CONFERENCE ON FLY ASH USES

Technical Papers

Organised by :

iNDEXTb

Industrial Extension Bureau

(A Government of Gujarat Organisation)

Ahmedabad-380 009.

C O N F E R E N C E   O N

FLYASH
USES

T E C H N I C A L   P A P E R S

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Co-Sponsor :

The Institute of Engineers,Gujarat Centre

C O N F E R E N C E

ON

F L Y A S H

USES

TECHNICAL PAPERS

(Second Edition)

Compiled by

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(Minerals)

INDUSTRIAL EXTENSION BUREAU
(A Govt. of Guj.Organization)
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P R E F A C E

FLYASH is a waste material available in plenty from Thermal Power Stations of Gujarat. All generated waste poses serious environmental problem and calls for its efficient management and disposal. Future expansion and creation of new thermal capacity by lignite fuel will also add to this problem.

FLYASH Uses Conference is organised by iNDEXTb to create awareness among Architects, Builders, Engineers, Brick Manufacturers etc. for constructive uses and for production of value added Fly ash based product projects in the State.

I am pleased to place before you the Technical Papers and project profiles presented in the book which will be of immense use to the delegates and promising entrepreneurs.

Sd/-
DR. M K JAIN

Dt:March, 1992
Ahmedabad

TECHNICAL SESSION-I

1)	Technology & Economics of value added products for construction sector	Dr C Rajkumar NCB, New Delhi
2)	Physico-chemical characteristics of Flyash from thermal power plants and its commercial exploitation for construction use	Dr U D Datir Joint Director Gujarat Engineering Research Institute, Baroda
3)	Experience of AEC Pilot Plant in utilisation of Flyash	Shri D D Singhvi Ahmedabad Electricity Company

TECHNICAL SESSION-II

1)	Utilisation of Flyash for value added products	Dr B K Chaturvedi Central Power Research Institute, Bangalore
2)	Technology & Process available for flyash utilisation	Dr R B Hajela Central Building Research Institute
3)	Processes available for commercial exploitation of Flyash from Gujarat.	Shri S N Mukherjee & Shri Samirsen Central Fuel Research Institute, Dhanbad

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UTILIZATION OF FLYASH IN MANUFACTURING OF BUILDING BRICKS

By

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INTRODUCTION

Realising the seriousness of disposal problems associated with themanagement of 30 million tonnes (1990) of flyash, annually produced in India, National Council for cement and Building Materials (NCB) has been studying the utilisation potentials of this material.The studies conducted so far have shown that manufacture of building materials or components, particularly bricks and blocks, is the most promising direction of utilization(1). The technology developed in NCB has been tried at laboratory and pilot scale levels and found to be suitable for commercial manufacture of good quality bricks.

The paper discusses the process of manufacture developed at NCB, performance evaluation of bricks, experience gained during the manufacture of bricks at pilot plant scale, observations on a three year old building constructed of the bricks and the issues related to the industrialisation of flyash brick technology.

MANUFACTURING PROCESS :

The manufacturing process broadly consists of three operations, namely,mixing,pressing and curing.Dry mixing in a blender

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disperses the various raw materials to form a homogeneous mix. This is followed by addition of water and mixing the wet mass in an edge mixer. In order to ensure that the finished product has the required dimensional tolerances, the bulk mixture is placed into moulds of stipulated size and pressed using a mechanical press and having a predetermined ram travel. Both plastic and semi-dry methods of moulding were tried. To ensure uniformity in shape, dimensions and strength, semi-dry method of moulding using mechanical press is recommended. After moulding, the bricks are cured in a wet and hot medium of saturated steam. The aim of curing using heat is to speed-up the process of setting and hardening of green bricks, thereby achieve the desired strength and other physical and mechanical properties in a shorter period. Before curing in steam the bricks are air cured for 24 - 36 hours depending upon the ambient temperature conditions, mainly to gain the minimum strength required for handling and to resist internal pressure that are likely to develop during steam curing.

Material flow adopted in this process is shown in Figure-1 (enclosed). Various methods of curing were tried, namely, hot water curing, steam curing at atmospheric pressure and autoclave curing. For the pilot scale production steam curing at atmospheric pressure was adopted as it had a number of advantages over the other methods. Hot water curing requires longer period and results in poor surface finish, damage to edges and handling of bricks becomes cumbersome. Whereas, steam curing process obviates all these drawbacks and results in better quality bricks. Autoclave process entails higher capital investment as well as higher energy requirements. Steam curing is the middle course which has been found to give quality bricks. Accordingly, the bricks were steam cured for a time cycle of 10 to 12 hours.

RAW MATERIALS :

For the manufacture of lime-flyash bricks the basic raw materials required are flyash, lime, gypsum and sand, of which the last mentioned one is optional. The process is based on the reaction of lime with the silica of flyash to form calcium silicate hydrates which constitute the main binder in these products. Depending on the characteristics of the flyash to be used and the strength requirements of bricks the proportiona of the different raw materials are selected. The ranges of raw material proportions followed are : Flyash : 70-80(%); Lime: 8-15(%); Gypsum: 2-5(%) and Coarse sand: 0-10(%).

Flyash

Indian flyashes essentially contain 70 -85% silica, alumina and iron oxide together. The glass content generally varies from 20 to 30%, which is low compared to European flyashes (2). The chemical and physical characteristics of Indian flyashes tried in the current investigation are given in Table -1.

TABLE - 1

Characteristics of Indian Flyashes

Constituent/Parameter	Range
1. Chemical Analysis (%)	
SiO_2	57.4 - 66.5
Al_2O_3	16.6 - 31.3
Fe_2O_3	3.8 - 12.5
CaO_2	0.9 - 1.9
MgO	0.6 - 1.1
Na_2O	0.15 - 0.3
K_2O	0.4 - 0.99
LOI	0.7 - 9.2
2. Fineness (cm / gm)	3430 - 3632
3. Lime reactivity (N/mm^2)	4.5 - 5.5

Flyash for manufacturing bricks should preferably satisfy the following requirements :

* Available SiO_2 should not be less than 35%
* Available Al_2O_3 should not be less than 15%
* Available MgO should not be more than 5%
* LOI should not be more than 12%

Lime

Lime plays an important role, making active Al_2O_3 and SiO_2 in the flyash to hydrate resulting in certain physical and chemical properties. Whereas hydrated lime was used in the pilot scale process, quick lime is recommended for industrial production. When quick lime is used, the wet mass should have a water content close to that required for completing the slaking process. If the slaking continues even after the moulding operation is completed, the moulded bricks are likely to show cracking due to volumetric expansion of quick lime. As the lime industry is not well established, the quality of raw material varies significantly and it is necessary to ensure proper quality control in terms of following technical requirements.

* Available CaO should not be less than 60%.
* Slaking temperature should not be less than 60°C and its slaking time should be within 15 min.
* Available MgO should not be more than 5%.

Gypsum

Gypsum plays a key role in speeding up the hardening processes and contributing to early strength. Its purity should be above 35%.

Sand

Coarse sand is recommended to achieve proper grading of the basic mix thereby imparting good compactability to the semi-dry mix. Addition of sand was also found to check formation of

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Laminar cracks caused by entrapped air attempting to move towards the surface.

PERFORMANCE EVALUATION:

As burnt clay bricks are the popular walling material, any substitute should at least meet the minimum requirements for the former. The composition of lime-flyash bricks was designed on this basis. Lime- flyash bricks made by NCB technology are comparable to Grade 100 - 125 fired clay bricks. Table - 2, gives their comparative properties.

TABLE -2.

COMPARATIVE PROPERTIES OF DIFFERENT TYPES OF BRICKS

Type of Brick	Properties			
	Comp. Strength N/Sq.mm	Water absorption %	Density kg/cu m	Shrinkage %
Hand pressed flyash bricks	7 - 9.5	15-20	1350-1450	0.087
Machine pressed flyash bricks*	10 - 17.5	13-17	1550-1650	0.079
Burnt clay Grade 100	10	20 max.	1700	-

* Maximum pressure applied 8 N/Sq.mm

LONG TERM PERFORMANCE :

Under the action of CO_2 in the air, $Ca(OH)_2$ present in the flyash bricks changes to $CaCO_3$ and it is known as carbonation. To study the variations in development of carbonation front in flyash bricks exposed to outdoor and indoor environments, 25 mm diameter cores were extracted from an existing flyash brick wall which had been in service for at least three years. The wall had not been given any rendering and thus had been exposed to the CO_2 present in the environment. The extracted cores were split into halves and exposed surfaces were sprayed with 1% phenolphthalein to identify the progress of carbonation front. While the exterior surface showed advancement of carbonation front to a distance of 30 mm (average), the corresponding value for the interior surface was 50 mm(Average). This would imply that the indoor bricks get carbonated faster than outdoor bricks, the increase in the present case being as much as 60%. The difference could be attributed to the higher rate of hydration that continued in the outdoor bricks whereas in the case of indoor bricks, the hydration was controlled within the residual moisture available within the brick.

The bricks exposed to outdoor environment for a period of five years were found to be fully carbonated. This period could be longer for well-compacted, mechanically pressed bricks. Measurements made on bricks of different ages show that within a period of 3 months, the carbonation front had extended to a distance of 10mm (all round) from the external surface. In any manufacturing unit, the finished products are likely to be kept exposed to outdoor environment for periods ranging from few days to some months. Particularly, when the demand is slack, a month's storage is likely, in which case if the quality of bricks is not satisfactory, it could be further affected by carbonation. In such situations, the bricks would have got carbonated to a larger extent even before its use in construction. Bricks, which had a rendering of 10 mm cement mortar plaster, were examined and found to have been well protected from carbonation effects. This was not true for bricks rendered with lime wash or cement paint.

To assess the reduction in strength due to carbonation, bricks exposed to outdoor environment for five years and above were tested. Their compressive strength was found to be 6.0 - 9.5 N/sq.mm, the average being 7.9 N/sq mm. When the results were compared with the original strength, the reduction in strength was observed to be about 33%. This observation relates to bricks made by hand-moulding and hot water curing and hence, the level of reduction in strength should be taken with some reservation. For machine made bricks the reduction in strength is not likely to exceed 20% as reported by other investigators. In view of the reduction in strength, the specification formulated by Chinese authorities (3) stipulate that the residual strength of bricks after full carbonation

OBSERVATIONS ON PROTOTYPE CONSTRUCTION

A prototype house was constructed using lime-flyash bricks manufactured on pilot scale. The unit was provided with normal openings for doors and windows and setbacks for receiving cupboards. The construction was kept under observation to assess the performance of lime-flyash brick masonry.The walls were left unplastered and thus the external faces were exposed to different weathering agents. The following observations were made over a three-year period.

* Number of bricks showing horizontal hair cracks were 8% on exterior and 3% on interior surfaces.
* Damages to edges, after the construction of brick masonry not noticed.
* Weathering of external surface, such as peeling or pop-outs not noticed.
* Debonding of mortar along vertical joints noticed at a few locations.

The unit continues to be under observation to assess its long term performance.

INDUSTRIALISATION OF FLYASH BRICK TECHNOLOGY:

While the technology of manufacturing flyash bricks is well established, it is necessary to consider a number of techno-economic aspects, if it is to be made economically feasible.

* In the wet flyash system of disposal, the bottom ash and flyash get mixed and the final separation of the materials in the ash pond further complicates ensuring of the quality requirements of the flyash. When the raw material is collected from such a source it becomes necessary to have a much higher target strength to achieve the required characteristic strength of bricks. A number of new thermal power plants are establishing dry flyash collection system which would ensure supply of flyash within the acceptable range of variation in the chemical compositions and other parameters.

* The percentage break-up of the manufacturing cost of flyash bricks is shown in Figure-2(Enclosed).Though these values may be typical to the cases investigated, the indications are that the cost of lime and the expenses on fuel and power are likely to be the sensitive factors in costing.

The break-up is representative of a plant of capacity 100,000 bricks per day working 330 days and 90% capacity utilization.

* Transportation of flyash is cumbersome and adds to the cost of production. While working out the cost analysis of bricks it was found that the transportation of flyash beyond 50 km will make flyash bricks unattractive

pricewise compared to other products.

* The supply position of burnt clay bricks vis-a-vis demand is not satisfactory in most urban situations. Under such circumstances, flyash bricks are an economically viable alternative building material provided the demand centres are close to the thermal plants producing flyash. Transportation of finished product beyond 100 km is also not recommended as it adds to the cost of bricks.

* Where a substantial housing activity is projected and a steady demand for ten years or so could be guaranteed, a brick manufacturing unit of installed capacity of 100,000 bricks per day and above could be economically viable. The level of mechanisation will depend upon the production capacity envisaged.

ACKNOWLEDGEMENT

This paper is based on an R&D project carried out at the Construction Development Institute of the National Council for Cement and Building Materials (NCB-CDI).This paper is being published with the permission of the Director General,National Council for Cement and Building Materials.

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Physico-chemical Characteristics of Flyash from thermal power plants of Gujarat

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1.0 The report covers physical as well as chemical properties of flyash from five Thermal Power Stations of Gujarat. The Report highlights the Pozzolanic properties of flyash. It also covers the properties of flyash produced from Gandhinagar, Mithapur, Sabarmati, Ukai and Vanakbori Thermal Power Stations. Total 59 samples of flyash were collected from these Thermal Power Stations. The testing of flyash was done as per IS:1727-1977. Out of which 32 samples failed in lime reactivity test, 30 in fineness test and 23 in compressive strength test.

