National Seminar On Environment pollution (UGC sponsored), Dept of Civil Engg. S.V.R. College, Surat 1981

DEVELOPMENT OF NEW COMPOSITE USING FLYASH:

The industrial waste disposal of flyash which is now being taken very lightly by thermal power plant will create accute problems of land pollution at the rate of 82 hectares or more/year by the end of 1981, in Gujarat alone. Air pollution by dust nuisance in areas like Gandhinagar and Ukai requiring wetting process for storage of flyash. Loss of agricultural land leads to loss of production and housing development.

Looking to above facts in terms of socio-economic sense. It is necessary to plan productive maximum utilization of ash. Uptill now flyash was successfully used as:

(i) Filler materials specially in reclamation of land and mines.

(ii) In manufacturing of siuteved aggrigate.

(iii) As an argillaceous raw material in the manufacture of portland cement.

(iv) Cleaning oil conamiuation.

(v) Minor percentage in concrete mix.

After number of trials new composite have developed by using following composition with 85% flyash + 14.9 cement + 0.1% Chemical agent:

The above composite was moulded in standard brick mould of Burnt Clay Brick. (I.S. 1077-1976). The mould can be taken up immediately mannually (Note: These composite can be used for machine moulding also). After it is kept one day for drying in air and it is cured for 28 days. The composite strength of brick of S.G. Region is 50 kg/cm^2 Absorption % is vary between 15 to 25.

These bricks made of new composite were tested for the following characteristics.

(i)	Compressive strength	75 kg/cm^2.
(ii)	Absorption %	18 to 21.
(iii)	Thermal conductivity (Results are in between the range of brick & five brick and very low compare to ~~xx~~ asbestos Board).	0.24 $kcal/mhr^o$ C.
(iv)	Acid Resistance Test Mean % loss (By weight) (which not possible in ordinary burnt clay brick so these can be used for acid resistant floor after checking other properties).	1%

These results are encouraging and confirms to IS: 1077-1976 for Burnt Clay Building Bricks.

(v) The Chemical analysis of Ukai Thermal Power Plant flyash is within the range of other thermal power plant of India and abroad and confirms with IS: 3812 (Part-I, II, III) 1966, but unusual feature is tracing of Na_2O and k_2O in very minor %.

(vi) Hydrometer test shows 78% of fine particle size between range 0.002 mm. -0.075 mm (silt size) and rest of % of size are finer than 0.002 mm.

(vii) To study the particle shape Beck Metallurgical Microscope was used. The shape of particles is flat, silty and has lower silica. The sample mass is in amorphous state. The presence of spherical particles will give good results of workability of mortar and concrete.

ADVANTAGES:

1. Uniform quality of brick because material are more or less uniform within specified ranges.
2. Low density (1.25) compared to common burnt clay brick (1-5 gm/cc) will reduce dead load.
3. Size and edges remains perfect.

4. Breakage loss will be negligible.

5. Higher and controlled strength is possible.

6. Wall using this bricks have plane surface relatively hence it can be painted directly (Thick plaster is eliminated).

7. No shrinkage observed.

8. Thermal conductivity of new composite material is lower than ordinary brick masonary with plaster.

9. Acid resistance property is excellent. It gives loss in weight within permissible limit (IS: 4860-1968).

10. Wider range of colour, pigments can be added according to the choice of customer as heating process is eliminated.

11. It can be manufactured by small scale rural industry with unskilled labour.

Lastly the impact on Man and Environmental by there waste is led to pollution and enchrochement of land. Disposal at high cost do not serve the purpose as it create health hazard to society. Advantage of saving agricultural clayey soil now being consumed for bricks can not be ignored. For government organization with social cost of environmental, pollution control, may not cost more than 15.00 paisa/brick, whereas the higher price of burnt clay bricks in South Gujarat is 18.00 paisa. It will incedently create mass scale employment and rural industry in all places around thermal power stations. It is cheaper to cast flyash brick around thermal power station than to cast flyash as row material for brick manufacturing.

The work has been awarded the M.E. degree of South Gujarat University in 1978.

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TECHNOECONOMIC FEASIBILITY OF BRICKS MADE FROM INDUSTRIAL WASTE OF A THERMAL POWER PLANT

Raijiwala D. B.* and Desai M. D.**

Abstract

"The mass building activity associated with the needs of residential and industrial growth centres will need huge quantum of bricks. To utilise industrial waste of thermal power project known as flyash, the appropriate technology has been initiated by authors for producing bricks of equal or better specification than available local burnt clay bricks from the black cotton soils of South Gujarat region. The paper presents the technoeconomical aspects of flyash bricks compared to burnt clay bricks."

The common building brick is not only one of the oldest but also the most extensively used building material in construction work. It is essentially a local building material and consequently there exist large variation in the quality of raw material, the process of manufacture and the quality of finished product. Rapid building activity, to be on rational lines, needs a certain degree of uniformity in the construction materials.

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1. Burnt clay bricks of South Gujarat Region :

Though high strength bricks have been manufactured from latteritic and residual murrum soils in many parts of the country, the regions having non plastic silt, sand delta as well as black soil have posed serious problems for making standard burnt clay bricks.

A study[16] was carried out to test different categories of bricks from South Gujarat region in accordance with I.S. Code.[8] The results have been tabulated as shown in table-1.1.

Table-1.1 Test results of bricks of South Gujarat Region (Bricks from different manufacturers were marked A to H)

Mark on sample	No. of sample tested	Average compressive strength N/mm^2	Water absorption %	Efflorescence	Dimensional tolerances within limits
A	18	3.10	26.74	Very high	No
B	20	3.38	25.26	high	No
C	20	2.84	24.17	Very high	No
D	18	5.81	14.99	moderate	No
E	20	3.52	22.97	high	No
F	20	4.46	20.49	high	No
G	20	6.12	19.76	moderate	No
H	20	4.21	21.31	Very high	No

The results eventually reflected that most of bricks are not within the specified limits of I.S. In the third revision the Sectional Committee decided to keep the minimum compressive strength as 3.5 N/mm^2 and water absorption less than 20% upto class 125.

