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Field Manufacture of Clay Fly Ash Bricks from Alluvial Soils

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ABSTRACT

Field demonstrations to manufacture clay fly ash building bricks from alluvial soils of Hardwar (U.P.) and Faridabad (Haryana) utilising waste fly ash from BHEL Hardwar and Haryana State Electricity Board, Thermal Power Plant, Faridabad were undertaken at private kilns at pathri (Hardwar) and Kherikalan (Faridabad). Over one lakh clay fly ash bricks were manufactured at each of the kilns by manual mixing of 10 to 15% by volume of fly ash to the sandy loam of Pathri (Hardwar) and 30 to 35% by volume of fly ash to clayey loam of Kherikalan (Faridabad), hand moulding and firing in Bull's kiln in the temperature range of 980-1020°C. Clay fly ash bricks of strength varying from 70 to 170 kg/cm², water absorption 10 to 18%, bulk density 1.50 to 1.75 g/cc and free from efflorescence were manufactured. The addition of fly ash reduces the coal consumption upto 25 percent during firing and does not affect the quality of the manufactured building bricks. Its use reduces the disposal problems besides heavy cost of disposal met by the thermal power plants. The cost of production of clay fly ash bricks is almost the same as that of normal clay building bricks.

Introduction

The growing shortage of coal and its high cost of transportation have created difficulties in the production of good quality building bricks and has grossly affected the productivity to meet the demand of bricks in the country. This situation is likely to grow as the country is passing through energy crisis. In view of this it has been felt quite to use alternative fuels instead of coal for burning bricks and to develop a suitable technology to utilise the inferior grade of coal, agricultural wastes such as rice-husk, ground nut shell, bagasse, saw dust etc. In [illegible]. Another approach to this problem is to conserve fuel consumption by utilizing unburnt carbon present in some industrial wastes like fly ash, cinder, rice husk ash etc. as an admixture to suitable brick earths. The Central Building Research Institute has carried out extensive investigations on this approach, wherein industrial waste as fly ash has been utilised in the manufacture of good quality building bricks.

The results of these investigations have been put to commercial application by demonstrating the process to the industry. The results of the field demonstrations carried out on alluvial soils of U.P. and Haryana are given in this paper.

Characteristics of Raw Materials Used

A. Fly Ash

Fly ash is an important industrial waste presenting disposal problems besides a health hazard in the region where it is thrown away. Most of the

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thermal power plants in the country are located around big cities, wherein the demand of building bricks always increasing and fly ash also is abundantly available. Some field domonstrations for the manufactvre of clay fly ash bricks were undertaken at Pathri (Hardwar) at the request of Bharat Heavy Electricals, Ranipur (Hardwar) and at a private kiln at Kherikalan, Faridabad. For these trials, the fly ashes from 15MW thermal power plant at BHEL Ranipur (Hardwar) and 100 MW Haryana State Electricity Board thermal power plant at Faridabad were utilised. These plants are disposing off about [illegible] tonnes of fly ash per day respectively. The characteristics of the fly ashes from the two plants are given in Table 1 which show that the BHEL fly ash is comparatively coarser than Faridabad fly ash and the unburnt carbon present in BHEL fly ash is relatively 2-4 times higher than the Faridabad fly ash.

B. Soils

The alluvial soils were taken for the trial manufacture of clay fly ash bricks and were selected from the private kilns at Pathri near BHEL Hardwar and Kherikalan (Faridabad) which were used for the manufacture of bricks using conventional practices. These soils are sandy to clayey loam possessing low to medium plastic index of Pathri soil is low. The characteristic nature of these soils and the variations in their properties are given in Table 2. These soils are free from calcareous nodules and predominantly contain mica group of clay minerals. They are a mixture of illite, muscovite and kaolinitic clay minerals.

Preparation of Clay Fly Ash Admixtures and Moulding of Bricks

The soils from the two kilns at Pathri (Hardwar) and Kherikalan (Faridabad) was dug upto a depth of 1.8 to 2.0 metres. The fly ash was sieved with a screen of 1mm size to remove the lumps formed and other impurities in the form of aggregates which get admixed during or long exposure of fly ash to the atmosphere. The sieved fly ash is manually laid over the brick earth in alternate layers. For preparing admixtures, the following proportions were found optimum for hand moulding of bricks.

Mix Proportions by Volume

Soil	*Pathri (Hardwar)*	*Kherikalan (Faridabad)*
	65 88	65-70
Fly Ash	12-15	30-35

To achieve these proportions in the field, 0.40-0.50 cu m (14-17 cu ft) of BHEL fly ash or 1.3-1.5 cu m (45-50 cu ft) fly ash from Faridabad was mixed with 2.8 cu m (100 cu ft) of soil. Fly ash and soil were laid in alternate courses over each other. The mixtures so obtained were two to three times dry-mixed manually. The mixture was watered to make a loose consistency of clay fly ash mass and left overnight for complete disintegration of clay nodules. The wet clay mass was manually kneaded and mixed several times to ensure uniform mixing. A slightly higher moulding moisture 2 to 3 percent above plastic limit in the clay mass was retained for proper moulding. This soil fly ash mixture was used for hand moulding. It was found sufficient to mould 1500 bricks at Pathri and 1800 bricks at Kherikalan. In this way mixturers at several lots were prepared by the brick moulders to mould about one lakh bricks, of 22.5x11.2x7.6 cm size. The bricks were put to over too setting pattern for drying in the open, as is conventionally adopted. There were no significant losses of bricks during drying and the drying time was almost similar as found for bricks without fly ash. The details of fly ash consumption for moulding one lakh bricks at both the kilns are given in Table 5A. The liner drying shrinkage in clay fly ash bricks at both the kilns was found to vary within a range of 3 to 5 percent.