INTRODUCTION

Flyash is a waste material available in plenty from Thermal Power Stations. It is a finely divided residue resulting from combustion of pulverised coal, which is transported by fuel gases of boilers. At ordinary temperatures, flyash in presence of moisture can chemically react with calcium hydroxide to from compounds possessing cemetitious properties. Thus, this waste material can be

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utilized as Pozzolana either with lime or in past replacement of cement. Flyash is also used in preparation of lime flyash bricks, flyash concrete, lime pozzolona mixture, sintered flyash, light weight aggregate and lime flyash cellular concrete block & slabs etc.

Flyash when used with cement has ollowing advantages :

a) Fixes free lime in concrete and mortar by forming stable silicates.

b) Reduces bleeding, shrinkage and heat of hydration of cement.

c) Reduces alkali-aggregate reaction and controls sulphate attack

d) Reduces permeability

e) Improves workability and plasticity

f) Reduces ost of construction

2.0 Availability of flyash :

Flyash is available from Industries or Power Plant which utilize pulverised coal as fuel for boilers. With the growth of Industries are availability of flyash also increases.

Availability of flyash at five thermal power stations of Gujarat for the year 1990 is as under :

Sr No	Power Station	Annual output in Metric tonne(Approx.)
01	Gandhinagar	1,80,000
02	Mithapur	1,11,000
03	Sabarmati	2,80,699
04	Ukai	6,00,000
05	Wanakbori	12,20,398

3.0 Necessity of testing of flyash :

It is experienced that the quality of flyash produced from thermal power stations differs on account of quality of coal used, process of combustion and method of collection of flyash. Variation therefore, may occur of various parameters of the final product. For use in construction industry, uniformity in quality of flyash is quite essential. At the same time, the flyash should possesses pozzolona properties, which can be observed through physical and chemical test only. Physical tests as lime reactivity, compressive strength, fineness can be performed as per IS: 1727- 1967 while in chemical analysis percentage constituents of silicon dioxide, Alumina oxide, Iron oxide, Magnesium oxide, sodium oxide, sulphur trioxide and loss of ignition are to be determined.

4.0 Requirement :

The values of various parameters for ascertaining quality of flyash are prescribed as IS 3812-81 under the title 'Specification for flyash for use as pozzolana and Admixture'. The limits specified in IS 3812-81 are as under :

A. Physical Requirement :

Sr. No.	Characteristic	Requirement Grade-I	Requirement Grade-II
a) by	Fineness specific surface area in cm^2/g by Blain's air permeability method, minimum	3200	2500
b)	Lime-reactivity average compressive strength in kg/cm^2 minimum	40	30
c)	Compressive strength of pozzolona cement mortar at 28 days in kg/cm^2	Not less than 80% of corresponding plain cement mortar.	

B. Chemical Requirement

Sr No	Characteristic	Requirement % by wt. Minimum	Maximum
a.	Silicon dioxide +Aluminium oxide +Iron oxide	70	-
b.	Silicon dioxide	35	-
c.	Magnesium oxide	-	5
d.	Total sulphur as sulphur trioxide	-	3
e.	Available alkalies as sodium oxide	-	1.5
f.	Loss of ignition	-	12.5

5.0 Sample collection and its testing :

Flyash samples were collected every month from five thermal power stations of Gujarat. Total 59 samples of flyash were collected during the year 1990 regularly every month. The samples collected were tested for ascertaining their physical properties and chemical constituents as per IS 1727-67. All test results of flyash samples are presented vide table 1 to 5. Graphical representation of these test results is given vide plate 1 to 10.

6.0 Discussion of test results :

Test results reveal that almost all the samples of flyash satisfy the requirement of chemical constituents as laid-down in IS 3812 - 81 except for about 8 samples from Mithapur Thermal Power Station in which silica content is less than 35 per cent and 2 samples have limits of sulphate (SO_3) content more than required value of 3 percent. There is a great variation and failure in lime-reactivity, fineness and compressive strength values. Out of total 59 samples tested 30 samples failed in lime-reactivity test, 30 samples in fineness test and 23 samples in compressive strength test Percentage failure of these test values power station-wise is indicated as under :

Percentage failure of Flyash

Sr No.	Station	Lime reactivity	Fineness	Compressive strength
01	Gandhinagar	33	33	25
02	Mithapur	58	58	25
03	Sabarmati	45	66	45
04	Ukai	50	25	42
05	Wanakbori	73	73	45
		42	55	36

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It is seen from the table that flyash samples from Gandhinagar thermal power station is of better quality compared to that of flyash from other thermal power stations.

7.0 Recommendations and conclusion :

Flyash finds extensive use in various field provided it is of good and uniform quality. Flyash produced from the power stations differs widely in quality and the quality from each power station is also not uniform and also not upto the required standard. Such quality of flyash restricts its use as Pozzolanic material.

Test Results of Flyash from Gandhinagar Thermal Power Station

Sr No.	Months of the year 1990	Chemical Analysis(%)						Physical Properties			
		$SiO_2+Al_2O_3+Fe_2O_3$	SiO_2	MgO	SO_3	Na_2O	Loss on igni-tion.	Lime reac-tivi-ty in kg/cm^2	Fine-ness in cm^2	Compress-ive stren-gth of pozzolana cement mortar at 28 days in kg/cm^2	Compressive strength of plain cement mortar at 28 days in kg/cm^2
01	January	89	56	3.0	1.0	0.60	5.0	33	3250	160	180
02	February	95	63	1.5	Nil	0.60	2.8	32	1200	145	180
03	March	94	63	1.7	0.14	0.70	1.3	22	2400	130	180
04	April	96	64	0.60	Nil	0.20	3.6	23	2500	160	200
05	May	95	59	0.80	0.20	0.30	4.0	32	3700	155	200
06	June	89	57	0.70	Nil	0.35	5.0	43	3000	160	200
07	July	95	58	3.0	0.60	0.60	2.7	38	3100	140	180
08	August	88	60	2.0	Nil	0.26	6.6	26	1200	130	180
09	September	91	57	2.1	0.30	0.36	2.9	48	2600	170	200
10	October	92	62	2.2	0.30	0.38	6.3	60	3200	150	180
11	November	93	65	3.2	1.10	0.17	5.9	22	2300	130	180
12	December	92	61	2.2	0.8	0.1	1.1	32	3100	160	180

Test Results of Flyash from Mithapur Thermal Power Station

Sr No	Month of the year 1990	$SiO_2+Al_2O_3+Fe_2O_3$	SiO_2	MgO	SO_3	Na_2O	Loss on ignition	Line reactivity in kg/cm^2	Fineness in cm^2/g	Compressive strength of pozzolana cement mortar at 28 days in kg/cm^2	Compressive strength of plain cement mortar at 28 days in kg/cm^2
01	January	65	27	1.7	1.6	0.8	18.0	30	1800	160	180
02	February	61	24	5.0	3.5	1.4	16.0	31	1500	150	180
03	March	66	28	0.80	3.8	0.80	17.60	26	1300	145	180
04	April	76	33	0.30	1.50	0.60	8.60	26	1300	185	220
05	May	71	30	3.7	3.2	0.80	9.0	35	2500	160	220
06	June	73	26	4.0	3.0	0.8	11.0	27	1250	150	180
07	July	76	30	5.0	3.0	1.0	9.30	25	1500	160	200
08	August	75	30	1.7	0.16	1.1	8.0	28	1500	130	180
09	September	96	63	1.7	0.16	0.26	2.2	24	3040	170	200
10	October	93	59	2.1	Nil	0.26	2.7	32	3000	175	180
11	Nivember	93	59	2.1	Nil	0.26	2.7	33	3040	180	200
12	December	98	60	1.2	Nil	0.2	1.7	25	3000	150	180

Test Results of Flyash from Sabarmati Thermal Power Station

Sr No	Months of the Year 1990	$SiO_2+Al_2O_3+Fe_2O_3$	SiO_2	MgO	SO_3	Na_2O	Loss on igni-tion.	Lime reac-tive-ty in kg/cm^2	Fine-ness cm^2	Compress-inive stre-ngth of pozzo-lana cement mortar at 28 days in kg/cm^2	Compressive strength of plain cement mortar at 28 days in kg/cm^2
01	January	84	60	3.0	1.70	0.60	3.0	32	1800	146	180
02	February	91	56	2.8	0.10	0.65	2.4	31	3800	145	180
03	March	95	66	3.0	Nil	0.80	0.40	12	1200	130	180
04	April	94	64	0.60	Nil	0.37	3.0	34	2100	150	200
05	May	89	64	0.60	Nil	0.40	2.8	50	1250	140	200
06	June	91	64	0.70	0.30	0.30	3.0	25	2150	166	200
07	July	84	53	2.0	Nil	0.40	2.0	26	2200	150	200
08	August	88	54	3.6	1.3	0.18	1.2	26	2200	170	180
09	September	90	57	2.8	0.80	0.14	2.0	23	3800	145	180
10	October	91	59	1.90	Nil	0.26	2.2	31	3200	130	180
11	November	92	60	1.80	Nil	1.1	1.4	36	2600	150	180
12	December	98	62	2.0	0.4	0.23	1.4	30	3000	150	180

Test Results of Flyash from Ukai Thermal Power Station

Sr No	Months of the year 1990	Chemical Analysis (%)						Physical Properties			
		$SiO_2+Al_2O_3+Fe_2O_3$	SiO_2	MgO	SO_3	Na_2O	Loss on ignition.	Lime reactivity in kg/cm^2	Fineness in cm^2	Compressive strength of pozzolana cement mortar at 28 days in kg/cm^2	Compressive strength of plain cement mortar at 28 days in kg/cm^2
01	January	88	56	2.0	Nil	0.40	2.0	32	3200	140	180
02	February	95	60	2.0	Nil	0.30	1.40	38	2400	145	180
03	March	94	59	2.6	0.8	0.30	2.0	25	3000	130	180
04	April	95	61	2.0	Nil	0.30	1.60	13	3000	170	200
05	May	89	61	3.0	Nil	0.36	2.0	30	3800	160	200
06	June	93	61	3.0	Nil	0.30	1.7	47	3100	150	180
07	July	95	61	3.0	0.5	0.30	2.0	34	3200	130	180
08	August	97	64	0.9	Nil	1.1	0.5	26	2600	178	220
09	September	93	63	2.6	Nil	0.5	1.3	30	2800	160	220
10	October	99	63	0.8	0.6	0.5	0.5	24	2300	140	180
11	November	98	62	1.4	Nil	0.4	1.7	22	3000	150	180
12	December	98	64	0.6	0.4	0.6	0.5	20	2300	160	180

Test Results of Flyash from Wanakbori Thermal Power Station

Sr No.	Months of the Year 1990	Chemical Analysis (%)						Physical Properties			
		$SiO_2+Al_2O_3+Fe_2O_3$	SiO_2	MgO	SO_3	Na_2O	Loss on ignition.	Lime reactivity in kg/cm^2	Fineness in cm^2	Compressive strength of pozzolana cement mortar at 28 days in kg/cm^2	Compressive strength of plain cement mortar at 28 days in kg/cm^2
01	January	94	55	2.0	0.60	0.30	1.8	28	1600	130	180
02	February	94	54	2.0	0.60	0.20	2.0	23	1800	145	180
03	March	93	55	2.0	0.50	0.40	1.6	31	1700	150	180
04	April	97	66	0.40	0.60	0.40	1.2	15	1240	160	200
05	May	94	67	1.80	Nil	0.30	0.60	20	1300	170	200
06	June	95	66	2.0	Nil	0.40	0.70	22	1570	140	200
07	July	97	62	1.6	Nil	0.60	1.40	21	2000	140	180
08	September	93	61	3.1	0.50	0.18	1.20	30	2500	180	220
09	October	95	62	3.3	Nil	0.32	1.40	28	2300	170	220
10	November	96	62	3.0	Nil	0.30	1.40	33	1600	180	220
11	December	98	60	1.2	Nil	0.2	1.70	27	2700	130	180

LOW COST FLYASH UTILISATION TECHNOLOGY

By

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Constructions Limited
Ahmedabad.

Huge quantity of flyash generated from thermal plants has caused a gigantic pollution problem. The efforts for its utilisation in many gainful purposes have been made since late sixties by various research institutions and public enterprises but nothing has really been seen yet in commercial utilities. It is a matter of disappointment that inspite of long time research in this field flyash utilisation in the country could not reach even upto 2% of its total generation. The tituation is still worsening day by day due to increase in coal consumption in old and new installed thermal power stations. It is now high time to find the reasons for past failures and emerge with the practical solution to increase the utilisation of flyash. After detail survey in this respect, it is revealed that the main hinderances for restricting flyash utilisation in the past were-

1. Unawareness in the public, regarding new and improved technologies, as the same were not properly propagated.
2. Availability of the high capital cost oriented technologies, producing building material at higher cost than similar conventional material.
3. Neither any Government organisation nor research laboratories have ever made serious efforts to produce and

4. Non-availability of the desired quality of flyash.
5. Uptil now, flyash based building materials were not seen in the market hence its public acceptability could not be ascertained.

