fly Ash and Chemical Composition:

Loss on Ignition	.....	1.02 %
Silica as sio2	.....	6.85 %
Iron as Fe2 O3	.....	0.72 %
Alumina as Al, O,	.....	2.08 %
Calcium as Cao	.....	2.61 %
Magnesium as mgo	.....	0.75 %
KjO Pottasium	.....	0.07 %
Na2O Sodium	.....	40.73 %
Sulphate SO2	.....	45.17 %

Fly Ash

Gypsum:

Gypsum is a very soft sulfate mineral composed of calcium sulfate dehydrate, with the chemical formula CaSO4 2H2O. It is found in alabaster, a decorative stone used in Ancient Egypt. It is the second softest mineral on the Mohr's scale of mineral hardness. It forms as an evaporate mineral and as a hydration product of anhydrite. Gypsum is a common mineral; with thick and extensive evaporate beds in association with sedimentary rocks. Gypsum is deposited from lake and sea water, as well as in hot springs, from volcanic vapors, and sulfate solutions in veins. Hydrothermal anhydrite in veins is commonly hydrated to gypsum by groundwater in near-surface exposures.

Gypsum

Chemical composition of gypsum

Sl.	Chemical Compositions	% of components
1	SiO_2	0.86
2	Al_2O_3	0.56
3	Fe_2O_3	0.05
4	CaO	34.6
5	P_2O_5	1.23
6	SO_3	53.2
7	Na_2O	0.56
8	LoI	8.9

Lime:

Lime is truly a versatile material in building construction projects. Lime can be used to prepare the construction site by stabilizing the soil or remediating Brownfield sites. Lime can be used in the construction of masonry systems as a component of mortar or the masonry unit. In the hardened state, lime products react with carbon dioxide to regenerate calcium carbonate or limestone. Initial strength is needed in most applications; additives such as gypsum, cement or pozzolan are mixed with lime in construction applications.

Lime

Lime can react with pozzolanic materials in the mortar or plaster to produce a cement-like product. The strength of lime-based mixes can be modified based on the application. This is beneficial in restoration applications where low strengths and high vapor permeability are needed. The hydrated lime is used for fly ash brick making should conform class-C grade as specified IS: 712:1984.

Chemical Composition of Lime

Sl.No	Chemical composition	% of component
1	SiO_2	> 2.5to 1.23
2	Al_2O_3	> 1.5 to 0.56
3	Fe_2O_3	> 2
4	CaO	> 83.3 to 94.3
5	K_2O	1.23
6	MgO	> 0.5 to 1.23
7	SO_3	< 0.5
8	$CaCO_3$	< 10
9	CO_2	< 5
10	Na_2	0.4 to 0.5

Water:

Water is an important ingredient of brick as it actually used for manufacturing of brick. Hence it helps to bind all the raw materials for giving proper mix. Water used for making brick should be free from impurities. Meteoric water is required for the preparation of various mix proportions. The pH of water should be over the value of 7 and free from organic and dissolute matter satisfy the standard water quality for construction IS 3025

Physical Analysis of Flv Ash

Density 1.36 gm/cc Specific gravity 2.69 Specific surface 2866 cm2/gm

Sieve analysis

Above 300 micron ..... 10 %

300 to + 150 micron ..... 35 %

below 150 micron ..... 55 %

Setting time

Initial 7 minutes

Final 145 minutes

Compressive strength

7 days 275 Kg/cm2

28 days 395 Kg/cm2

Section of fly ash

The fly ash will be good for brick production, if the loss on ignition is below 5 %.