While analysing the results it has been viewed that the South Gujarat region the soils used for manufacturing of bricks are silty fine sand (deltaic alluvium) or black cotton soil and both of them are generally not suitable for making bricks unless specially treated. The kiln temperature is never uniform and will not reach the specified value which results in more quantity of unburnt bricks having very high dimensional tolerances, efflorescence and water absorption. It has been observed average 12 to 15% breakage while transportation to the site. The range of market cost varies from 450 to 550 Rs/1000 bricks. ([illegible] Production of brick is very low during monsoon period).

2. Basic need for bricks of standard quality :

An alternative approach has been thought for manufacturing of bricks, the first criteria will be cost and hence the waste materials are to be surveyed, which should be available in abundance with negligible price. The pioneering work started (1976) by this Department, in this direction by utilizing flyash waste from Ukai Thermal Power Station for making good quality bricks. This material being mixture of silica and alumina, a suitable binding agent is required for moulding and a plasticiser for quick demoulding at low water content. The presented work is a summary of the work carried out by different researchers at U.G. and P.G. levels under the guidance of authors.

3. Flyash and its properties :

Flyash is a finely divided residue resulting from the combustion of grounded or powdered bituminous coal or sub-bituminous coal (lignite) and transported by the flue gases of boilers fired by pulverised coal or lignite. It is extracted by cyclone separation or electrostatic precipitation. The effective use of flyash as a pozzolana in the manufacture of cement and for part replacement of cement, as an admixture in cement mortar and concrete and in lime pozzolana mixture, has been arestablished in the country in recent years.

Only Ukai Thermal Power Project is producing at least 1 million tonne/year flyash and by the end of sixth plan it is expected to reach a quantity of 4.7 million tonne/year, its dumping as well disposal will be costing 140 million Rs/year.[16] The disposal moquires large quantum of agricultural land and the problems of air pollution are unimaginary.

4. Suitability of binders for making bricks :

Several binders were tried by different researchers from time to time.

Table-3.1 Chemical Composition (Ukai Flyash)

Content	%
Loss of ignition	3.75
Silica	52.07
Alumina	28.12
Ferric oxide	6.11
Calcium oxide	3.45
Magnesium oxide	5.20
Sulphuric Anhydride	0.86
$Na_2O + K_2O$	0.31

Physical Properties :

Property	
Colour	Whitish grey with slight black tinge
Fineness (Blaine's Method)	350 m^2/kg
Lime Reactivity	4.2 N/mm^2
Drying shrinkage	0.07 %
Sp. gravity	2.24
Dry Bulk density	870 kg/m^3

4.1 Lime :

Komar, A[10] (1974) reported that lime-slag brick is prepared in U.S.S.R. from 3-12 % of lime and 88-97 % of slag, and lime-flyash bricks from 20-25 % of lime and 75-80 % of flyash by weight. These bricks have a bulk density of 1400-1600 kg/m^3, coefficient of heat conductivity 0.5-0.6 Kcal/m.h C and compressive strength 2.5-7.5 N/mm^2 at 90 days- curing. They are used for erecting walls upto three storeys showing good frost resistance.

Prose, MC[1] (1984) mentioned that 10 % lime + 10 % sand + 80% flyash with 0.2 % accelerator, pressed at 15.75 N/mm^2 bricks were moulded and steam cured. The cost has been reported as Rs 600/ 1000 bricks. For the production of 1 lakh brick, 280 Metric tonne flyash was consumed. These bricks were approved by National Research Development Corpn., West Bengal and Tamil Nadu Housing Boards.

Gardin, M.D.[6] (1978) made bricks with 5 to 20 % lime and 95 to 80 % flyash + cinder ash and obtained 6 day strength as 1.6 to 4.3 N/mm^2. Water absorption varied from 19 to 32 %.

Pitre, S. G. [11] and others made series of laboratory experiments with slaked and unslaked lime with flyash, surkhi, kiln ash, cinder and stone dust to be used as mortars. With lime different materials, the proportions recommended are 1:2 to 1:5 and obtained compressive strength upto 4.1 N/mm^2 at 28 days.

There are several drawbacks regarding lime as binder - Lime is not available in a consistent good quality throughout the country. Lime needs longer curing and for quicker strength steam curing is advisable which is uneconomical. Lime should be used in a finely powdered form otherwise free quick lime with water creates expansion cracks in the bricks.

4.2 Gypsum :

Gypsum is also one of the industrial waste from the chemical industries. Authors have also made series of experiment with lime-gypsum and cement-gypsum proportions.

Chittaranjan, N.[5] (1983) made blocks with gypsum, lime, flyash in proportion of 1:5 : 12.5 by volume with water/lime ratio as 3.2 and obtained compressive strength 4.12 N/mm^2 and water absorption 23.72 %.

The proportioning of gypsum should be watched very carefully because it has direct effect on the setting of cement. Authors used gypsum as a effluent powder from Navin Fluorine Industries, Udhana and obtained brick strength upto 11 N/mm^2 and water absorption 14.24 % with 7 to 17 % gypsum, 7 to 17 % cement, 28 to 33% flyash and 58 to 33% fine sand.

4.3 Polymers :

Experimental studies were carried out by Verma, R.C.[18] (1979) with different monomer systems as binders. Methyl methacrylate (MMA), styrene, polyvinyl acetate (PVA), acrylonitrile, isophthalic grade of polyester resin were applied in experimental study and compressive, tensile, flexural strength were obtained as 72.85, 41.15, 40.41 N/mm^2. Water absorption and acid resistance were almost negligible values. Such binders can be considered for heavy erosion structures like spillway buckets but not for mass production of bricks.

The drawbacks in using such monomer system are very expensive cost of monomers and costly polymerization processes (either by x radiation or by thermal catalytic).

4.4 Cement :

Cement can be adopted as binder very conveniently due to following reasons :

- Availability is easy, available in standard good quality, physical/chemical properties can be checked, curing is quicker, cost is moderate.

Gardin, M. D.[6] made blocks with cement content upto 25 % and obtained compressive strength of 4.54 with moderate water absorption.

Shastri, V. R.[16] (1978) plotted different curves for replacement of cement by flyash- consistency (Graph-4.1), setting time (Graph-4.2) compressive strength (Graph-4.3), water absorption- acid resistance- thermal conductivity (Graph-4.4).