To achieve the objectives of maximum utilisation of flyash in gainful utilities, the following facilities should be provided to the prospective entrepreneurs -

1. Allotment of land on easy terms at a place nearer to the source of flyash (power station)
2. Supply of flyash in dry state and in desired fineness by selection of the particular E S P hoppers.
3. Making available indigenous low cost machineries for production of flyash bricks, blocks, slabs, tiles, activated pozzolana, portland pozzolana and lime pozzolana cement.
4. Making available simple, indigenous manufacturing process, producing quality materials as per building norms or Indian Standard Specifications, either cheaper or at par in cost with similar conventional building materials of similar quality standards.
5. Government should provide incentives in taxes and also in marketing by compelling public institutions, housing boards etc. to use these materials.

AREAS OF UTILISATION OF FLYASH

1. Manufacturing of construction materials.
2. Construction of road, and development of agricultural land, mines spoils, irrigation projects.
3. Extraction of metals.
4. Manufacturing of utility products, like cleaning power, dry distemper,sodium silicate etc.

FLYASH BASED CONSTRUCTION MATERIALS

1. Activated Pozzolana
2. Portland pozzolana cement
3. Lime Pozzolana cement
4. Flyash Bricks
5. Flyash lime gypsum hollow/solid masonary blocks
6. Flyash concrete heavy-duty paving slabs
7. Lime pozzolana concrete flooring tiles
8. Lightweight aggregate
9. Road construction material

PRODUCTION OF FLYASH BRICKS

BRICKS:

Bricks used in masonary construction work are of various kinds, with different manufacturing processes, depending on the brick-mix contents.

1. Soil or mud stabilised bricks, in which no firing is needed

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* Feel its fineness by rubbing it between thumb and finger. It should not be coarser than colgate tooth powder.
* Take a pinch of flyash and rub it lightly on your palm. Clean the palm with the other hand. No black spots remain on the palm. Resultantly, the unburnt carbon in ash is tolerable.

RAW MATERIALS:

A mix of flyash, lime, gypsum, sand and set accelerator is prepared by intimate mixing in suitable blender/mixer. Manual mixing will not give the desired results and hence hand mixing should be avoided. The formulations of economical brick-mix is the speciality of this technology, which ultimately gives compressive strength of 80 to 110 kg/Cm2 to the flyash bricks.

The content of flyash in the brick mix be kept at 80% to 82.5%.

WATER:

The water/brick mix ratio be maintained between 6% to 7%. This percentage changes with different brick- mix raw material ratio. A ball prepared from the wet mix be rolled or pat on the palm. A very little quantity of water should be seen on the top after patting or rolling of the ball. No droplet or flowable water should be seen.

MOULDING :

For moulding the bricks, we get so many types of indigenous machineries like :-

a. Manual press (without power)

b. Vibro-press (with power)

c. Hydraulic press, with or without vibration

d. Screw press with or without wire cutting arrangement

e. Tamping head moulding machines

Besides the above, imported plants are also available, but they are mainly for sand lime autoclaved bricks. Soil or mud stabilised bricks manufacturing plants are also available in some countries like France, Belgium and Germany. Selection of the machinery depends on the brick-mix contents.

For manufacturing "Flyash lime stabilised bricks" the best suited machinery is "vibro-press" machine, which is an indigenous low cost machine, and can be run by ordinary semi-skilled worker. Its production capacity is 1000 bricks/shift and can be operated for two shifts without any operation or maintenance load. The maintenance cost is so low that it can be ignored. 15 lakhs bricks can be produced from each machine, and by this time you can change all the major parts, and the machine is then ready for next lot production.

CURING :

The stabilised bricks, after moulding, are further hardened by curing. The chemical changes occur in the brick-mix contents after moulding, and heat of hydration is evolved. The rate of evolution of heat of hydration depends on the contents and their ratios in the mix. Faster the evolution of heat of hydration, earlier will be the setting.

By the process of curing -

a. the effect of release of heat of hydration is mitigated and lowered; and

b. Sufficient water for alkali solution is provided to accelerate pozzolanic reaction.

There are different processes of curing -

1. Steam curing under high pressure,(normally called autoclaved curing).
2. Steam curing under normal pressure
3. Hot water dip curing
4. Hot water air curing
5. Water tank curing
6. Water curing in open air

The cost of curing in all the processes vary and minimum cost involvement is in "water curing in open air",and maximum cost involvement is in "autoclaved pressurised curing".

In this case, curing of flyash stabilised bricks is made by hot water curing in open air. Water is heated by low cost solar collector and further increase in temperature of water is made by covering the brick stack by black tarpaulin after watering the stack by solar collector hot water. Unpressurised hot water vapours are produced and it moves in whole of the stack between individual bricks. It accelerates the pozzolanic reaction, and reduce final setting time.

PROCESS :

1. Various raw materials of brick-mix, in desired proportion are blended intimately in dry or wet form. Water/brick-mix ratio is maintained as explained above.
2. The wet brick-mix is fed into the machine mould. The vibration is given for a while and the mould is again fed. The stripper head is pressed and vibration is given simultaneously for about 8 seconds. The mould is lifted and 4 bricks produced pallet is removed and kept on the platform for air-drying.
3. Next day, the bricks produced on the previous day are put in the stack. The stack is formed with much care to see that curing water and air for drying reaches to every brick.

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4. After 3 days the solar collector hot water in small quantity is poured on the fresh stack without any pressure.
5. After 5 days, the solar collector water is poured on the brick stack for 2 times a day.
6. The bricks stack after each watering are immediately covered with black P.V.C. tarpaulin, with a clear space of 250 mm from the top layer of the bricks, inside the closed cover.
7. The curing is continued for 15 days and the tarpaulin cover is removed. The bricks are then left in the stack for drying for 7 days. In winter season, parabolic solar reflectors are used for drying or heating the bricks stack.
8. The bricks are ready for despatch after 22 days, from the date of manufacturing.
9. The compressive strength of the bricks produced from the brick-mix and manufacturing process suggested herein, will be 80 kg/Cm^2 to 110 kg/Cm^2.
10. The cost of production of 1000 bricks of 225x110x75mm size with labour cost comes to Rs.400 to Rs.450.

FLYASH BRICKS

Manufacturing Project

COST ESTIMATES

(For production of 10000 bricks/day)
(Size: 225x110x75 mm)

Particulars	Qty.	Value (Rs.lakhs)
1. Land	5000 S.Mtrs	On Lease
2. Building & Civil Works	120 S.Mtrs.	Rs. 1.00
3. Machineries -		
a. Vibro-press brick moulding machines	6 Nos.	Rs. 1.50
b. Blender	1 No.	Rs. 0.35
c. Handling Pallets	---	Rs. 0.40
TOTAL FIXED ASSETS		Rs. 3.25
4. Working Capital Margin		
a. One month block for 2.5 lakhs bricks @ Rs.450 per 1000 Nos. Rs.1.12 lakhs, for raw materials and labour.		
b. W.C. Margin @ 25%		Rs. 0.25
TOTAL PROJECT COST		Rs. 3.50

5. PROFITABILITY

i. Cost of production for 30 lakhs bricks @ Rs.450 per 1000 (with raw materials & labour) — Rs. 13.50

ii. Utilities

Electricity	- Rs.12000
Water	- Rs. 6000
Misc.consumables	- Rs. 6000
Repairs & Maint.	- Rs.12000

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iii.	Interest on Rs.3.25 lakhs @ 18% -do- Rs.1 lakhs @ 18%	Rs. 0.76
iv.	Lease amount of land	Rs. 0.60
v.	Administrative overheads @ Rs.8000/-/month	Rs. 0.96
		Rs. 16.18

6.	Sale proceeds of 30 lakhs bricks @ Rs.700 per 1000 Nos.	Rs. 21.00
	Net profit per year on fixed investment of Rs. 3.25 lakhs (148%)	Rs. 4.82

FLYASH LIME GYPSUM HOLLOW BLOCKS
Manufacturing Project

COST ESTIMATES
(For production of 2000 blocks/day)
(Size: 400x200x100mm)

Particulars		Qty.	Value (Rs. lakhs)
1.	Land	5000 S.Mtrs.	On Lease
2.	Buildings & Civil Works	120 S.Mtrs.	Rs. 1.00
3.	Machineries -		
	a. Vibro-press brick moulding machines.	6 Nos.	Rs. 1.50
	b. Blender	1 No.	Rs. 0.35
	c. Handling equipments, tools solar collectors and reflectors	-	Rs. 0.40
	d. Wooden pellets	-	Rs. 0.45
	e. Moulds	-	Rs.0.30
		TOTAL FIXED ASSETS	Rs. 4.00
4.	Working Capital Margin		
	a. One month block for 50000 Nos. of blocks @ Rs.3/-each Rs.1.5 lakhs, for raw materials and labour		Rs. 0.40
		TOTAL PROJECT COST	Rs. 4.40

5. PROFITABILITY

i. Cost of production for 6 lakhs blocks @ Rs.3/-each (with raw materials and labour) — Rs.18.00

ii. Utilities

Electricity -	Rs. 12000
water	Rs. 6000
Misc.consumables	Rs. 6000
Repairs & Maint.	Rs. 12000

iii.	Interest on Rs.3.25 lakhs @ 18% -do- Rs.1.50 lakhs @ 18%	Rs.	0.81
iv.	Lease amount of land	Rs.	0.60
v.	Administrative overheads @ Rs.8000/-	Rs.	0.96
		Rs.	20.73

6.	Sale proceeds of 6 lakhs blocks @ Rs.4.50 each	Rs.	27.00
	Net profit per year on fixed investment of Rs.4.0 lakhs (156%)	Rs.	6.27

Note: Vibro-press brick moulding machines are common for manufacturing bricks and blocks, by change over of the moulds.

FLY ASH UTILISATION - A PROSPECTIVE FOR THE PRODUCTION OF BUILDING MATERIALS

By

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1.0 INTRODUCTION

Fly ash is a finely divided powder thrown out as a waste material at the thermal power plants using pulverised coal to raise steam in the boilers. It is carried away from the boilers by flue gases and is extracted from them by mechanical collectors or electrostatic precipitators or a combination of both.

Investigation carried-out since early sixties at CBRI and other research centres in India have shown that :

(a) Average values of different chemical constituents in Indian fly ashes fall well within the range of the average values of fly ashes produced abroad. The Indian fly ashes, however, contain relatively higher amounts of SiO_2, Al_2O_3 and unburnt fuel as determined by loss on ignition (L.O.I.)and lower amounts of Fe_2O_3 and SO_3.

(b) Mineralogically, Indian fly ashes contain mullite, magnetite, haematite, quartz and appreciable quantity of glass as found in fly ashes produced elsewhere.

(c) The fraction passing 44 micron IS sieve in Indian fly ashes is comparatively lower. For instance, while most of the American fly ashes had more than 80 per cent of the material passing 44 micron sieve, only 3 Indian fly ashes out of 22 samples were found to belong to this category. Some of the reasons for this can be attributed to the fact that at present most of the Indian thermal power plants, the fly ash is collected by mechanical collectors and even this fraction is mixed up with the coarser fractions collected in middle and bottom hoppers.

(d) As compared to foreign fly ashes, Indian fly ashes are less reactive. This is attributed to :

i) higher content of coarse particles,

ii) higher water requirement for a given degree of workability of cement mortar and concrete, and

iii) lower content of spheroidal glass.Treatment with acid addition of alkalies and some trace chemicals, grinding, sieving, and recalcination are known to enhance pozzolanic activity of flyash.

(e) Chemical composition and physical properties of fly ash varies from sample to sample even at the same plant. A study on in-plant variation in the quality of flyash produced at some of the power plants, however, showed that the individual test values generally remained within the limits specified in IS:3812-1981 specification for fly ash for use as pozzolana and admixture'.

(f) As coal is a variable material, flyash therefrom is also a variable byproduct showing variable characteristic properties as specific surface, hence reactivity, carbon content, given in Figure - 1.