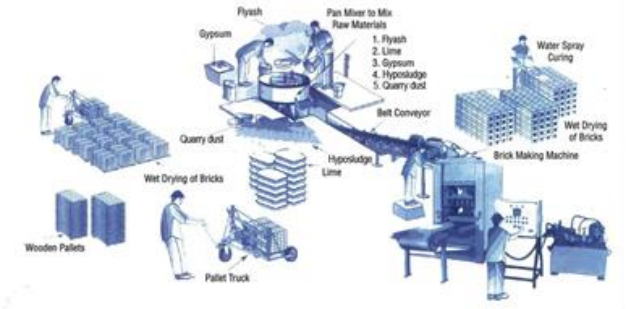
Various mixes with fly ash

Fly ash: sand: lime: gypsum Cement: fly ash: sand Cement: fly ash: red soil

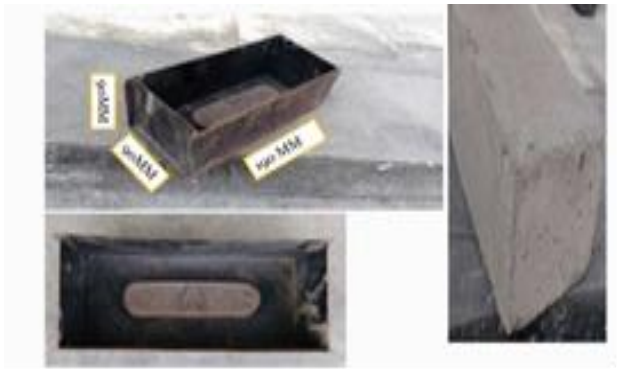
Production of fly ash bricks

The machines used for the manufacture of stabilized mud blocks can very well used for the manufacture of fly ash bricks of conventional sizes. Some motorized machines are also available in the market for the production of bricks and the output of these machines. The machine manufactured by the Engineers Enterprises, Coimbatore produces 8000 to 10,000 of bricks conventional sizes per day. Another motorized machine manufactured by the same Industry is used for manufacturing blocks of large size 39 x 19x 19 cm based on the vibro compaction process. This machine is of Egg laying type and movable. Mix is feeded in the machine and the machine lays compressed blocks on the ground similar to egg laying i while moving. This operation requires large space for the manufacture and the convenient of the machine. The Initial cool of Installation is high.

The above machines are installed in NLC precast yard and are well suited for the manufacturing of bricks commercially. Theses motorized machines are suitable for the centralized production of bricks. But for small projects, the hand pressed type machine is more suitable as the machine can be transported easily to the site and bricks can be manufactured at the site itself.



Brick making process



Production of Fly ash Bricks

The different proportions adopted are,

1) Fly ash: Sand: Lime: Gypsum

65 % : 20 % : 10 % : 5 %

Brick production with above proportion of mix requires mechanical type machine. The gypsum and lime added instead of cement for stabilization. First the lime and gypsum is fed in to the grind ring unit where grinding operations takes places. After grinding and mixing is completed then this mixture is fed in to the mixer where sand and fly ash and water is added After through mixing the mortar is fed in to the compressing unit where this is fed in to the moulds and then compressed with the compression ratio 1:7 the filling and compression takes place the simultaneously and

gives more output of 8000 to 10,000 bricks of size 23x11 x7.5 cm .The wet bricks are stacked and cured for nearly for 15 days then taken for construction. The cost of bricks produced in this type is about Rs. 1.50 per number.

2) Cement: Sand: Fly ash

The proportions adopted are cement: Sand: fly ash i) 5% : 20 % : 75 % ii) 10 % : 85 % : 5% The first mix is suitable for hand pressed machines and the bricks manufactured in this type is of size 23x 11 x7. 5 cms and cost is about Rs. 1.60 per number.

The second mix is suitable for manufacturing big size solid blocks ofsize39xl9xl9cms. Theses blocks can be manufactured in egg laying type machine described earlier. These blocks are useful for foundation works. The compressive strength of this block is 60 kg/cm 2 and cost is Rs. 18/ number.

3) Cement: Fly ash: Red earth

i) 10% :40%:50% ii) 10% :30% : 60 %

Good soil for this production should contain the following

Gravel — 15%

Sand — 50 %

Silt — 15%'

Clay — 20%

The physical property of the red soil based on the above percentage is given below;

Specific gravity — 2.32%

Liquid limit — 18.64%

Plastic limit — 14.48%

Shrinkage limit — 13.28%

Water absorption — 8 to 11%

Manufacturing agencies in AUREKA in Auroville is manufacturing the latest module of machine by the name AURAM press 3000 multi-mould manual press making economical size of blocks for construction.