Firing of Bricks

The dried bricks were transported by mules and were manually set in the kilns. The usual setting pattern was adopted for setting these bricks also in the Bull's kilns. Handling green strength of clay fly ash bricks was good and no appreciable losses during lifting from the drying yard and setting in the kiln were observed.

The normal practice of firing the bricks in Bull's kiln was adopted. The bricks were fired in the temperature range of 980-1020°C. Grade 1 coal

from Bihar was used for firing the bricks. The coal consumption for firing clay fly ash bricks at Pathri (Hardwar) and Kherikalan (Faridabad) was 11.8 and 12 tonnes per lakh of bricks respectively.

Brick Production

The clay fly ash bricks manufactured and bricks without fly ash additive as obtained from the kilns were classified in three grades on the basis of colour, shape and ringing sound. These results are given in Table 3. It shows that the production quality of clay fly ash bricks is similar to that of conventional bricks. However, in some bricks were fly ash existed in the form of lumps some bloating and cracking had occured. Such bricks were classified under overburnt and rejects.

Properties of Fired Bricks

The Clay fly ash bricks and the ordinary clay bricks as obtained from both the kilns were sampled and tested as per IS 5454-1969 'Clay Building Bricks for Sampling' and IS 3495-1973 (Pt.IV) Method of Test of Bricks respectively for compressive strength, water absorption, bulk density, colour, ring and efflorescence. The testing results are given in Table 4.

It is seen from Table 4 that strength of first quality clay fily ash bricks is improved as compared to conventional first class bricks, whereas the strength characteristics for second and third quality bricks were similar.

The clay fly ash bricks in general are 10-15% lighter than conventional bricks and show slightly higher water absorption but within the range prescribed.

Well burnt first quality bricks did not show any efflorescence and were showing metallic ring and bright red appearance. However, colour of second and third quality of clay fly ash bricks was yellowish red.

On the basis of these results, it may be concluded that the bricks of strength 70-170 Kg/cm^2, water absorption 10-18 percent, bulk density 1.50-1.75 gm/cc and free from efflorescence conforming to IS : 3102-1971 'Classification of Burnt Clay Bricks' can be manufactured by the addition of fly ash to the alluvial soils of Hardwar and Faridabad regions if the firing temperature ranges between 980-1020°c.

Economics in the Use of Fly Ash For the Brick Production

Fly ash being a fine material is pumped out from the thermal power plants as slurry into ash ponds. Wet fly ash is further lifted on trucks and is thrown out at some distances. In this process fly ash forms lumps which do not disintegrate readily on wetting. Sometimes the fly ash gets contaminated with calcareous silicates in the form of fine aggregates. In the presence of these impurities clay ash bricks may show a tendency of cracking during firing and reduction in strength. It is, therefore, essential to remove such nodules by dry sieving through 1 mm size sieve. This entails an additional 12 mandays labour to supply sieved fly ash to manufacture one lakh bricks.

The moulders must adopt proper mixing of fly ash with the soil and some additional wages for this extra work is justified. It generally comes to 2/- per thousand moulded bricks and may provide an incentive to the moulders. This slight increase in the cost of moulding helps to produce good quality hand moulded clay fly ash bricks. The details are given in Table 5A.

The use of fly ash offers a considerable saving in fuel consumption, which depends on the proportion of fly ash mixed with the soil and the unburnt carbon present in fly ash. At Pathri and Kherikalan, a saving of 4.2 and 4.0 tonnes of coal per lakh bricks was obtained against 16 tonne coal required for one lakh clay bricks. Further, the use of fly ash reduces the consumption of soil by 10-20 percent. Thus, it results in an increased productivity of bricks from the same resources of clay and coal. The overall saving in the use of fly has obtained at Pathri (Hardwar) and Kherikalan (Faridabad) as given in Table 5B is Rs. 8.45 and Re. 1/- per thousand bricks respectively.

more is a definite energy savings by using fly ash in brick manufacturing which could be upto 25 percent of coal consumption in the field production of bricks.

Conclusions

1. Building bricks of strength 70 to 170 Kg./cm², water absorption 10 to 18%, bulk density 1.60-1.75 g/cc and free from efflorescence can be manufactured by the addition of 10-15% by volume of fly ash to the sandy loam of Pathri (Hardwar) and 30 to 35% with clayey loam of Kherikalan (Faridabad).