5.0 Flyash – Cement Brick :

5.1 A dry mixture of flyash/cement was prepared in the proportion of 85/15, 88/12 and 90/10 % (weighment basis). Addition of plasticiser 2 % by weight of cement in the water was for the purpose of quick demoulding and low apparent porousity. Water content is judged by 0.91x combined consistancy (cement + flyash). The process involved hand mixing, moulding with pressure of 0.6 to 0.8 N/mm^2. Demoulding within 5 to 7 minutes, 24 hours air curing and 7 to 28 days curing in water pond.

5.2 Results :

Proportion flyash/cement (weighment basis	Combined consistency (flyash + cement) %	Compressive strength N/mm^2 168 hrs.	Compressive strength N/mm^2 672 hrs.	Water absorption %	Efflorescence	Dimensional tolerances within limits
85/15	54	2.89	4.67	18.68	Moderate	Yes
88/12	55.5	2.22	4.00	24.48	Moderate	Yes
90/10	56.5	2.00	3.33	28.89	Moderate	Yes

Note : Water absorption can be controlled by water repelling agents (WRA).

6. Cost Aspects :

6.1 For proportion of 90/10 - flyash/cement brick (225mm x 100 mm x 75 mm)

One ~~Our~~ brick require 200 gm cement
1800 gm flyash

For 1000 bricks

Material	Quantity	Rate	Amount Rs
Cement	4 bags	70 Rs/bag	280.00
Flyash	1.8 metric tonne	10 Rs/metric tonne	18.00
Plasticizer + accelator	4 kg (2% by weight of cement)	6 Rs/kg	24.00
Labour charges + machinery	------Lumpsum ------		60.00
			382.00
Profit (20%)			76.00
Say Rs 460 / 1000 bricks			458.00

6.2 For 1 MWH Capacity :

Requirement of coal/MWH = 0.6 M.tonne

Ash content = 30 %

Ash collection/day = 0.6 x 24 x 0.3

= 4.32 M.tonne/day

This quantity is sufficient to produce 2500 bricks.

According to a report[16] of Central Research Institute (1971), in fifth plan the Government had spent 200 million Rs for disposal of 8 million tonnes of flyash.

i.e. 25 Rs for dumping/disposal of 1 tonne flyash

i.e. 0.6 x 0.3 x 25 = 4.5 Rs / MWH.

7. Conclusions :

The socioeconomic aspect of consumption of agricultural farm land for burnt clay brick making, the hazards of land and air pollution and enormous cost of disposing flyash waste from thermal power projects indicate need for utilising it for bulk consumption. Flyash bricks if matching IS code specification must be considered as a technically sound proposal even if the cost is slightly higher.

1 MWH power production will yield 4.32 M.tonne of flyash per day is enough to produce 2500 bricks with suitable binders like cement/lime/gypsum etc. The appropriate technology and costing will depend on availability of cheaper binder, site conditions, labour and plant facility with investment feasibility. A never wire cut brick making plant can be erected along with a thermal power project with a investment of a fraction of a project which will give output of bricks instead of disposing flyash.

With slightly higher cost of flyash bricks the merrits are no pollution, no disposal cost, perfect IS shape and strength, less breakages during transit, less thickness of plaster, light weight, low apparent porousity.

Note : The National Service Scheme of S.V.R. College unit has built the watchman's quarter's at South Gujarat University campus with flyash bricks since three years ago.

Acknowledgement :

Authors express sincere thanks to Prof. and Head, Applied Mechanics Department and Principal, S.V. Regional College of Engineering and Technology, Surat-395 007, for constant encouragement and facilities at the institution.

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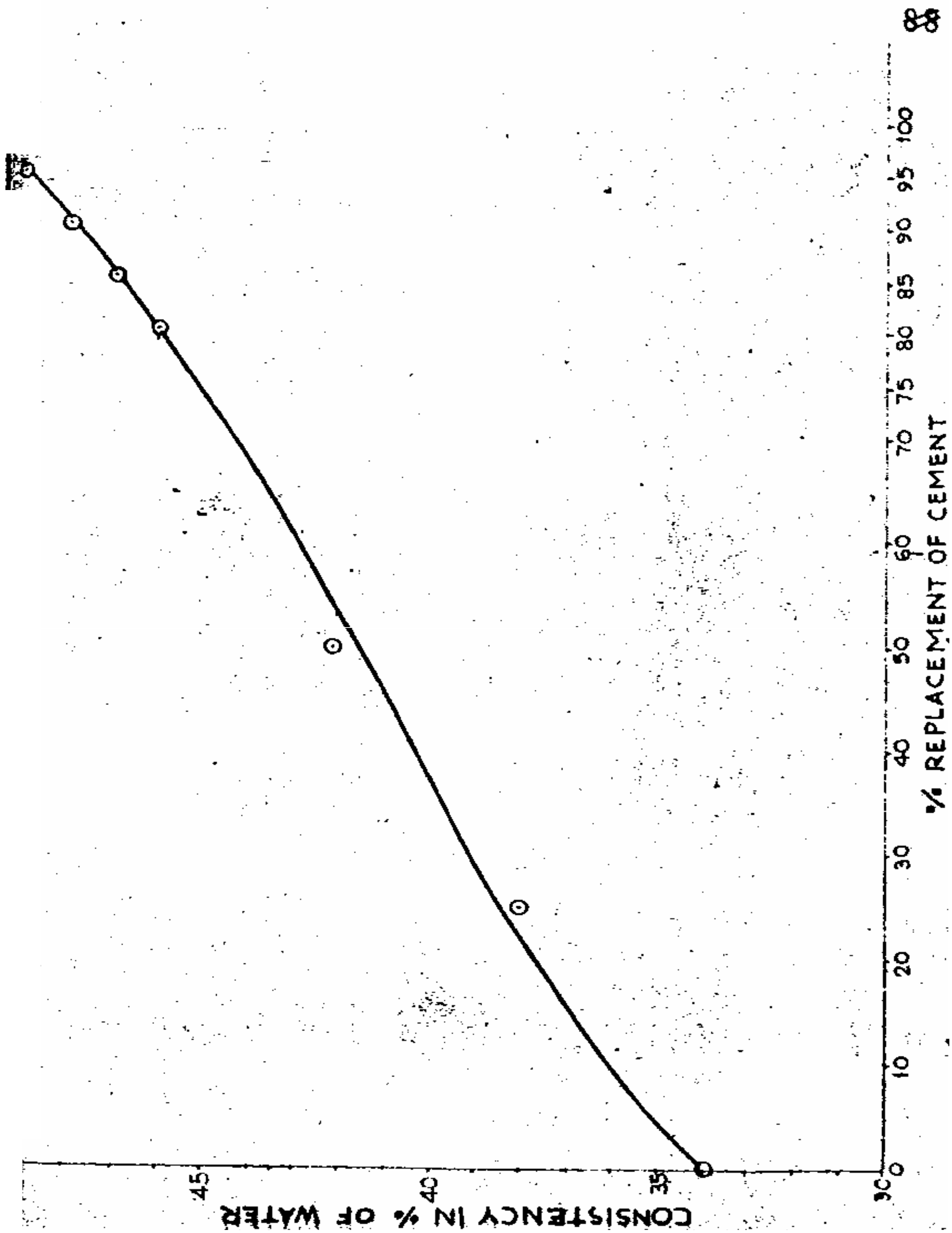
88
CONSISTENCY IN % OF WATER
30
35
40
45
% REPLACEMENT OF CEMENT
0
10
20
30
40
50
60
70
75
80
85
90
95
100