1) 24 x 24 x 10 cm for load bearing walls

2) 24 x 11.5 x 10 cm for Halt blocks.

3) 19 x 9 x l0 cm for compound wall

IV. STABILIZED MUD BLOCKS:

Stabilized mud blocks are also known as compressed earth blocks and soil cement blocks. The use for the construction has recently attracted the attention of users and building professionals. The SMB are made of mud stabilized with 5 % of cement and lime etc. and compacted in the block making machine with no burning. SMB are good walling material as burnt brick and is economical, stronger, energy saving and simple to manufacture. The country bricks are stabilized by firing them in the chambers. The SMB are stabilized by adding cement and by compressing them in the block making machine to the required compressive ratio.

Production

The production process of stabilized Mud blocks involves following steps:

- Selection of suitable soil and stabilizing agent.
- Mixing the stabilizer and moisture.
- Block pressing
- Stacking of blocks and curing

Good soil for the mud block production should contain the following,

Gravel - 15%

Sand - 50 %

Silt - 15%

Clay - 20 %

Normally the soil may be classified as Gravely soil, Sandy soil, Silty soil, Clayey soil. According to the original soil quality, some easy improvement can be done either by adding materials, sieving or stabilizing.

Gravely Soil:

Soil to be sieved to remove the coarse gravel and fine clay powder may be added.

Sandy soil:

Sieving is only required to loosen and aerate the soil.

Silty soil:

Sieving is required if the lumps are too big and cohesive and slight crushing might be required.

Clayey soil:

The soil may be spread in a thin layer about 15 cm thick on level ground and about 15 % moisture sprinkled on the lumpy soil the soil may be left in that condition for a day and then lumps may be broken on softening the soil. In Pondicherry and around Cuddalore District, good quality red soil is available at reasonable cost. This may be transported to the site for block making. But transporting must not increase the cost of blocks. The red soil gives fine aesthetic finish and preferable.

Mixing the stabilizer and moisture

The stabilisation implies modification of the properties of soil-air-water system in order to obtain lasting the properties computable with particular application. The stabilizer may usually be lime or cement. Lime gives better results on clayey soil-normally 5 % of stabilising agents are required to be added for good results.

First the soil is to be measured and spreader on the level ground. Over this the stabiliser has to be spreader to equal thickness and mixed thoroughly so that no color of cement is seen. Then water has to be sprinkled and mixed thoroughly by hand. After all the water is added, test whether the moisture content is optimum. Optimum water content is the one which is sufficient enough to complete the hydration process and further it should be sufficient enough to make a computable plastic mix so thai handling and compaction could be facilitated. The mix may be tried with various water contents. Observations were made for about 5 to 10 minutes and concluded that the water content corresponding to the stage at which the balls made with the mixes kept on the surface should not disintegrate or distort by itself, was selected as the required water content. If the water is found more, some dry mortar may be added to reduce moisture. The mortar has to be prepared in batches. Larger bath size means that the last few blocks will be pressed after the initial setting of cement. This leads to poor strength gain.

Block pressing:

Various agencies are manufacturing the presses ie., block making machine. In our area AUREKA in Auroville is manufacturing the latest model of machine by the name AURAM press 3000 multi mould manual press. Any size of blocks can be manufactured by changing the required mould. Various sizes and shapes of blocks that can be manufacture from this machine are given in the sketch enclosed

Economical size of blocks for construction

a. 24 x 24 x10cm: Suitable for load bearing walls of two storey buildings.

b. 24 x 11.50 x 10 cm: Half blocks to create bonding.

c. 19 x 9 x 10 cm: Suitable for compound walls and

A .C sheet roofs

Technical Specification of the machine.