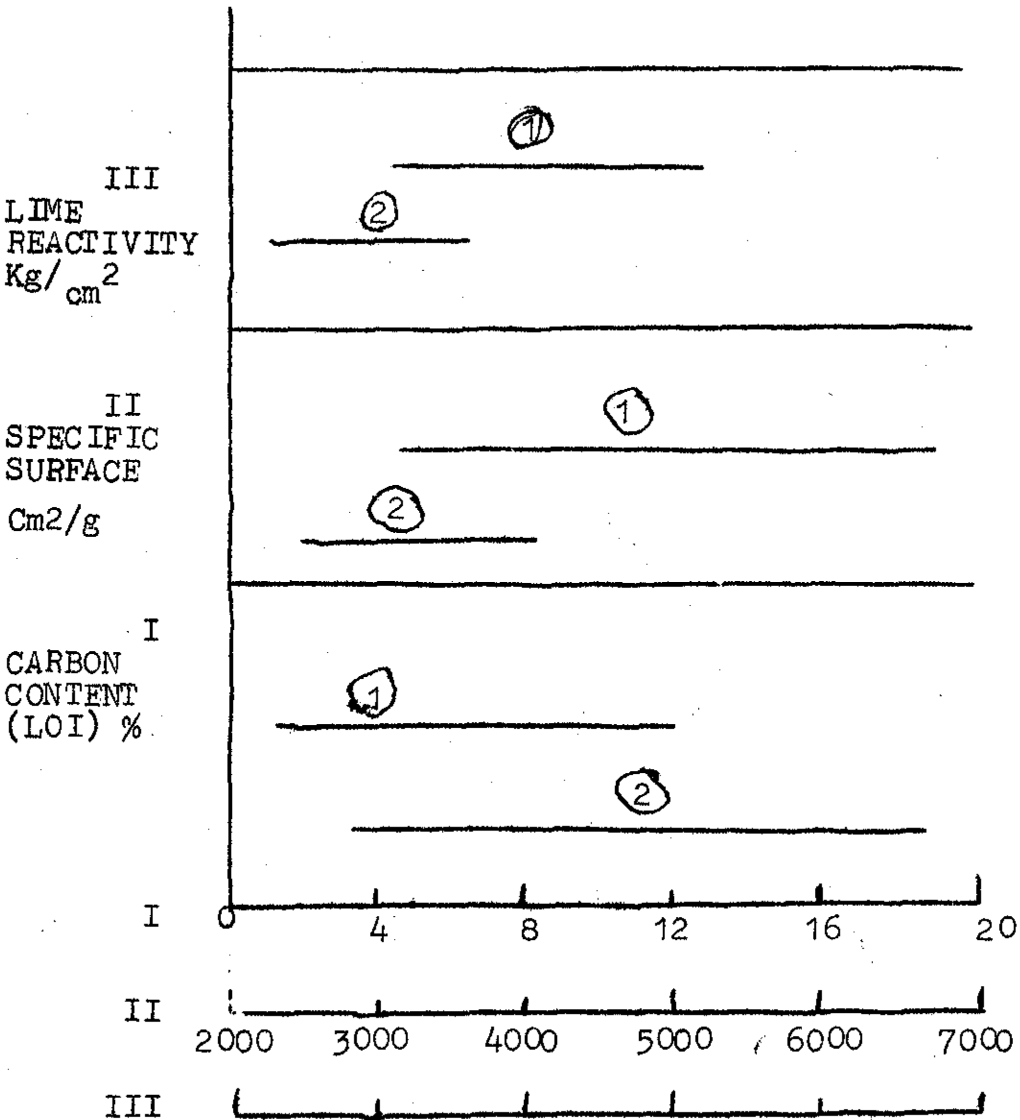
There are at present over 60 thermal power plants in India, producing about 35 million tonnes of fly ash every year. With further addition in capacity of the existing power plants and commissioning of some super thermal power plants, the annual production of fly ash is estimated to be about 37 million tonnes by the year 1989-90 and is expected to be doubled by the turn of the century. The serious problem of fly ash disposal will thus get worsened further in the years to come.

2.0 CURRENT ASH DISPOSAL PRACTICES

At the thermal power plants, fly ash is currently disposed off in the following manners :

2.1 Wet System

In the wet system, fly ash is mixed with water and sluiced to settling ponds or dumping areas near the plant. Being cheaper than any other manner of fly ash removal, it is most widely used at present. Availability of large areas of waste land for ponding, unrestricted water supply, regular emptying of filled-up ponds, are no doubt, essential for



(1) DRY COLLECTED FROM HOPPER (ESP)

(2) MIXED FLYASH AND BOTTOM ASH , (POND ASH)

Fig. 1 VARIABILITY IN THE QUALITY OF FLYASH satisfactory operation.

2.2 Dry System

In the dry system, fly ash in dry form, is generally carried away pneumatically into an overhead silo or a storage bunker at the plant. Removal of dry fly ash by mechanical means such as screw feeders, could be resorted to only when the quantity of flyash to be handled is small or there are some other special reasons.

Large quantities of fly ash can be disposed off in building of roads and embankments, reclamation of low-lying land and refuse dumps, filling of mines, treatment of polluted waters and unsuitable soils for agriculture. These uses are well known and are adopted, whenever required and wherever applicable.

3.0 ENVIRONMENTAL POLLUTION BY FLY ASH

According to World Health Organisation, the air quality standards should ensure that the concentration of the contaminants does not cause any direct or indirect adverse effect. IS: 10193(Part 1) 1982, requirements for ambient air quality with regard to sulphur dioxide (SO_2) and suspended particulate matter (SPM) are :

SO_2 concentration	-	Not to exceed 60 ug/m^3 as annual arithmatic mean
SPM concentration		
Region A	-	Not to exceed 200 ug/m^3 as annual 24 hours arithmatic mean

Region B - Not to exceed 200 ug/m^3 as annual 24 hours arithmatic mean

Region C - Not to exceed 200 ug/m^3 as annual 24 hours arithmatic mean.

Emission of huge quantities of fly ash, generally, much higher than the specified maximum limit of 500 ug/m^3 for SPM, is a common sight at the thermal power plants. It pollutes the environment and is a great nuisance for people living in nearby townships. Indian coal being low in sulphur content, pollution of atmosphere due to SO_2 is fortunately negligible. While fly ash primarily contains insoluble inorganic constituents such as SiO_2, Al_2O_3, $Fe2O_3$, CaO and MgO, traces of radio activity has also been detected in some fly ashes produced abroad. Indian fly ashes require thorough examination in this regard.

4.0 TRENDS IN FLY ASH UTILISATION

There are nearly fifty major areas where fly ash can be utilized. Almost all these areas have been investigated in India as follows :

(a) For the manufacture of portland pozzolana cement, pozzolana metallurgical cement, masonry cement, oil-well cement, low heat portland cement.

(b) Raw materials for manufacture of low energy ordinary portland cement.

(c) Fly ash concrete, mass conorete, cellular concrete floating concrete, etc.

(d) Aggregate, sintered fly ash light weight aggregate for concrete.

(e) To construct structural fills, high way embankments, dams and dykes, filling of mines.

(f) Construction material for high-ways, roads.

(g) Land reclamation and soil modification

(h) Fly ash based bricks/blocks, cellular concrete blocks/ slabs.

(i) Filler for fertilizer, paints, cleaning/washing powder, poly-propylenes, asbestos, etc.

(j) Recovery of minerals and elements like iron, aluminium & titanium, making of ferro-silicon alloy, rare elements such as Ge, Ga, Rb, etc.

(k) Separation of cenoshperes for using in insulating cable tape and fabrics, acoustical uses etc.

While reclamation of low-lying land and refuse dumps and building of roads and embankments has been the major area for flyash utilisation, extensive R & D work has been carried out in India and abroad on the utilisation of fly ash in the production of different building materials, which can be produced from Indian fly ashes, is given below :

4.1 PORTLAND-POZZOLANA CEMENT

The portland-pozzolana cement conforming to IS:1489-1976 can be manufactured using fly ash and gypsum or by intimately blending together portland cement and fly ash in suitable proportions. The intergrinding method is convenient to adopt as it does not require any major addition to the plant and equipment already available at a cement factory.

The portland-pozzolana (fly ash) cement is suitable for use wherever ordinary portland cement is usable under normal conditions. It produces less heat of hydration, increases water impermeability, reduces alkali-aggregate reaction and o offers greater resistance to attack of aggressive waters than ordinary portland cement. It is, therefore, particularly suitable for marine and hydraulic structures and other mass concrete constructions.

4.2 Ready-Mixed Fly Ash Concrete

Portland cement concrete in which a part of the cement has been replaced with fly ash is termed as fly ash concrete. When it is prepared and supplied to consumers in a plastic, unhardened, ready-for-use state, it is called ready-mixed fly ash concrete. The process of producing ready-mixed flyash concrete consists of the following two operations :

a) Proportioning of fly ash concrete mix.

b) Batching and mixing of different ingredients.

The flyash concrete is proportioned so as to attain its 28 day compressive strength equal to that of the corresponding plain cement concrete. Different proportioning methods including the one developed at CBRI, can be used for this purpose. The batching and mixing of different ingredients is generally done at a central batching and mixing plant. Some-times, different ingredients are taken in a truck mixer at the batching plant and are mixed either during journey or on arrival at the site of delivery.

The ready-mixed concrete has the advantages of better, quality control, reduction in wastage and pilferage of materials, labour and supervision, which are normally associated with concrete prepared at site.

4.3 Precast Fly Ash Concrete Building Units :

The use of fly ash concrete in the production of various types of precast building units such as concrete building blocks (solid or hollow), RCC transmission poles, columns, beams, hollow core slabs, doors and window frames, etc., has been made in a limited way by different organisations in India. It was observed that breakage of these units during handling at the time or removal from the casting yard and subsequent stacking for water curing was more. The higher breakage was attributed to their having lower strength at 1 or 2 days when the units were removed. Work done at CBRI has shown that fly ash concrete with 20 per cent less cement, by weight, than the corresponding plain cement concrete, can be so proportioned as to attain equal 1-day compressive strength. With equal 1-day strength, precast fly ash concrete units can be lifted and handled without higher breakage than the corresponding plain cement concrete units. Large number of precast hollow concrete building blocks, flooring and roofing units such as cored units, channel units, cellular units were prepared using flyash concrete having 20 per cent less cement, by weight. The strength and other properties were found to be comparable with those produced using corresponding plain cement concrete.

4.4 Sintered Fly Ash Lightweight Aggregate

The manufacture of sintered fly ash lightweight aggregate (SFALA) involves (i) pelletization or nodulisation of fly ash and (ii) sintering of fly ash pellets or nodules at 1100°-1200°C. The pelletization of fly ash is done by feeding flyash into a tilted rotating pan under a fine spray of water. The rotary motion of the pan causes the material to cascade and with this pellets are formed which are strong to withstand subsequent handling.

Normally, fly ash contains sufficient amount of unburnt carbon to provide for the fuel required for sintering. The sintering of the pellets is generally done either in a vertical shaft kiln or on a moving grate sintering strand. The use of rotary kiln has been tried on an experimental basis. A stationery grate sinter pot is also reported to have been successfully used in Poland. The production of SFALA form of the Indian fly ashes has been successfully carried out on a pilot plant moving grate sintering strand at CBRI. The aggregate is suitable for use in the production of structural lightweight concrete and precast lightweight concrete building units for use as load bearing and non-load bearing elements.

4.5 Lime-Fly Ash Cellular Concrete

To produce lime-fly ash cellular concrete quicklime, flyash and gypsum are taken in certain proportions and wet mixed in a high speed mixer to form a thin slurry. A small amount of aluminium powder is then added and mixed into the slurry. Hydrogen gas liberated by reaction between lime and aluminium aerates the slurry which is poured into steel moulds to about 2/3rd depth and left undisturbed to set. The stiffened material is out into blocks of desired sizes which are then autoclaved at a steam pressure of 11-12 kg/cm^2. After taking out from the autoclave, the blocks are allowed to cool and stacked for use.

The cellular concrete consists of fine grained silicate structure having small non-communicating air cells. It can be produced to conform to different dry bulk density requirements in the range of 400 to 1442 kg/m^3. It possesses low thermal conductivity (0.07 to 0.21 kcal/m/hr/°C for density 400 to 1000 kg/m^3) and a good fire resistance. Like wood, it can be sawn, chiselled, planed, screwed and nailed. Its Building units having dry bulk density of 700 kg/m^3 or higher are suitable for load bearing walls in buildings of 2 to 3 storeys and partition walls in multistoreyed buildings. Its low density permits use of large building units with saving in the cost of handling and construction.