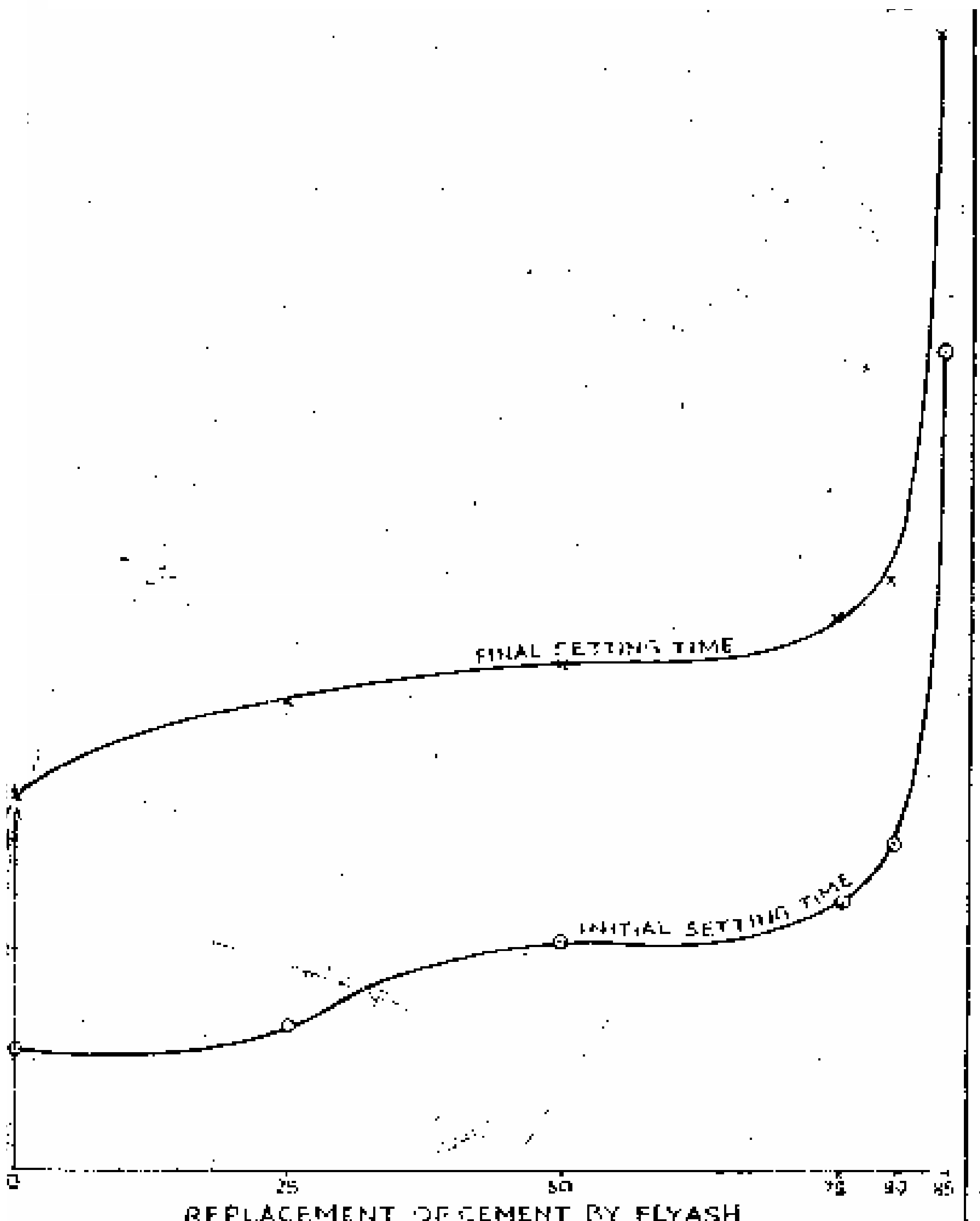
FINAL SETTING TIME
INITIAL SETTING TIME
0
25
50
75
80
85
REPLACEMENT OF CEMENT BY FLYASH