2. The use of fly ash with the brick earths gives savings upto 25% coal used for burning bricks, depending upon its proportion to the soil and unburnt carbon contents.

3. The cost of production of fly ash bricks is almost at par with the cost of production of ordinary clay bricks. But the use of fly ash in brick manufacturing reduces cost of disposal of fly ash incurred by the thermal power plants.

4. There is no specific difficulty in the mixing and processing of clay fly ash mixture in moulding and handling of bricks. The additional labour cost incurred in the mixing of fly ash could be an incentive to the moulders which otherwise gets neutralised with the saving in the fuel.

Acknowledgement

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Table 1

Properties of Fly Ash

Sl. No.	Properties	Fly Ash	
		Bhel Hardwar	Haryana state Elect. Board, Faridabad
1.	Loss on ignition, % (W/W)	15-20	4-5
2.	Surface areas cm²/g	4000-4500	4600-4900
3.	Bulk Density kg/m³	650-700	850-900

Table 2

Characteristics of Alluvial Soils of Pathri (HARDWAR) and Faridabad

S. No.	Properties	Pathri (Hardwar) Soil	Khori Kalan (Faridabad) Soil
A.	**Mechanical Analysis**		
	Clay, %	19-22	17-30
	Silt, %	26-29	16-25
	Sand, %	50-55	45-65
B.	**Atterberg Limits**		
	Plastic limit	15-20	15-20
	Liquid limit	24-25	25-30
	Plastic Index	5-6	10-15
C.	Clay minerals	Mixture of illite and kaolinite	Mixture of illite and kaolinite

Table 3

Production Classification of Clay Fly Ash and Conventional Bricks Manufactured at Hardwar and Kherlikalan

Sl. No.	Production classification	Hardwar		Kherlikalan	
		Clay fly ash bricks	Conventional clay bricks	Clay fly ash bricks	Conventional clay bricks
1.	First quality %	77	76	78	73
2.	Second quality %	16	16	15	17
3.	Third quality %	4	7	4	7
4.	Over burnt and rejects %	3	3	3	3

Table 4

Properties of Clay Fly Ash and Conventional Clay Bricks Manufactured at Pathri and Kherikalan (Faridabad)

Sl. No.	Properties	Hardwar		Kherikalan	
		Clay fly ash bricks	Conventional clay bricks	Clay fly ash bricks	Conventional clay bricks
A.	**First Class**				
1.	Compressive strength kg/cm²	138-170	105-135	100-151	95-140
2.	Water Absorption, %	10-16	11-1	12-16	11-15
3.	Bulk Density, g/cc	1.60-1.75	1.77-1.81	1.60-1.70	1.60-1.80
4.	Efflorescence	Nil	Nil	Nil	Nil
5.	Colour	Brick red	Brick red	Brick red	Brick red
6.	Ring	Metallic	Metallic	Metallic	Metallic
B.	**Second Class**				
1.	Compressive strength kg/cm²	65-90	69-88	70-95	50-90
2.	Water Absorption, %	15-18	15-16	16-18	15-18
3.	Bulk density, g/cc	1.50-1.60	1.67-1.72	1.64-1.62	1.68-1.72
4.	Efflorescence	Nil	Nil	Nil	Nil
5.	Colour	Light brick red	Light brick red	Light brick red	Light brick red
6.	Ring	Dull	Dull	Dull	Dull
C.	**Third Quality**				
1.	Compressive strength kg/cm²	56-65	48-53	50-70	30-50
2.	Water Absorption, %	18-20	16.5-18	19-22	19-23
3.	Bulk density, g/cc	1.40-1.50	1.56-1.75	1.48-1.53	1.60-1.66
4.	Efflorescence	Nil	Nil	Nil	Nil
5.	Colour	Light brick red	Light brick red	Light brick red	Light brick red
6.	Ring	Dull	Dull	Dull	Dull

Table 5

Estimate of Expenditure and Saving in the production of Clay Fly Ash Bricks

Basis : 1. one lakh bricks

2. Rates prevalent in 1980 in the respective areas.

A. **Extra Expenditure in the Use of Fly Ash**

ITEMS	Pathri (Hardwar)	Khorikalon (Faridabad)
1. Cost of fly ash Rs. 4/tonne	104.00 (26 tonnes)	240 (60 tonnes)
2. Sieving and mixing of fly ash to the soil Rs. 3/1000 bricks	300.00	300.00
3. Transportation charges from Power station to kiln sites (8-10 kms) Rs. 100/truck/6 tonnes	450.00 (26 tonnes)	1000.00 (60 tonnes)
Total	854.00	1540.00

B. **Saving in the production of Clay Fly Ash Bricks**

1. Saving in clay, Basis: cost of clay Rs. 2/1000 of conventional bricks	20.00 (saving 10% basis)	40.00 (saving 20% basis)
2. Coal consumption Rs. 400/tonne Basis of conventional coal consumption; 16 tonnes/lakh bricks	1680.00 (4.2 tonnes savings)	1600.00 (4 tonnes savings)
Total saving	1700.00	1640.00
C. Net saving per lakh bricks Rs.	846.00	100.00