Available force	:	150 KN
Compression ratio	:	1.60 to 1.83
Block height	:	25 and 50 ; then upto 100 in 5mm increments
Practical output	:	125 stocks per hour
Net weight	:	365 to 415 kgs

Stacking the blocks and curing:

The blocks ejected from the mould are of fragile nature. Hence great care must be taken for lifting the block from the machine to the slack yard. First the blocks are stacked near the machine and covered with plastic sheet and allowed to dry to three days. After three days the blocks; in re -stacked near the construction site and cured for 10 days. Top of slacks may be covered with palm leaves or straw to prevent the evaporation of water

V. FINENESS OF RED SOIL IN CUDDALORE DISTRICT

Sl. No	ISI sieve number		Residue in Percentage	Remarks
	Micron	Size in mm		
1	2300	2.36	1.00	Small gravel particles
2.	1190	1.18	2.33	-
3.	600	0.60	19.67	-
4.	300	0.30	59.00	-
5.	150	0.15	11.33	-
6	-	-	6.67	Silt

Properties of red soil in Cuddalore District

1. Specific gravity - 2.32
2. Liquid limit - 18.64%
3. Plastic limit - 14.48%
4. Shrinkage limit - 13.28

Cement of 43 grade OPC in used for making SMB's

Basic requirements of SMB:

1. Dry compressive strength (28 days) - 4 to 6 Mpa (+40% after 1 year; +50% after 2 years)
2. Wet compressive strength (28 days) - 2 to 3 Mpa (after 1-day immersion)
3. Dry bending strength (28 days) - 0.5 to 1 Mpa
4. Dry shear strength (28 days) - 0.4 to 0.60 Mpa
5. Absorption (28 days) - 8 to 11% (after 1 day immersion) .
6. Apparent bulk density - 1700 to 2000 kg/m3
7. Energy consumption - 120-175Kcalx 103/m3

VI. CONSTRUCTION

The Fly ash blocks can be constructed in load bearing and non-load bearing walls in cement mortar a burn clay bricks Based on the experience of HUDCO the following have been derived

For two storied load bearing structures the basic compressive strength required for the brick's minimum 2 MPa

For single storey the bricks should have minimum compressive strength of 1.2 MPa The fly ash bricks are not normally having a aesthetic appearance as SMB. Hence colour washing is necessary

Compressive Strength of stabilized soil cement block with fly ash

S. No.	Mix proportion C:FA: S	Compressive Strength in N/m2 Days				Remarks
		7	14	21	28	
1.	10:20:70	2.46	2.52	2.76	2.92	The block size 24x24x 10 cms are tested under wet condition
2.	10: 30:60	2.56	2.77	3.00	3.20	
3.	10:40:50	2,65	2.96	3.10	3.27	
4.	10:50:40	2.12	2.22	2.37	2.40	

Fly ash Generation and its Potential uses

Name of Work	Industry	Production Availability (million tonnes / Year)	Potential user building materials
Fly ash	Thermal Power plant	30	Cement, Brick, light weight aggregate for concrete
Steel and Blast furnace slag	Iron and steel industry	35	Cement
By Product gypsum	Fertilizer phosphoric acid, hydrofluoric acid industry	4.5	Cement, Plaster of pans, Plaster Board
Cylinder	Thermal power station and Railway using lump coal	3.0	By product gypsum aggregate
Mixing drilling	Zinc, Copper, Iron beneficial plant	5.0	Calcium slicate brick
Red mud Water works silt	Aluminium Industry Water works	1.5 10.0	Corrugated roofing sheet Bricks
Rice husk	Rice mills	25.30	Particle Board

7 Mix proportions

Sl.No	Fly ash %	Lime %	Quarry dust %	Gypsum %
1	60	20	15	5
2	60	15	15	5
3	60	10	15	5
4	60	5	15	5
5	60	0	15	5

Quantity of Materials used

Sl.No	Fly ash kg/brick	% of Slag Added	Lime kg/brick	Sand kg/brick	Gypsum kg/brick
1	1.698	0	0.566	0.4245	0.1415
2	1.698	5	0.4245	0.4245	0.1415
3	1.698	10	0.283	0.4245	0.1415
4	1.698	15	0.1415	0.4245	0.1415
5	1.698	20	0	0.4245	0.1415

VII. CONCLUSION

In this paper an attempt has been made to utilize the fly ash generated in large quantities from different industrial sources, as a building material. Different compositions of the fly ash bricks have been tried and tested for their strengths. The composition of the constituents of fly ash bricks has to be judiciously decided considering the nature of locality available soil, the nature of works to be carried out and may utilization of fly ash have generated.

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