FIG. 4.2

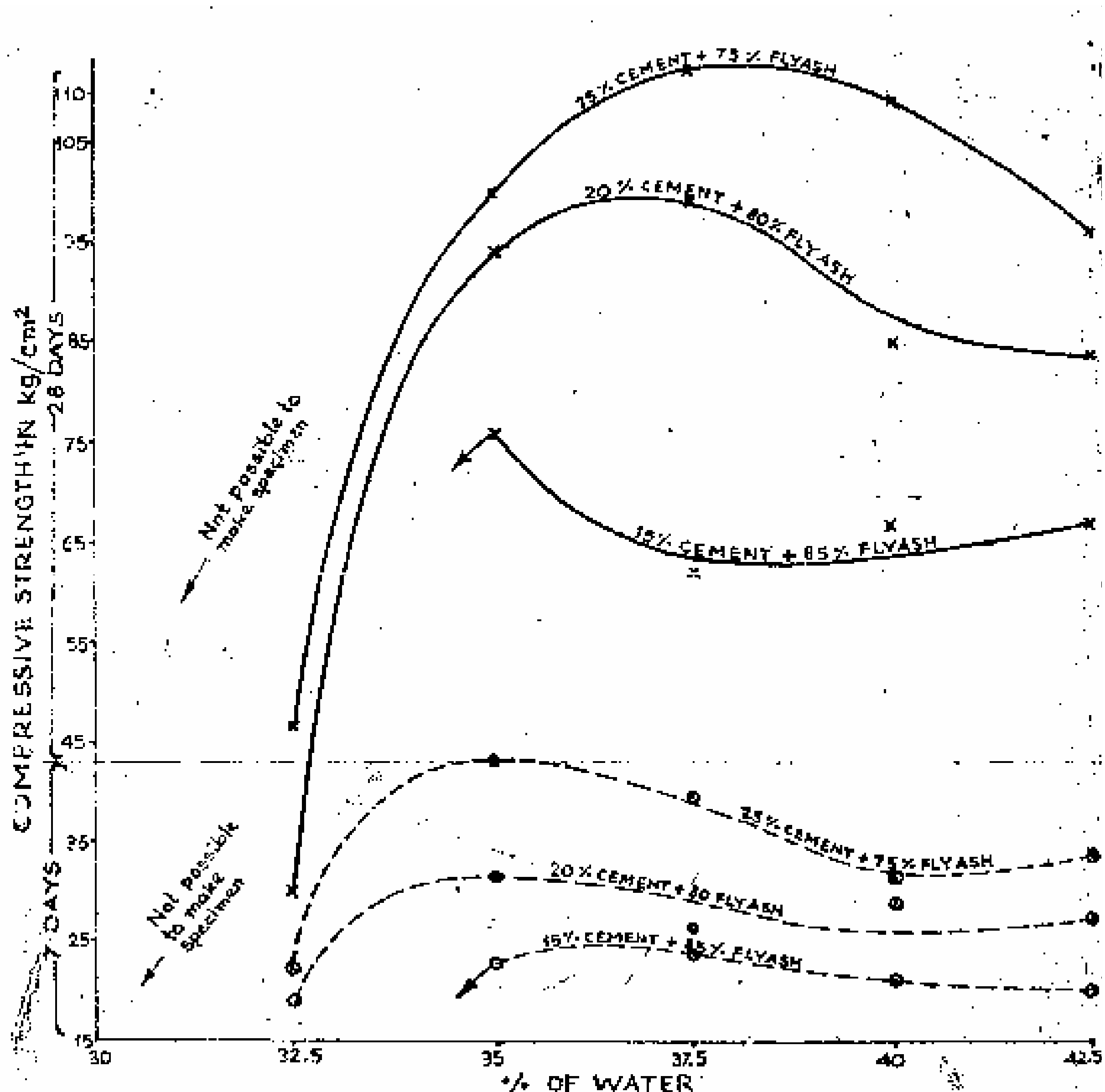
COMPRESSIVE STRENGTH IN kg/cm2
28 DAYS
7 DAYS
% OF WATER
20% CEMENT + 80% FLYASH
15% CEMENT + 85% FLYASH
Not possible to make specimen
Not possible to make specimen
30
32.5
35
37.5
40
42.5

FIG. 4.3

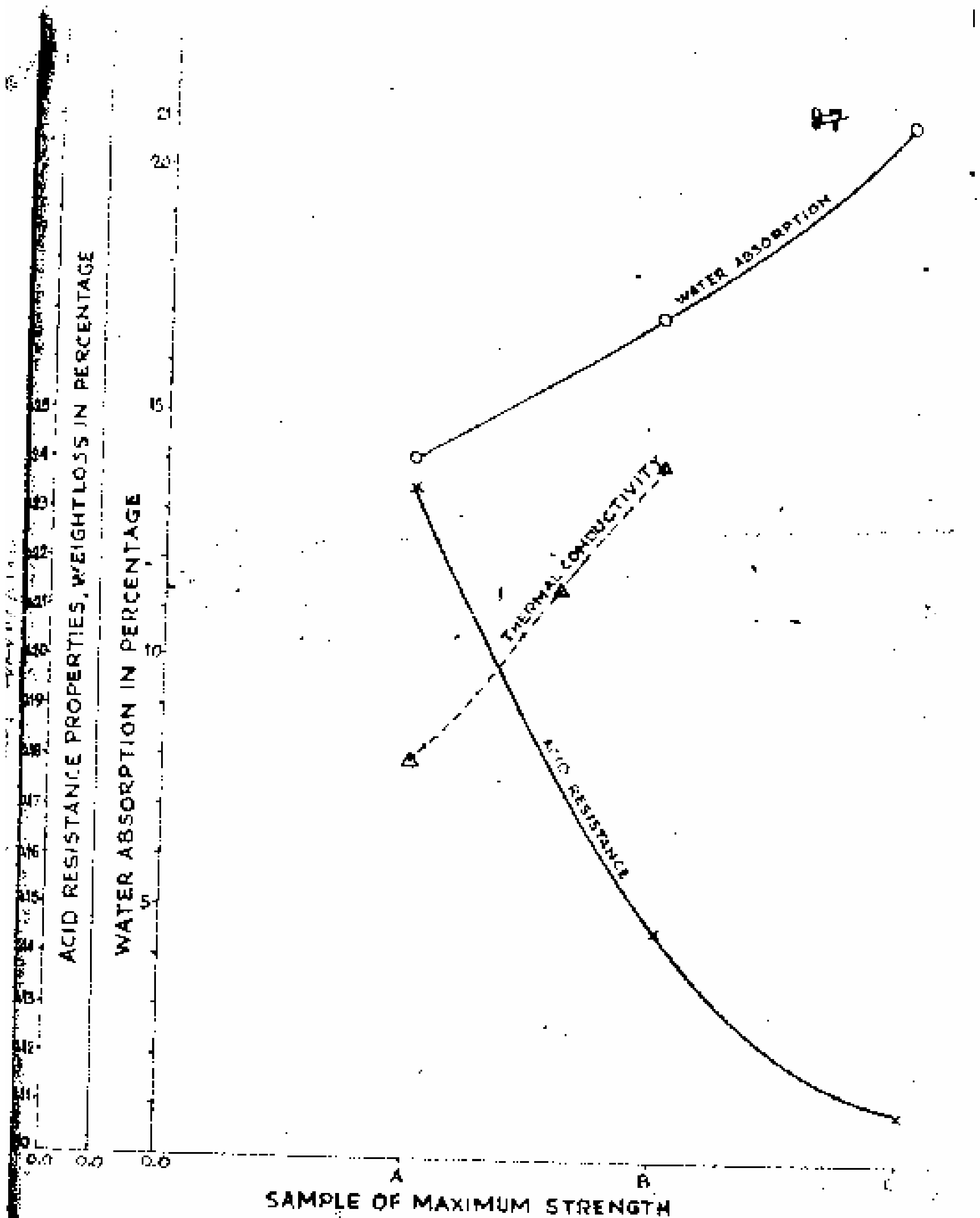
ACID RESISTANCE PROPERTIES, WEIGHTLOSS IN PERCENTAGE
WATER ABSORPTION IN PERCENTAGE
WATER ABSORPTION
THERMAL CONDUCTIVITY
ACID RESISTANCE
A
B
SAMPLE OF MAXIMUM STRENGTH