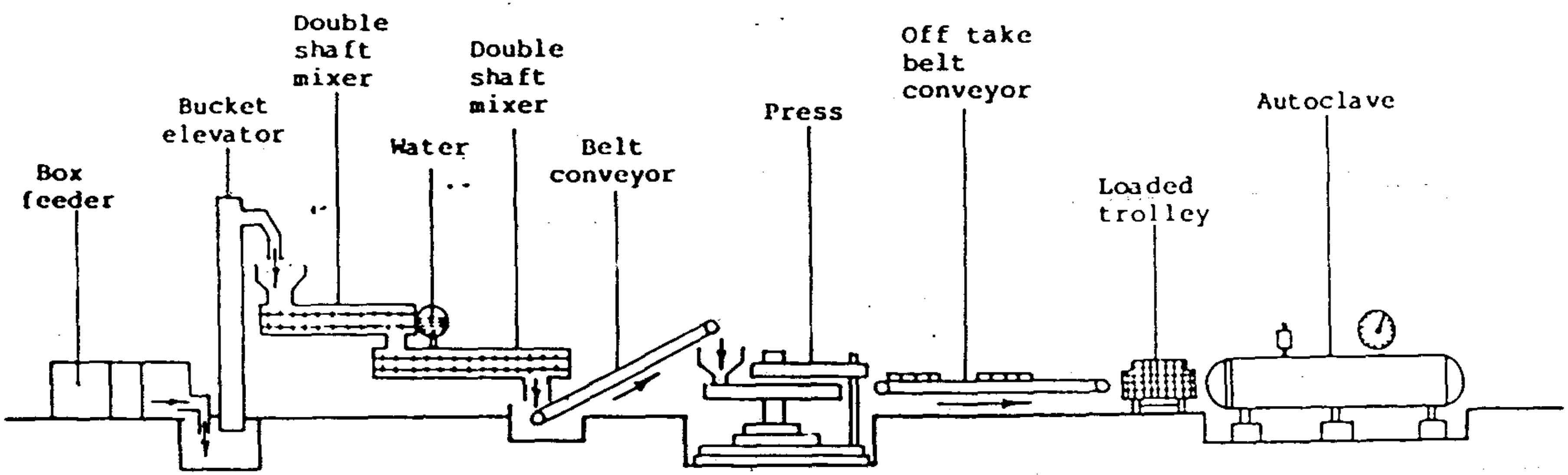


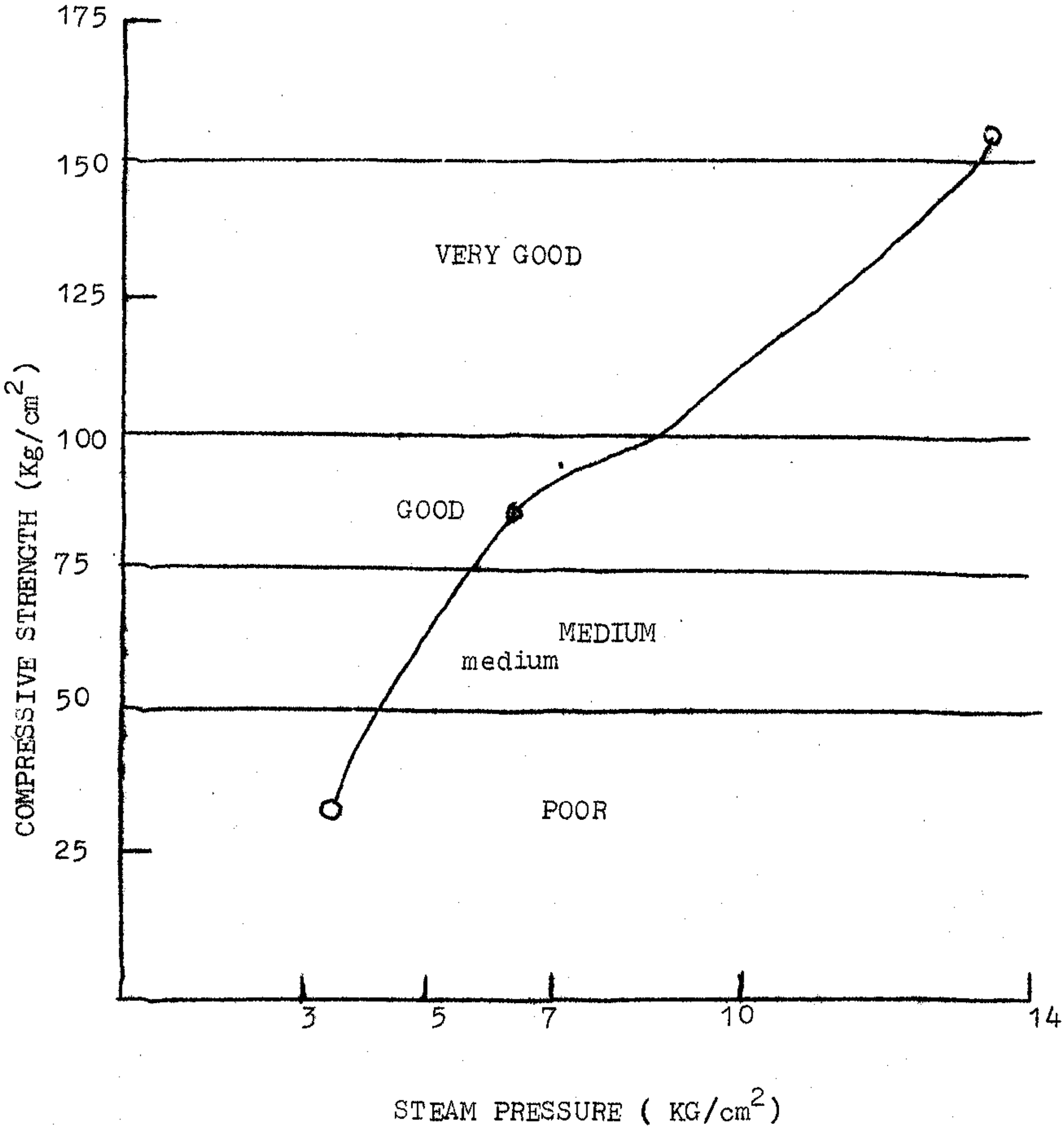
Fig.2 SCHEMATIC DIAGRAM FOR PRODUCTION OF FLYASH-SAND-LIME BRICKS

4.6 Fly Ash Building Bricks

Good quality high strength building bricks can be produced from fly ash using sodium silicate, cement or lime as binder. The mixture of fly ash, binder and coarse fillers such as bottom ash, cinder, sand, etc., in suitable proportions, is moulded into bricks under pressure. While the sodium silicate bonded bricks are burnt at 1060°C - 1150°C. The lime bonded fly ash bricks are autoclaved under saturated steam at a pressure of about 14 kg/cm^2, the cement bonded flyash bricks are water cured at ambient temperature to obtain the desired strength and dried before use.

4.6.1 Fly Ash-Sand-Lime Bricks

The CBRI process of making fly ash-sand-lime bricks was patented in 1972 on the basis of investigations started since 1968. The process essentially consists of moulding under pressure(not less than 300 kg/cm^2 a semi-dry mixture of flyash (70-90 parts), sand(10-20 parts) and lime(7-10 parts)into bricks, and autoclaving them under steam pressure of 10-14 kg/cm^2 saturated steam for 4-6 hours. The process produces bricks of wet compressive strength 100-250 kg/cm^2 water absorption 8-15 per cent, depending on the quality & grading of flyash and quality of lime.The process shows 30% saving in energy as compared to production of burnt clay bricks.



PRESSURE OF STEAM CURING AND COMPRESSIVE STRENGTH OF FLYASH-SAND-LIME BRICK

IS : 4139 - 4976 Specification for Sand Lime Bricks

Fig -3

The flow sheet diagram of the process is shown in Fig.2 and the effect of steam pressure on the compressive strength of bricks in Figure-3. The Institute is setting up the first commercial plant of fly ash-sand-lime bricks, 36000 bricks/ day, for Damodar Valley Corporation at Durgapur(West Bengal) and also helping the National Thermal Power Corporation of India (NTPC and other prospective clients in planning of future plants of fly ash sand-lime bricks.

These developments assume special significance in India where agricultural soil otherwise used for making burnt clay brick has to be conserved and also energy saved at all costs; with special features of substantial utilization of fly ash and reduction of air-borne pollutants. The test results of the bricks, made in the laboratory pilot plants, from DVC local raw materials, are given in Table - 1.

TABLE-1

Properties of Fly Ash-Sand-Lime Bricks(DVC)

Mix Composition (by Weight)			Auto-claving Conditions		Wet Compressive strength (kg/cm^2)	Bulk Density (kg/m^2)
Fly Ash	Sand	Lime	Pressure (kg/cm^2)	Duration (Hours)		
70	20	10	14	6	106	1422
70	20	10	14	4	105	1410
70	23	7	14	6	90	1415
60	30	10	14	6	117	1500
60	30	10	14	6	112	1485

4.6.2 Clay Flyash Bricks

The process of manufacturing clay-fly ash bricks from all types of soil is similar to that of normal clay building bricks production except that a certain amount of fly ash is mixed in the clay before moulding bricks. The actual amount of fly ash added varies according to the plasticity of the clay and could range from 30 to 70 per cent, by volume, as the clay charges from moderately plastic to highly plastic.The fly ash acts as a good opening material and effectively eliminates drying shrinkage cracks in the bricks produced from highly plastic clay. The unburnt carbon in flyash provides extra fuel forbburning during firing. The rate of fire travel during burning of clay-flyash bricks in the brick kiln is also increased. In a large scale production trial,overall fuel consumption per lakh bricks has been found to reduce by 4-5 tonnes and production of first class bricks increase by 15 per cent. The characteristic properties of clay flyash bricks from Black, red and alluvial soils are given in Figure 4,5 & 6.

The flyash building bricks are usable in place of common burnt clay bricks for all types of brick masonry.

4.7 Portland Cement Clinker

Being comparable with clay as a source of SiO_2 and Al_2O_3 fly ash has been found suitable for use, in place of clay in the raw mix for producing portland cement clinker by semi-dry process.The nodules of the raw mix containing flyash are burnt

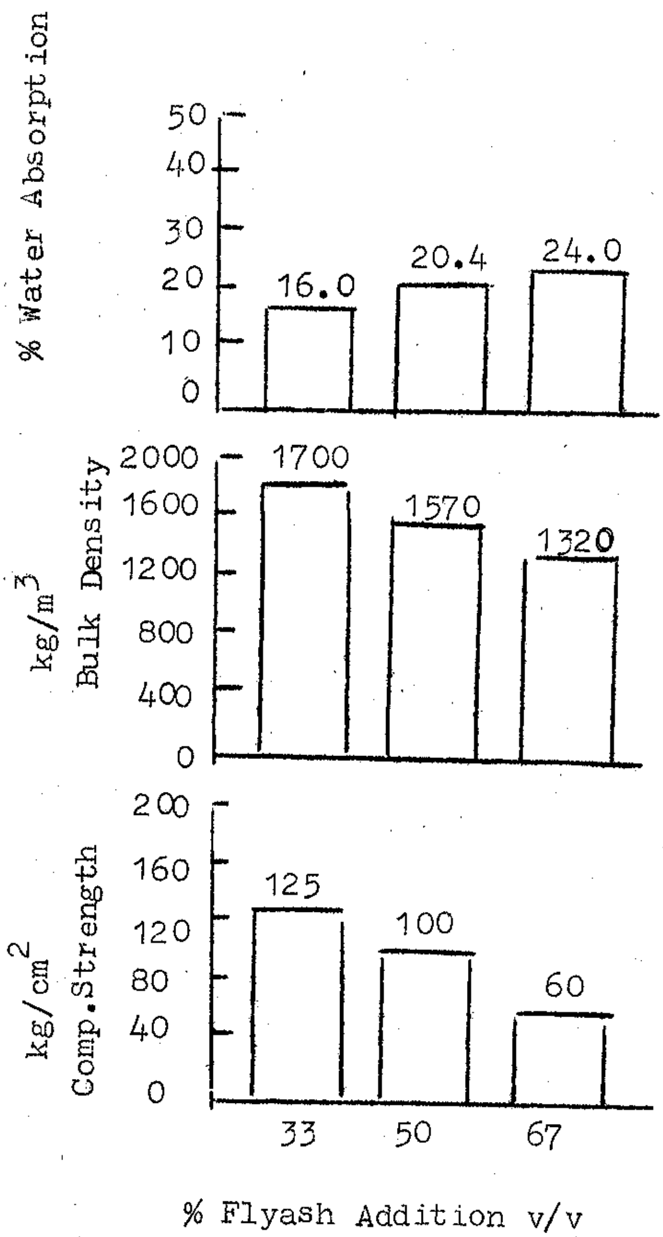


FIG.5 PROPERTIES OF CLAY BONDED FLYASH BRICKS FROM RED SOILS OF KORBA (MP)

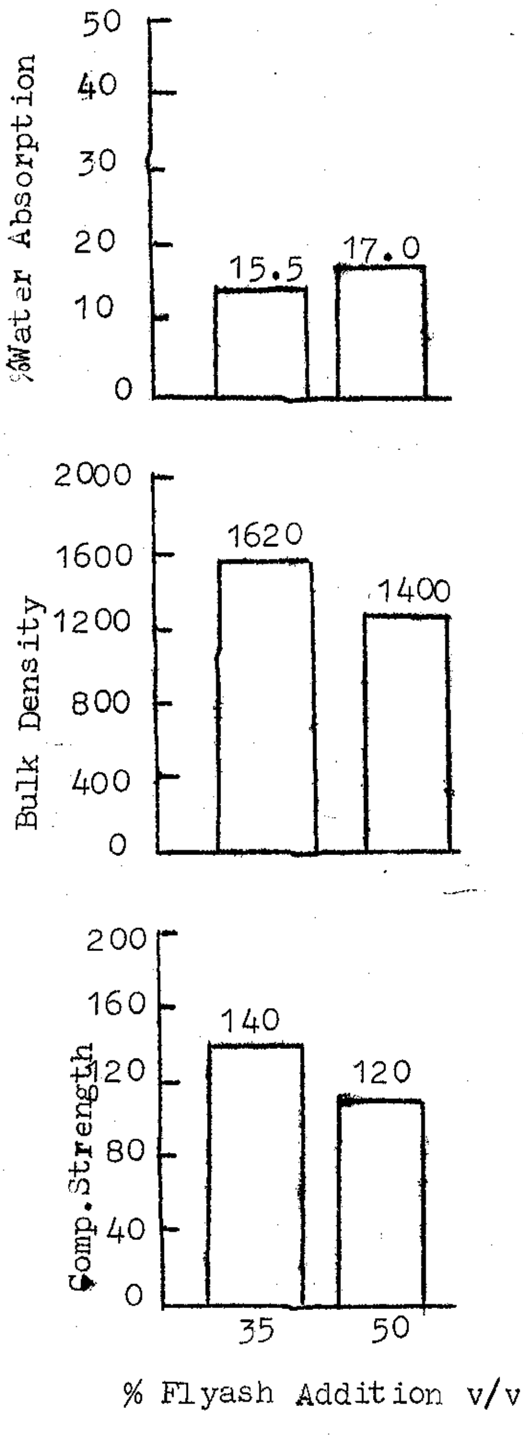


Fig.4 PROPERTIES OF CLAY BONDED FLYASH BRICKS FROM BLACK SOILS OF BHOPAL (M MP)