FIG. 4-4

TECHNO ECONOMIC FEASIBILITY OF LIME-GYPSUM-FLY ASH BLOCKS AS APPROPRIATE TECHNOLOGY TO RURAL HOUSING

Ranjiwala, D.B.* and Desai, M.D.**

1. Introduction:

The appropriate technology of the adobe rural housing construction means the unburnt sun dried bricks/blocks laid in mud/lime mortar. Due to the low-cost and traditional use, and their dependence upon the low level skill and indigenous materials, masonry and adobe dwellings are very common in most rural and poor urban regions of many less developed countries of the world. Such houses will have a brittle lateral-load-resisting system and a destructible vertical-load-supporting system of the shear-bearing type in the form of unreinforced bearing and partition wall. Only in India more than 120 million people are living in adobe houses which are constructed on self help basis only.

For a low cost rural housing authors have worked out the percentage cost itemwise (Refer Table No.1)

TABLE No-1 :

Item	% of the total cost
Foundation and Footing	6
Blocks and its manufacturing	28
Wood works	21
Roofing	11
Mortar finishing	6
Door/Windows	9
Sanitary block	5
Miscellaneous (Painting/Electricity/plumbing)	12

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While reviewing the Table-1, the prime costing is with blocks and its manufacturing. In that aspect, the authors have discussed the cost economics of making cheap/durable adobe blocks from the effluents of different industries.

2. Materials:

2.1 Lime: Building limes shall be classified as class-A: Lime is supplied as hydrated lime, Class-B: and Class C: limes supplied as quick lime or hydrated lime (Table No.2)

TABLE No-2: Constituents of Lime

	Class-A (%)	Class-B (%)	Class-C (%)
Calcium and Magnesium Oxide	60 to 70	70	85
Silica, Alumina and Ferric Oxide	25	15	-
Insoluble Matter	5.7	7	5
Other	0 to 10	8	10

Lime should be used in a finely powdered form otherwise free quick lime with water will create expansion cracks in blocks.

2.2 Gypsum: Gypsum is a byeproduct from chemical industries and its composition varies largely from the type of industrial complex. Gypsum used by authors in experimental study is a product of 77 to 81 percentage dehydrated Calcium Sulphate.

2.3 Flyash: There are more than 30 Thermal Power Stations in India producing about 7.8 million tonnes of flyash per year and this quantity will be doubled at the end of sixth five year plan. It has been reported(13) that Rs. 15 has been spent for dumping/disposal of one tonne flyash. The disposal acquires large quantum of agricultural land and the problems of pollution are unimaginary.

Flyash is a finely divided residue resulting from the combustion of grounded or powdered bituminous coal or sub-bituminous coal(Liguite) and transported by the flue gases of boilers. It is extracted by cyclone separation or electrostatic precipitation. The effective use of flyash as a pozzolana in the manufacture of cement and for part replacement of cement, as an admixture to cement mortar/concrete, in lime pozzolanic mixture has been established in the country during recent years. The Government of India has appealed to all thermal power projects to come with suitable recommendation for fruitful consumption of flyash byeproduct. Analysing the chemical/physical properties of Ukai flyash (Table No.3) the authors have submitted a consultancy report for the mass production of cellular hollow blocks from lime-gypsum-flyash.

Table No.3: Ukai Flyash: (Chemical Compositon)

Content	Percentage
Loss of ignition	3.75
Silica	52.07
Alumina	28.12
Ferric Oxide	6.11
Calcium Oxide	3.45
Magnesium Oxide	5.20
Sulphuric Anhydride	0.86
$Na_2O + K_2O$	0.37

Property	
Colour	: Whitish Grey with slight black tinge.
Fineness (Blaine's Method)	$350 m^2/kg$.
Lime Reactivity	: $4.2\ N/mm^2$
Drying Shrinkage	: 0.07 %
Sp. gravity	: 2.24
Dry bulk density	: $870\ Kg/m^3$

Block making process and Experimental results:

The block making process is quite simpler, after dry mixing of three ingredients in the dry powdered form the controlled quantity of water (to be judged from the combined consistency) should be homogeneously mixed. As an appropriate technology to rural regions authors have produced blocks with unskilled labour(tribal people of backward areas around the thermal power project) with wooden moulds, for their own housing colonies, having cost economics to Rs. 550/m^2. For the mass production of such blocks authors have adopted either CINVA-RAM block press or wire cut Eleon's block making machine having capacity of 20000 blocks/day.(Table No.4) . The Chief advantage of this process is that it totally eliminates the kiln process which is used for the manufacture of burnt clay bricks.

4. Conclusion:

Adobe rural hose - a poor Man's shelter - can be built only once in his life and it should be protected from all hazardous forces like the other precious structures, to achieve this goal the elements used for such dwellings should be cheap, durable, light weight, locally available and can be erected on self help basis only.