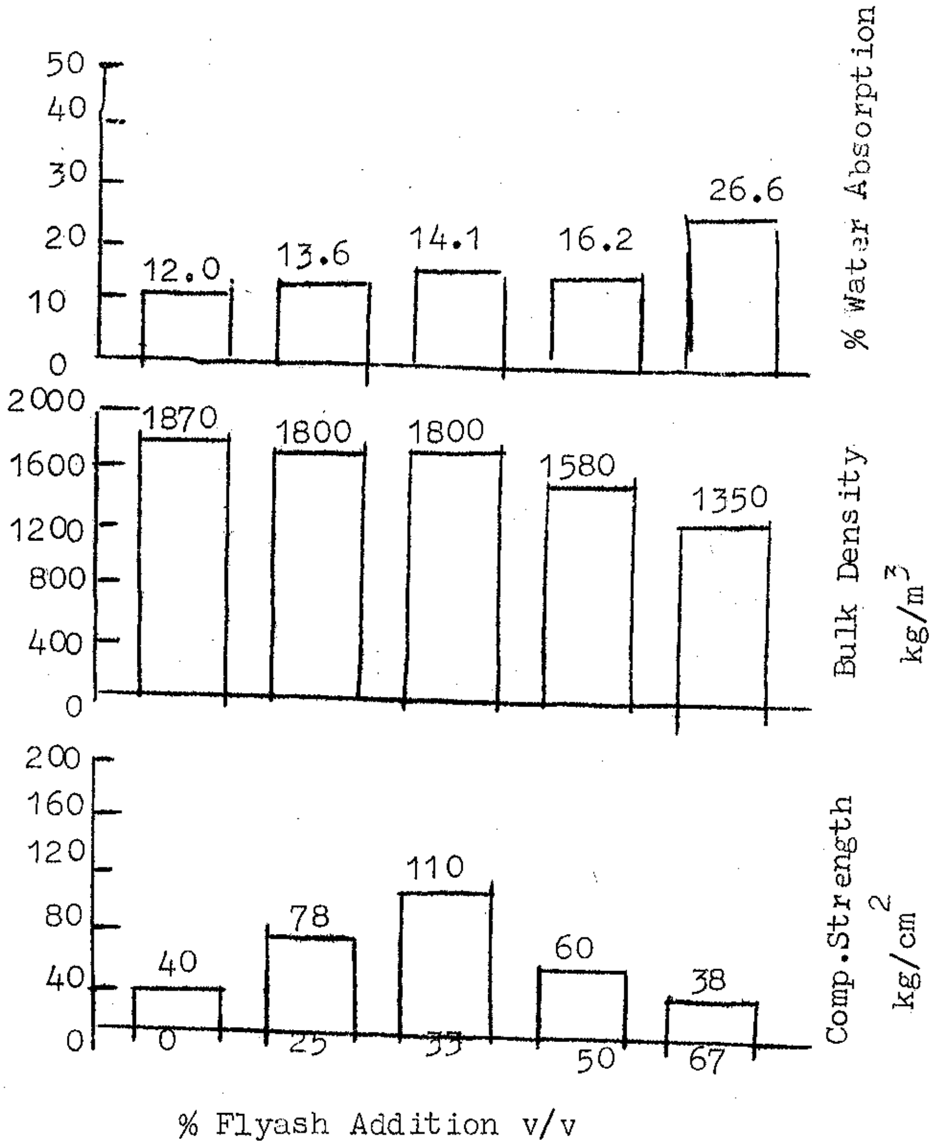


FIG.6 PROPERTIES OF CLAY BONDED FLYASH BRICKS FROM ALLUVIAL SOILS OF PATRATU (BIHAR)

in the rotary kiln at 1350°C instead of 1450°C normally employed for conventional raw mix containing clay. Besides as substantial saving in fuel consumption, the use of ash in the raw mix has been found to enable production of cement clinker with MgO content of 6 per cent without causing unsoundness in the final cement. In this way, it helps in the utilisation of magnesian limestone of marginally higher MgO content, which at present is not used by the cement industry.

4.8 Oil-Well Cement

Oil-well cement is used for cementing the steel casings of oil-wells to the rock formation. Work carried out of CBRI has shown that fly ash can be interground with portland cement clinker, gypsum and some additives in certain proportions to produce cement conforming to the requirements of an oil-well cement. Such flyash based cements are reported to have been successfully used in oilwell cementing abroad.

4.9 Masonry cement is mainly intended for use, in place of ordinary portland cement, in masonry mortars. It imparts the much desired properties of high workability, plasticity and water retentivity to the masonry mortars. Work carried out at CBRI has shown that masonry cement conforming to the standard specification IS: 3466-1967, can be produced by intergrinding 2 parts of fly ash, 2 parts ofhydrated lime and 1 part of portland cement or 2 parts of flyash, 3 parts of portland cement & 5 parts of granulated blastfurnace slag with suitable quantity of gypsum and air entraining admixture.

5.0 USE OF FLY ASH IN MASS CONCRETE IN INDIA

There have been only some scattered examples of the use of flyash in mass Concrete although the beginning was made in Rihand Dam in early sixties. But certainly the trend has not percolated deep in the construction of hydraulic structures in the country.

Generally the replacement of cement by flyash has been to an extent of about 15 to 20 per cent, by mass, in cement mortar and concrete, the typical examples for such applications have been given in Table 2.

TABLE -2

Use of Fly Ash in Hydraulic Structures in India

Sl No	Structure	State	Cement Replaced (Per Cent)	Source of Fly Ash
01	Gurgaon Canal	Haryana	15	Delhi
02	Jawahar Sagar Dam	Rajasthan	20	Delhi 'C'
03	Kakki Dam	Kerala	20	Nevveli
04	Narora Barrage	U.P.	15	Narduaganj
05	Rihand Dam	U.P.	15	Bokaro
06	Sone Barrage	Bihar	15	Bokaro
07	Umium Project	Assam	Not Available	Durgapur
08	Chandil Dam	Bihar	25	Talcher

The phenomenon of relatively lower strengths at early ages in concretes and mortars with partial replacement of cement with pozzolana is well recognised. This loss in strength, however, is more or less made up at later stage. The level of structural strength requirement in dams in relatively low and the rate of construction is also low, requiring a large span of time, may be a year or more, to achieve the full design load. As such flyash concrete and mortar can and have been used to advantage for such constructions.

6.0 Fly Ash for Road Pavements

A large quantity of fly ash could be utilized in roads and embankment constructions lime : fly ash: sand in 1:3:9 or lime:fly ash: sand; course aggregate in 1:3:20:40 ratio are particularly suitable for road pavements Table 3 shows the savings in conventional materials and cost in the use of fly ash in pavement layers, except in sub-base.

Table -3

Fly Ash Utilization in Different Pavement Layers and Saving Effected

Specification	Flyash Requirements Per Kilometer (Tonne)	Savings in Percent	
		Conventional Hard Stone/ Soil	Cost
Fill/Embankment Material	9600	75-100	-
Sub-Base 1. Lime Flyash Stabilized Soil	120	100	20-30

Sub-Base/Base Course				
1.	Lime Flyash Concrete	117	30	-4
2.	Lean Cement Flyash Concrete	97	30	-1
3.	Lime Flyash WBBM	21	30	-7.8
Wearing Course				
1.	Cement Flyash Concrete	52	-	6
2.	Roller Compacted Concrete	75	-	15
3.	Flyash as a Filler Material in Asphaltic Concrete (thickness : 10 cm)	40	-	10-15

The highlight intial cost of construction is offset by the long life and less maintenance cost.

7.0 Techno-Economic Viability of Fly Ash Utilisation

Techno-economic feasibility studies on producing different building materials from fly ash, carried out at CBRI, have shown that :

a) Production of portland-pozzolana cement using flyash conforming to IS: 3812 - 1981, is a viable proposition. In fact, some of the cement factories in the country are already using fly ash in the production of portland-pozzolana cement. A major impediment in the large scale use of fly ash is non-availability of fly ash in dry form. At most of the thermal power plants, the fly ash disposal system delivers wet fly ash. The transportation of flyash from thermal power plants to cement works situated apart over long distances poses another problem. Another factor which works against fly ash utilisation in the production of portland-pozzolana cement, is the easy availability of brick bats from brick kilns, situated near a cement plant, at a comparatively cheaper rates.

Production of sintered fly ash aggregate (SFALA) provides an opening for large scale fly ash utilisation, since more than one tonne of raw fly ash is required to produce one tonne of SFALA. The laboratory and pilot plant trials carried out at CBRI have established production of SFALA from Indian fly ashes and its use in precast lightweight concrete building units. The CBRI pilot plant has now been shifted to Bandel at the request of W.B. State Electricity Board and SFALA is being produced on it using Bandel fly ash. CBRI has developed technology for producing 30 tonnes SFALA per day in sintering hearths. For large production, say 100-200 tonnes per day, a moving grate sintering strand would be required.

Production of lime-fly ash cellular concrete using upto 80 per cent fly ash in the raw mix is economically viable. In India, cellular concrete has been produced first by Hindustan Housing Factory, New Delhi, using cement and ground sand in the raw mix and marketed under the trade name of 'Vayuten'. Subsequently, its production was taken up by the Cellular Concrete Plant, Ennore, Madras and Siporex India Limited, Pune. It has a big scope of use in high-rise buildings and other housing projects.

d) About 25 million clay-fly ash building bricks have already been produced in the country by NTPC and other public Sector Undertakings and Private brick manufacturers. Besides establishing techno-economic feasibility, the production of clay-fly ash building bricks in such a large numbers indicates big scope of fly ash utilisation.

Production of fly ash-sand-lime building bricks is technically sound proposition and is of particular advantage in areas where good quality brick making clay is not available. DVC has taken up establishing a fly ash-sand-lime brick plant at Durgapur. The plant and machinery for setting up the plant is available indigenously.

8.0 STANDARD SPECIFICATIONS ON FLY ASH

A survey of standards of different countries for suitability of fly ash for use in cement and concrete is summarised in Table-4.

TABLE -4

Survey of Standards of Different Countries for Suitability of Fly Ash for Cement Manufacture Based on Its Chemical Composition.

Country	Norm	$SiO_2+Al_2O_3$ $+Fe_2O_3$ (Min)	SiO_2 (Min)
1	2	3	4
Australia	AS N 1129	-	-
Australia	O Norm B 3319 + B 3320	-	-
Denmark	DS 411, DS 427	70(cement use)	40(Cement use)
Federal Republic of Germany	DIN 1045	-	-
India	IS:3812	-	-
Japan	JIS 6201	-	45
Russia	Gost 6269	-	40
Sweden	B-1(Eddition 2)	-	-
Turkey	TS 639	-	-
United Kingdom	BS 3892	-	-
U.S.A.	ASTM C 618	70	-

Composition (Per Cent)

CaO (Max)	MgO (Max)	SO_3 (Max)	Na_2O (Equiv. Max)	Cl	Loss on Ignition (Max)
-	-	2.5	-	-	8
-	-	5.0	-	0.1	5
12(Cement Use)	5	4.0	1.5	0.1	5
8	-	4.0	-	0.1	5
-	5	3.0	1.5	-	12
-	-	-	-	-	5
-	-	3.0	-	-	10
-	5	3.0	-	0.1	5
6	5	5.0	-	-	10
-	4	2.5	-	-	7
-	5	5.0	1.5	-	12

LACUNAE IN PRESENT INDIAN STANDARD SPECIFICATION FOR FLY ASH

Considering the special needs of hydraulic structures, flyash of requisite and consistent quality should be made available in the market in the required quantity. On perusal of Indian Standard Specifications, IS: 3812-1981, it is seen that there are serious lacunae in specification requirements of fly ash which hinder the use of fly ash in mass concrete and structural concrete construction.

(1) Packing of Fly Ash

IS: 3812-1981 "Specifications for fly ash" already provides a clause for supply of fly ash in bulk or in bags. At present, the fly ash is not available in bags from thermal power stations. The relevant clause (No. 9.2) should be implemented for effective quality control.

(2) Loss on Ignition

In Indian fly ashes, the loss on ignition, which mainly represents the unburnt carbon content is less than 6.0 per cent in majority of the cases. As such, it is felt that the maximum loss on ignition may be revised to 6.0 per cent against the present limit of 12 per cent, as in the specifications of U.S.A. and Japan to improve the quality of fly ash.

(3) Fineness (Specific Surface)

The specifications prescribes only a minimum value of fineness of 3200 cm^2/g for Grade I fly ash. There is thus no upper limit to the fineness. This may be revised to prescribe range in values as in BS: 3892 so that fly ash of reasonably uniform quality is produced and marketed. This range can be 320-400 m^2/kg.

CONCLUDING REMARKS

Large quantities of building materials are required to meet the demands of building industry which is estimated to build nearly 6 million dwelling units in urban areas alone during Seventh Five Year Plan Period. With increasing migration from rural to urban areas, the demand for housing is likely to increase. There shall, thus, be a tremendous scope for the growth of building material industry and the prospects of utilisation of different building materials from fly ash such as portland-pozzolana cement precast fly ash concrete building units, clay-fly ash building bricks and fly ash-sand-lime bricks, are are considered bright.

Several processes have been worked out including their techno-economic feasibility reports for mass construction of fly ash as building material. India does need a break-through in adopting these technologies, purely in view of national priorities in housing, such as introducing alternative building materials, solving disposal problems of flyash which may touch a production picture of 90 million tonnes/year in the next decade, and most importantly for safeguarding the ever-polluting environment around many thickly populated urban and rural areas.

Fortunately, the above mentioned wisdom has dawned, of course quite late, in the government and in private construction sector as well as in building materials industries. The CBRI, Roorkee with its accumulated expertise will continue to take a leading role in this stupendous task for realizing the cherished goal of channelling the utilization of fly ash through an effective, planned and phased programme.

Flyash Utilization project reports on glazed wall tiles, ceramic tableware-artware industry and acid resistance Brick

By

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UTILIZATION OF FLY ASH IN CERAMIC TABLEWARE AND ARTWARE INDUSTRY

The production of crockery and artware from the conventional raw materials is a running process for the ceramic industries. With the advancement of the growth of ceramic industries, the utilization of some newer material is an improved process. Large quantities of fly ash are being produced from various thermal power plants of this country based on pulverized coal firing. Heavy clay and structural products like building bricks, tiles, blocks have already been prepared successfully.

Keeping in view CGCRI Naroda Centre has developed an appropriate technology by utilizing the fly ash in tableware and art-ware industry. The wares possessed the characteristic as stoneware and can be adopted by medium and small scale sectors. The technology is cost effective due to the use of indigeneous machineries which are locally available and also the raw materials. For making a perfectly white glaze, it is advised to use frit glaze and to fire the wares in shuttle or tunnel kiln where firing problem is very less. The single fired materials can be fired in down draft kiln also by the application of coloured glaze on the ware for better outlook.

Nature of Fly Ash

It is refractory and abrassive in nature. Its particle size is very fine and specific surface area varies from 3500–8000 cm^2/g. The chemical and physical characteristics of fly ash suggest that it can meet the specifications for a siliceous or aluminous material. It contains maximum silica having crystalline and amorphous glassy phase. Among the crystalline phases there are quartz and mullite etc. and in amorphous phase, it contain silica and silicates of aluminium.

Manufacturing Process

The important steps in the process are :

1. Preparation of batch by choosing suitable raw materials including fly ash.
2. Grinding and mixing.
3. Shaping in jiggering and casting.
4. Drying and finishing of the products.
5. Biscuit firing at 1100°C - 1250°C with 1 hr. soaking in case of using frit glaze and glost firing at 1050°C-1100°C.
6. Single firing with coloured glaze at 1250°C with 1 hr. soaking.
7. Inspection.

Advantages of using Fly Ash

Fly ash contain silica in the range of 50 - 60%. It can be better substituted in place of quartz. Quartz is a hard lump and it requires more grinding to get a fine product. Fly ash is a find powder material so it can be mixed with the body compositions even in blunger which is cost effective.

A comparative statement of fly ash tableware with stoneware as per IS: 2838-1964 is given here.

Requirement	Stoneware	Fly ash ware
1. Craze resistance	The wares should be free from craze.	The wares are craze resistant.
2. Water absorption	It shall not be more than 3%	Water absorption less than 1%
3. M.O.R. kg/cm^2	The M.O.R. value should not be less than 350 kg/cm^2	M.O.R. value is 510 kg/cm^2
4. Resistance of body to acid	The resistance of body to acid shall not be less than 99%	The resistance of body to acid is 99.2%
5. Resistance of glaze to acid	The loss in wt. shall not be more than 10mg/dm^2	The loss in wt. is 8-9 mg/dm^2

Major equipments

Ball Mill, Blunger, Jigger-jolley preferably automatic and De-airing pug mill.

Project capital outlay and scheme of financing

The fixed capital cost on building is 22 lakhs and the fixed capital on plant is Rs.20 lakhs.

Working Capital

Working Capital corresponding to 75 days manufacturing cost is about 10-12 lakhs.

Preconstruction cost estimate

Rs. 52 lakhs.

Return on investment

About 25% after deduction of tax on returns.

Appendices

A. Specification of major equipment cost.
B. Cost of land and building
C. Detailed project report

Highlights

1. Comparable to stoneware.
2. Easy and plenty availability of fine raw materials saves time and energy during processing.
3. The manufacturing process is very simple and requires no sophisticated costly machineries.
4. The process is economically viable.
5. It gives sufficient strength and attraction and satisfy all the conditions as per IS in stoneware items.

B. ACID RESISTANCE BRICK FROM FLY-ASH

(CGCRI Technology for commercial utilization)

Acid Resistance bricks (Tiles) which resist corrosion are mainly used in most of the chemical plants for the storage tanks of Acid or alkalies or other solvent (acid in nature), A.R.Bricks are used, as lining in different types of vessel to prevent corrosion, Furnace chimney, power-plant chimney, irrigation canals, etc.

Central Glass & Ceramic Research Institute, Naroda Centre has developed a process for manufacturing Acid Resistance bricks from Fly Ash, with other ceramic raw materials. Fly Ash is the waste from power plant. As such, there is no any significant value of fly ash. Now-a-days cement plants are utilizing flyash for manufacturing of pozzolana cement. We have used flyash of A.F.Co., Sabarmati. The chemical composition is as under :

Chemical Analysis

		A.E.Co.Power-Plant	Gandhinagar Power Plant	Surat
SiO_2	:	56.70%	58.06%	54.48
Al_2O_3	:	24.45	22.61	22.50
Fe_2O_3	:	4.50	6.80	4.96
TiO_2	:	1.62	1.50	0.70
CaO	:	2.48	2.78	3.58
MgO	:	1.45	1.68	0.16
Na_2O	:	0.56	0.50	0.40

K_2O	:	0.50	0.87	0.75
SO_3	:	0.82	0.72	1.25
LOI	:	6.62	4.70	10.92
		99.70	99.66	99.70

Manufacturing Technique

Fly ash, Felspar, Non-plastic clay, plastic clay are the principal raw materials. Mixing of all these raw materials, moistening, seiving, pressing, drying and firing in furnace are the manufacturing steps.

Properties

1.	Water absorption	:		3.80 %
2.	Cold crushing strength	:		750 kg./cm^2
3.	Flexural strength	:		116 kg./cm^2
4.	Shrinkage of brick	:		8.5%
5.	Acid resistance:Loss in mass		i)	0.75 %
			ii)	0.62 %
			iii)	0.63 %
			iv)	0.82 %
			v)	0.68 %

Except water absorption, all the tests pass through Ist Grade quality of A.R. Bricks as per IS: 4860 - 1968.

Salient Features

* A waste material viz. Fly ash is the main raw material which is available in plenty from all thermal power- plants and big chemical plants.
* The process is very simple.
* It is an economically viable process.

Major Equipments

Muller mixture, seiving machine, pulveriser, press and furnace etc.

Economics

It is estimated that a unit with a capacity to produce 2 lakhs nos. of bricks per annum would need an investment of Rs.30.oo lakhs (approximately).

C. UTILISATION OF FLY ASH FOR DEVELOPMENT OF GLAZED WALL TILES

The use of fly-ash for making pozzolanic cement, cement concrete, bricks, light weight synthetic aggregates and in the construction of roads and pavements is well-known. The Central Glass and Ceramic Research Institute, Naroda Centre has investigated the possibility of utilisation of fly-ash for making glazed wall tiles.

Fly-ash, plastic clays, calcite, etc. were used for body preparation. Red lead, borax, boric acid, felspar, whiting, china clay, etc. were the raw materials used for the glaze preparation. The fly-ash collected from a local thermal power station had the following composition :

SiO_2 - 56.70%, Al_2O_3 - 24.45%, Fe_2O_3 - 4.50%, TiO_2 - 1.62, MgO-1.45, Na_2O - 0.56, K_2O-0.50, SO_3- 0.82, LOI - 6.62.

The Crystalline phases in fly-ash are observed by X-ray and DTA measurements were mainly free quartz, mullite, heamatite, magnesite etc.

Several composition were tried for wall tiles. The batch compositions were wet mixed in a pot or ball mill. Water of the body was removed by plaster of Paris moulds and dried in the dryer. The semi-dried body was sieved and tiles were pressed under a pressure of 300 Kg/cm^2.

The dried tiles were biscuit fired at 1050 - 1100 °C and glost fired at 950 - 960 °C in our electric furnace. The lead borosilicate fritted glaze maturing at 950°C- 960°C was developed in this laboratory for wall tile body.

For fitting, the batch was fired in 5 kg. refractory crucible in an oil-fired furnace at about 1300°C. The frit was mixed with china clay and was ground in pot mill. The sieved ground material was mixed with water to have glaze of prescribed specific gravity. The glaze was applied on the surface of the biscuited tile and fired.

Comparative study of performance of wall tiles made from flyash and as required by BIS: 777-1970

Properties	Wall tiles made from fly-ash	Performance required as per BIS:777-1970
Water absorption	16.0 - 16.5 %	Shall not exceed 18.0%
Impact strength	0.02-0.022 kg. fm/cm by pendulum apparatus (as described in BIS: 777-1970	Tiles when tested for impact strength as described in IS:777 shall not have value less than 0.02 kg. fm/cm.
Chemical Resistance	When tested by the method described in BIS:777, the glazed surface of the tiles did not show deterioration.	When tested for chemical resistance by the method described in IS:777 shall show no deterioration in glaze.

Further developmental work of the above product is in progress.

Pre-design cost estimates for the process on glazed wall tiles from fly-ash

1. Project capital outlay :

   Rs. 16,00000 - 17,00000 (approx.) for 300 tons. glazed tiles/annum.

2. Working capital (for 75 working days):

   Rs. 4,50,000 - 5,00,000

3. Cost of production of the tiles :

   Rs. 0.91 per tile ($4\frac{1}{4}$ " x $4\frac{1}{4}$")

List of machineries :

(1) Blunger

(2) Ball Mill

(3) Filter press

(4) Granulator

(5) Tile press

(6) Kiln

(7) Rotary kiln or tank furnace for making frits

(8) Roller mill

(9) Tile glazing unit by water fall method

(10) Weighing balance.

CFRI FLY ASH BRICK : A REWARDING TECHNOLOGY

by

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INTRODUCTION :

Brick is an essential yet the commonest of all building materials. Its requirement in the country is unending and the gap between the demand and supply is ever increasing. If one carries out strength-weakness-opportunities-threat(SWOT) analysis, the present time would appear to be the most opportune for modernising and mechanising the brick industry. The potential threat of the coal ash (both fly ash and bottom ash) from the 66 existing thermal power stations with pulverised coal firing system need hardly be underscored from the view point of pollution hazards and enormous waste of cultivable agriculture land being used for the dumping of ash. Clay brick industry is also destroying the fertile top soil to the extent of 50,000 acres every year now. India is far behind many advanced countries in utilizing this waste material and compared to the topmost 58% utilization in France, followed by West Germany and U.K., not more than 3% of fly ash is being used in India.

From the present level of 30-40 million tonnes per year of coal ash production, the estimated increase by 2000 AD will be about 125 million tonnes per year, with 15% annual rise in thermal capacity slated for the decade. It is not difficult, therefore to foresee the intensity of the ecological problems that would arise if proper care is not taken for the disposal of fly ash. It is estimated that about 28,300 hectares of storage land would be required for the fly ash if not utilized at all.

The National Housing Policy estimated a total of 300 billion bricks as the requirement for the period 1990-95. The present manufacturing capacity can meet upto 231 billion bricks thus leaving a huge gap between the demand and supply. Government of India through the Ministry of Urban Development has established the Building Materials and Technology Promotion Council(BMTPC) which strives to improve and modernise the conventional brick industry. There is also a Working Group on fly ash utilization constituted by Government of India which have recommended commercial utilization of fly ash through manufacture of building bricks. Even the existing power plants may have to undertake with high capital investment, at the instance of Department of Environment and Pollution Control of the Government of India, installation of Electrostatic Precipitators(ESP) to check particulate matter escaping into the atmosphere. To meet the exponentially rising demand of the building bricks, the only option most probably would be to rely on alternatives of the clay bricks. Time is not only ripe for promoting modern technologies, but also most conducive to augment production of building bricks at the present juncture with the maximum use of fly ash -

absolutely a waste material otherwise from the thermal power stations.

TECHNOLOGICAL DEVELOPMENT AT CFRI:

Among all the available technologies for the manufacture of building bricks from fly ash, the CFRI technology appears to be the most suitable and is already commercialised. Even though the CFRI Scientists developed the technology and subsequently patended in 1970, the first demonstration activities began in 1977 under the aegis of West Bengal Housing Board for construction of some of their utility buildings at Asansol Satellite Township Project, utilizing about 4.5 lakhs of fly ash bricks produced from a 1000 bricks per shift fly ash brick plant. These buildings have stood the test of time for over 14 years now and subsequently, in 1986 the first commercial venture in the private sector has infused further confidence among many more entrepreneurs and organisations to go for licencing the CFRI technology for industrial exploitation. The technical and economic feasibility of the project have also been established by WBHB, NRDC, W.B. Consulting Organization, Chem. & Met. Design Co. Pvt. Ltd., Development Consultants Ltd., etc. and all have upheld the economic viability for the commercialization of the process. Of late, a spate of recognition has come to the CFRI technology through the CSIR Technology Award - 1991, NRDC R-Day Award - 1992 and also the Bangur Memorial Award - 1990 for innovative technology of the Bharat Chamber of Commerce (awarded to M/s Jagatdhatri Brick Industries Pvt Ltd. for successful entrepreneurship based on CFRI Technology).

The CFRI Process :

Utilization of fly ash for building bricks appears to be a must. The CFRI process utilizes the unique pazzolanic property of fly ash which is susceptible to react with lime and sand in presence of moisture of develop complex calcium silicate hydrate compounds and steam curing helps to complete the reaction, thereby imparting strength to the bricks.