Experimental Study of Flyash Concrete

A K Desai
S N Desai
Dr M D Desai

General :

With increase in population every year the problem of providing housing is a herculean task for developing country like ours. At this stage it is already being accepted that mass housing is the only solution. In case of mass housing project cost of material and speed of construction are the major factors to be considered. Use of masonry blocks and precasted pannel wall can only satisfy the above two requirement. For mass production of blocks and panel walls, the material to be used should be so selected that it provides durability and economy to the final product.

In the light of above problem utilisation of flyash as a constructional material can be thought of. As much as 12 million tonnes of flyash is being produced as a waste from thermal power plants throughout the country, which is expected to rise multifold, with increase in number of such plants. Disposal of this flyash pose a serious problem to the power plant authority. The cost of power produced is increased, because of large area required for disposal and handling of huge quantity of flyash.

The paper discusses feasibility of utilising flyash in mass production of masonry blocks and pannel walls. The fly-ash utilization can lead to the benefit like,

- conversion of waste into wealth
- economising on expenditure for disposal
- increasing availability of much needed constructional material
- reduction in air, land and water pollution.

The experimental results for the basic properties such as compressive strength and workability for the trial mixes are reported.

Replacement of Cement by Flyash:

The addition of flyash in the form of replacement of cement, provides reduction in cost of concrete, on the other hand it is found that the flyash particle being spherical improves workability to considerable extent. The literature review also reflects that the silica content of flyash, combines with free lime and other calcarious compounds in cement which give rise to increase in later age compressive strength of concrete. Flyash (Bulk density: 800 - 850 kg/m^3) being lighter than cement, reduces to some extent the density of resulting concrete. The literature review also reflects that the addition of flyash reduces the permeability of concrete to some extent.

All above arguments advocate the beneficial use of flyash in production of concrete masonary blocks and pannel walls.

Experimental Programme :

In order to measure the basic properties of flyash concrete, trial mixes with varying flyash content (by percentage) were prepared. Proportions with three different W/C ratio and seven different flyash content were adopted for study.

Measurement of Workability :

The compaction factor test (I. S. : 7320-1974) which is more sensitive to small variation in workability is adopted for measurement of workability of concrete. The results obtained are reported in Table 1.

Determination of Compressive Strength :

15 cm cubic specimen were prepared for all trial mixes and tested for compressive strength (I.S. : 516) after curing period of 28, 56, 84 and 112 days to study the development of strength with age of flyash concrete. The results obtained are tabulated in Table 2.

Discussion:

The results of compaction factor test for workability reflects that addition of flyash increases the workability of concrete mix. It is possible to reduce the W/C ratio of the mix by adding flyash to obtain same workability level. The reduction in W/C ratio, in turn, increases the compressive strength, which can

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Table - 1 : Variation of workability of concrete for different W/C and percentage of flyash.

Sr. No.	Proportion of concrete mix.	W/C	% of flyash as replacement of cement by weight	Compaction factor measurement
1.	1 : 2 : 4	0.52	0	0.850
			10	0.850
			20	0.910
			30	0.921
2.	1 : 2 : 4	0.56	0	0.894
			10	0.923
			20	0.937
			30	0.941
3.	1 : 2 : 4	0.60	0	0.9
			10	0.931
			20	0.946
			30	0.950

Table - 2 : Variation of Compressive Strength with flyash content. Proportion of Concrete mix : 1: 2 : 4 (by weight)

Sr. No.	W/C Ratio	% Flyash Content	Compressive strength of 15 cm concrete Cubes Kg / cm²			
			28 days	56 days	84 days	112 day
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	0.52	0	280.0	287.4	392.9	398.5
	5	254.1	237.8	294.8	316.7	
		10	251.8	259.2	308.9	329.6
		15	194.8	220.7	259.3	287.0
		20	191.1	198.5	235.5	264.1
		25	191.1	206.7	248.88	264.44
		30	166.66	187.4	228.1	235.5
2.	0.56	0	248.9	258.5	259.3	--
		5	197.8	215.9	232.9	--
		10	162.9	188.9	198.9	--
		15	148.1	181.1	202.2	--
		20	144.4	174.4	190.4	--
		25	151.8	171.1	181.4	--
		30	146.6	157.8	174.1	--
3.	0.60	0	225.2	237.0	--	--
		5	205.2	232.6	--	--
		10	145.1	172.2	--	--
		15	139.3	156.3	--	--
		20	91.1	105.2	--	--
		25	84.4	102.2	--	--
		30	80.0	97.1	--	--

compensate for the loss of compressive strength because of partial replacement of cement by flyash. This can be verified by refering Table 1 & 2.

It is apparent from Table 2, that concrete mix with proportion 1:2:4, W/C ratio 0.52 and flyash content from 20% to 30% can satisfy the minimum requirement of M:15 concrete mix. So this 30% replacement of cement can very well economise the cost of material. It can also be seen that the long term strength i.e. after 84 days is equivalent to 28 days strength of ordinary concrete. So during the construction period the flyash will gain the compressive strength.

From the above discussion following conclusions can be drawn :

1) Replacement of cement by flyash in concrete is feasible and it is possible to reduce the cement consumption to achieve economy.

2) Replacement, as high as 30% flyash is feasible; and provide minimum basic property, at low cost of concrete.

3) Flyash utilisation in production of blocks and pannel walls can solve the problem of flyash disposal to some extent.

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BUILDING MATERIALS FROM INDUSTRIAL WASTE OF COAL BASED POWER PLANT

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1. Need for Housing

Providing housing is one of the basic preventive measures against disease death, social unrest and social upheaval because the house and its neighbourhood mould the character of the people. From the reports of National Buildings Organisation, it is estimated that the housing shortage in 1990 will be 22.3 million in rural areas, and 6.9 million in urban areas in India. The average number of persons per dwelling was 4.67 for one room, 2.84 for two rooms. Percentage distribution of census houses by predominant materials of wall and roof in rural areas is as under (Survey by NBO, India) - 11.6% houses have grass, leaves, bamboos, 58.3% houses have mud, unburnt bricks etc, 30.1% have burnt bricks, stone walls, 50.4% have a roof of grass, leaves, thatch, 49.6% have roof tiles, shingles, A.C. sheets, R.C.C. etc.