The CFRI process for producing the building brick is simple. 80% of fly ash (even bottom ash in admixture) with 10% each of sand and lime (with 70% CaO) are mixed, after the addition of 0.2% accelerator (inorganic chemical)] with water for moulding the bricks in a rotating table-press operated hydraulically (100-200 kg/cm^2). The bricks are uniform in shape, size, density, strength, etc. after nearly 2 days of natural drying and 3-4 hours of steam (2 to 2.25 kg/cm^2) curing at about 125°C. The scope of the CFRI technology for fly ash brick is enormous with nearly 38 million tonnes of fly ash being produced annually from the TPS (Flowcheme). Some essential aspects of the raw material requirements and the quality of the fly ash brick are given in Table-1.

TABLE-1

Salient Properties of CFRI Fly Ash Brick
A. Raw Material Requirements for 1000 Fly Ash Bricks
(Size 250 x 125 x 75 mm)

Fly Ash (unburnt carbon ∠ 10%)	:	2780 kg
Sand (Clay & Mica < 15%)	:	350 kg
Lime (CaO 65-70%)	:	350kg
Accelerator (Inorganic Chemical)	:	7 kg

B. Properties of Fly Ash Bricks

1.	Wt. of the Brick (Size 250x125x75mm)	:	3.6 Kg
2.	Bulk Density	:	Ca 1.55 g/cc
3.	Cold Crushing Strength	:	100-150 kg/cm^2
4.	(BIS Specification for Class-I burnt clay brick = 75 kg/cm^2)		
4.	Water Sorption Capacity	:	Ca 20 per cent
5.	Not affected by Salt and Air	:	Efflorescence proof
6.	Free Lime Content	:	0.25 %
7.	Expansion due to moisture movement	:	Ca + 0.06%

PLUS POINTS OF CFRI TECHNOLOGY :

The time tested advantages of the fly ash Brick produced by the CFRItechnology are :

1. Cheaper and stronger (crushing strength 100-150 kg/cm^2)
2. Saves energy as no firing of brick is required, instead stea-cured.

3. Uniform quality machine made bricks
4. Less mortar requirement between layers of bricks
5. Lower water a sorption capacity, better insulation and less seepage
6. Even plastering of outer walls may be avoided
7. Not affected by salt, air and water (no efflorescence)
8. Help conserve invaluable top soil for agriculture
9. Higher unburnt carbon (upto 10%) is tolerated in fly ash
10. Radio-activity in the brick is negligible to cause any concern(tested at BARC)

STATUS OF CFRI TECHNOLOGY

In 1986, the first commercial plant of 20,000 bricks/day in the private sector was commissioned by M/s Jagatdhatri Brick Industries Pvt Ltd., under the guidance of CFRI at Barrackpore near Calcutta. More than 12 million bricks have already been produced in this plant and sold in and around Calcutta. These fly ash bricks have also been tested and used by WBHB,Military Engg. Services, PWD(Roads & Housing), Calcutta Electric Supply Corpn., Howrah Improvement Trust, etc. in West Bengal for many of their constructional activities.

The second commercial plant, based on CFRI technology, of capacity 30,000 bricks per day has been put on stream at Raichur, Karnataka by M/s Bright Bricks Pvt Ltd. Another plant of similar capacity is also being set up at Vijaywada by M/s Thirumala Flyash Tech. Pvt Ltd. The biggest manufacturing unit for the fly ash brick (cap. 90,000 bricks per day) is in advanced stage of construction at Bandel in West Bengal under the aegis of pulver Ash Projects Ltd. of West Bengal Small Industries Corpn. at an estimated cost of Rs.10 crores. This project is receiving essential financial support from HUDCO & the National Housing Bank. Depending on circumstances of raw materials supply, equipment, etc., the project cost of a minimum economic unit of 20,000-30,000 bricks per day (as at Barrackpore) may require now Rs. 80 to 100 lakhs.

CFRI has already released the licence for commercial utilization of this technology, through NRDC, to more than 12 firms in the country and the different stages of various fly ash brick projects, based on CFRI technology, are presented in Table-2. The production costs refer to brick size of 250x125x75mm and cost will be reduced by Rs.60/- per thousand for the size 225x112.5x75 mm. The ex-factory cost of thousand bricks is around Rs.850 to 920/- (including interest and depreciation and taking the cost of lime as Rs.1200 per tonne). Major plant and machineries include pulveriser for lime, belt conveyors, mixers, Hydraulic Press, curing trolleys and chamber, boiler, electric motor, transformer,etc.

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Table -2

CFRI Fly Ash Brick Technology Licenced to Entrepreneurs & Organisations (As on March,1992)

Sl No	Name & Address	Year	Plant Cap. (Bricks)	Location	Status
1.	West Bengal Housing Board Calcutta	1977	1000/ Shift	Asansol, W.Bengal	Produced 4.5 lakh bricks in 1977-78,inoperative thereafter.
2.	Jagatdhatri Brick Industry Pvt Ltd. Barrackpore, W.Bengal	1982	20000/ Day	Barrack-pore, W.Bengal	Produced more than 12 million bricks & under regular produc-tion.Contempla-ting installation 3rd Brick Moul-ding Press
3.	Jyoti Industries Calcutta	1982			
4.	B K Poddar, Calcutta	1983			
5.	A L Chopra Calcutta	1984			
6.	Pulver Ash Proj.Ltd. 2 & 3 Black Burn Lane, Calcutta	1984	90000/	Bandel, W.Bengal	Construction work in progress & expected to be in production 1992-93
7.	Dakshineswewri Builders,W.Bengal	1984			
8.	Shree Krishna Ash Bricks & Allied Products(P) Ltd., Calcutta	1985	100000/ Day	Tribeni W.Bengal	Work in progress
9.	Bihar State Industrial Dev. Corpn., Patna	1987			
10.	Janapriya Develop-ers Ltd.,Calcutta	1988			

Table-2
(Continued)

1	2	3	4	5	6
11.	Bright Bricks (P) Ltd.,Raichur Karnataka	1989	30000/ Day	Raichur Karnataka	In production since 1991
12.	Thirumala Flash Tech.(P) Limited Vijaywada Andhra Pradesh	1990	30000/ Day	Vijaywada Andhra-Pradesh	Likely to be commissioned soon

NB : Two more private entrepreneurs from Bihar and West Bengal are in advanced stages of negotiation for their proposed fly ash brick plants at Patratu and Bandel respectively, while many others from all parts of the country are showing active interest in the manufacture of fly ash bricks.

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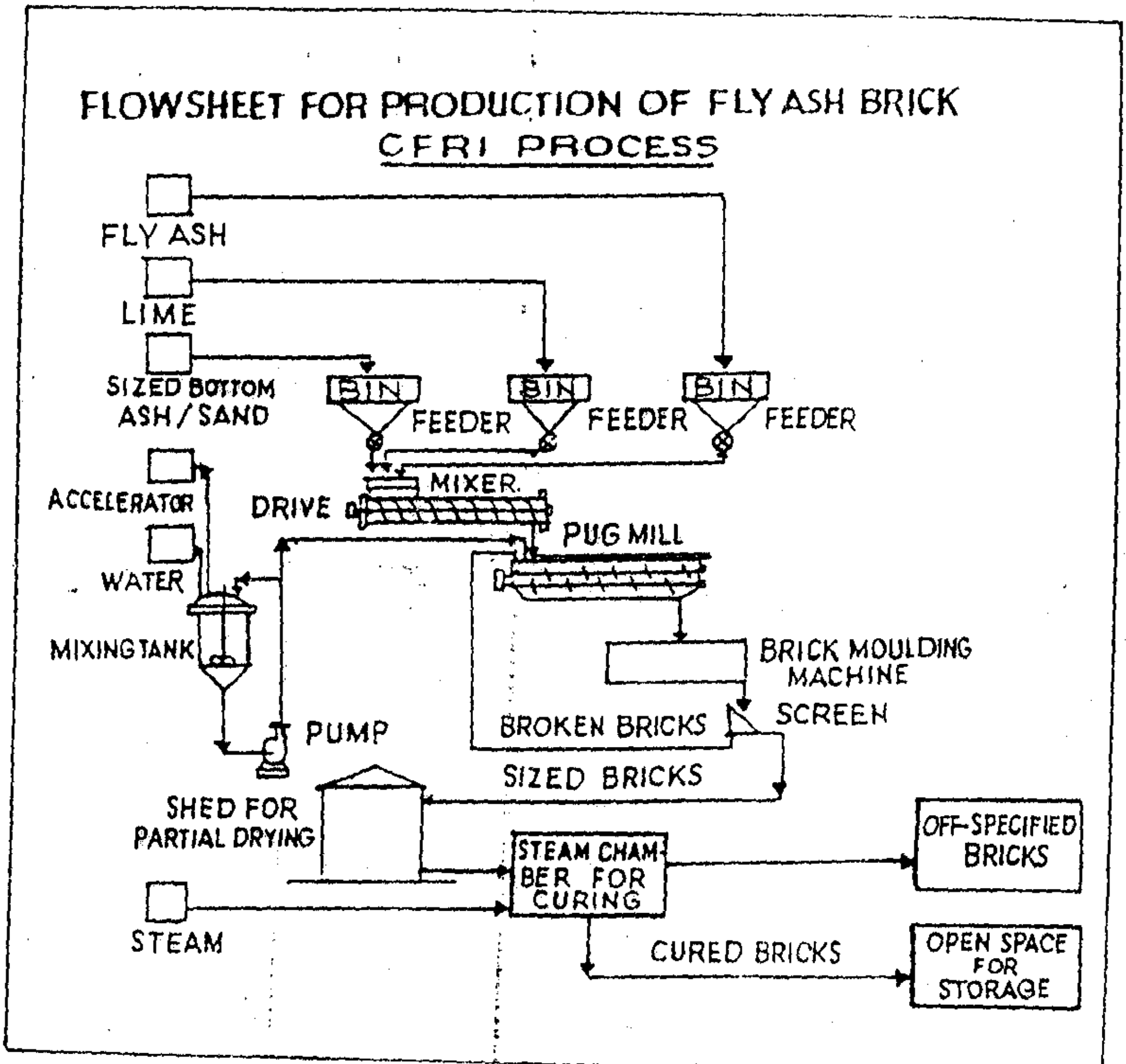
FLOWSHEET FOR PRODUCTION OF FLY ASH BRICK
CFRI PROCESS
FLY ASH
LIME
SIZED BOTTOM ASH / SAND
BIN
BIN
BIN
FEEDER
FEEDER
FEEDER
MIXER.
DRIVE
ACCELERATOR
WATER
PUG MILL
MIXING TANK
BRICK MOULDING MACHINE
SCREEN
BROKEN BRICKS
PUMP
SIZED BRICKS
SHED FOR PARTIAL DRYING
STEAM CHAMBER FOR CURING
OFF-SPECIFIED BRICKS
STEAM
CURED BRICKS
OPEN SPACE FOR STORAGE

UTILISATION OF FLYASH - A STATE OF VAGUENESS

By

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Utilization of Fly Ash, which was hitherto been considered as waste material, has assumed a great importance during the past few years, specially with regard to utilise the same as substitute for building materials. The reasons for gaining momentum in this status emerges out from the pollution control and hazard for which both consciousness and requirements are increasing.

Flyash have 'Puzzolonic characteristics' that is the properties achieved when reaction of calcium oxide with water takes place to form a compound with low solubility and high cementing properties. Thus, flyash after mixing with lime can be used for various building materials.

However, since the utilisation of fly ash for using it as different types of building materials have gained momentum, the news items on these subjects are being focussed in different news media in a variable nature of reporting. The rent items starting from the claims of individual personalities as well as corporate bodies claiming development of technologies and usages which are at variance so far as cost structures of different produce and the nature of usage thereof without giving requisite minimal details required for appraisal and appreciation.

Thus, the confusions are created when news/review items come out with captions "CEMENT FROM FLY ASH" OR "FLY ASH IS AS GOOD AS CLAY AND CHEAPER TOO".

It is needless to mention that with enormity of flyash generated and with the question of conservation of top soils from pollution control point of view for keeping the ecological balance, the measures in this direction have to be taken in a much faster pace. But these measures are to be taken in a well controlled, organised manner, to a fruitful direction keeping in view the long term consideration. In most of these new items/ reviews no positive aspects of the technologies are described & confined within the generalised statements about the utilisation of flyash, which left a void about the aspects described and thus the confusion created.

Basically the flyash can be used mainly on two aspects of building materials that is either using it as a cementation material or for manufacture of bricks. Aside the fly ash can be used in development of land, road, mines, agriculture and irrigation projects in the manufacture of utility products and in the extraction of valuable material from fly ash.

For construction materials number of technologies have been developed namely, Portland Pozzolona Cement; ready-made flyash concrete; precast fly ash concrete building units; sintered fly ash light weight aggregates, lime fly ash cellular concrete; fly ash building bricks etc.

The Government policy makers have realised the problem of waste utilisation and have set up the National Waste Management Council vide Circular No. 17(1)/87-P2/HSMD dated 25.1.1990. This council has been set up for streamlining the approach for utilisation of waste material of which flyash constitutes a major ingredient. The purpose is to guide the effort in its proper direction and keeping in view the long term approach attains a status of 'Proveness' and do not get lost in short term vagaries with disco-ordinated effort.

The fly ash utilisation as mentioned above may, thus, be divided in two main categories as building materials that is (i) Utilisation as a cementation material and (ii) Utilisation in 'Fly Ash Bricks ' making for building and industrial structures.