In India 40% of the population live in a one room house, 28.6% live in a two room house, 14.1% in a three room house, 7.8% in a four room house and 9.5% in a five or more room house, in rural areas.

This reflects very evidently, that there is an acute shortage of housing in developing countries and research towards cheaper building components should be accelerated rapidly.

2. Building Materials

While reviewing housing projects, the major component (34%) of building materials is in the forms of building bricks/blocks/cellular blocks etc. The burnt clay bricks and sun dried bricks/blocks laid in mud/lime mortar will be the generalised construction practice all over the country. For such types of construction and manufacture of burnt clay bricks mainly depends on the availability of good soil. The soils of India are broadly classified (5) as alluvial, lateritic marine, desert deposits, black cotton soil and red murrum. The expansive black cotton soil covers 3000000sq km area of Indian peninsula. Alluvial silt and fine sand is non cohesive/dilatant, unsuitable for moulding standard bricks/blocks. These bricks have distortion in shape, low compressive strength, high apparent porousity heavy efflorescence, large breakage while in transit (12 to 15%) (Table-1)[11].

Table:1

Test Results of Bricks of South Gujarat Region
(Bricks from different manufacturers were marked A to H)

Mark on Sample	No of Samples Tested	Average Compressive Strength MN/m.sq.	Water Absorption %	Efflor-escence	Dimensional tolerances within limits
A	18	3.10	26.74	Very High	No
B	20	3.38	23.26	High	No
C	20	2.84	24.17	Very High	No
D	18	5.81	14.99	Moderate	No
E	20	3.52	22.97	High	No
F	20	4.46	20.49	High	No
G	20	6.12	19.76	Moderate	No
H	20	4.21	21.31	Very High	No

The results eventually reflected that most of the bricks are not within the specified limits of Indian Standard Code of Practice (1077-1976), min. compressive strength is 3.5 MN/m.sq. and water absorption is less than 20%. The range of market cost varies from 400 to 500 Rs (25 to 35 pounds)/1000 bricks. The price inflation is because the suitable soil is to be excavated£* soil strata. There will be a huge loss of agricultural land which cannot be regenerated. Hence a phase has come for the search of alternative raw materials which can replace a long timely raw material namely soil mass.

£*after removing the top layer of expansive....

3. Newer Raw Materials

Alternative raw materials that have been used in experimental studies are lime, flyash, gympsum, sulphur, kiln ash, cinder, crushed stone, surkhi, etc., During the last few decades, a prominent cheap raw material as industrial effluent is - flyash.

Flyash is a finely divided residue resulting from the combustion of grounded or powdered bituminous coal or sub-bituminous coal (lignite). It is extracted by cyclone separation or electrostatic precipitation. At present 40 thermal power plants in India are yielding 9.2 million tonnes of flyash a year. A thermal power plant of 250 MW, 3320 Kcal/kg having an ash content of 39%, the quantity of coal required will be 240 tonnes/hour with maximum rating. The mechanical collector having 80% efficiency will collect 68 tonnes/

hour flyash in hoppers, whereas electrostatic precipitator having 95% efficiency will collect 80 tonnes/hour of flyash. Thus for a 250 MW thermal power plant with an annual load factor of 57% (5000 hours/year), the flyash output will be 400000 tonnes/annum. It has been reported[1] that Rs 15 (1 pound) has been spent for dumping/disposing of one tonne of flyash, but it acquires a large quantum of agricultural land and the problems of pollution are unimaginary.

4. Indian Flyashes

While comparing Indian Flyashes with the flyashes of different countries it has been revealed that Indian flyashes are richer in silica, alumina contents but possesses lower amounts of ferric, sulphuric anhydrides. (Table-2).[13]

Table 2:

Variation in chemical composition of Indian Flyashes

Chemical Constituent	Content % Maximum	Content % Minimum	Average %	Standard deviation
Loss on Ignition	16.60	0.30	5.96	4.68
SiO_2	66.74	37.15	55.34	6.76
Al_2O_3	28.87	18.31	23.72	3.01
Fe_2O_3	21.94	3.73	9.39	5.65
CaO	10.80	1.30	3.22	2.55
MgO	5.25	0.80	2.13	1.46
SO_3	2.91	Traces	0.94	0.75

Mineral composition[13] of flyash varies with fineness, mineral matter, combustion state of coal. The major mineral forms in the Indian coals are hydrated silicate (kaolinite), carbonate (calcite), sulphate (pyrites), quartz, feldspar etc. The specific surface of Indian flyashes using Blaine's air permeability apparatus ranges between 2194 to 6042 cm.sq/gm. It is greatly affected by unburnt carbon content, particle shape, particle size and sp. gravity of flyash. The pozzolanic activity of flyash can be estimated by lime reactivity tests and for Indian flyash, the strength is always greater than 4 N/mm.sq. (40 kg/cm²)

An experimental study[14] was conducted by Department of Applied Mechanics, S.V. Regional College of Engineering & Technology, Surat-395007 for the manufacture of lime-gypsum flyash bricks/blocks for Ukai Thermal Power Plant. (Table -3)

Table 3:

Ukai Thermal Power Plant – Flyash
Chemical Composition

Content	%
Loss of Ignition	3.75
Silica	57.07
Alumina	28.12
Ferric Oxide	6.31
Calcium Oxide	3.45
Magnesium Oxide	5.20
Sulphuric Anhydride	0.86
$Na_2O + K_2O$	0.31

Physical Properties:-

Property	
Colour	Whitish grey with slight black tinge
Fineness (Blaine's Method)	350 m.sq/kg
Lime Reactivity	4.2 N/mm.sq.
Drying Shrinkage	0.07 %
Sp. Gravity	2.74
Dry Bulk Density	870kg/m/cu/

5. Building Elements From Flyash

Several binders were experimented from time to time by researchers, like lime, gypsum, cement and polymers etc.

5.1 Bricks/Blocks

Cardin, M.D.[6] (1978) made bricks with 5-20% lime and 95.80% of flyash plus cinder ash, and obtained a 6 day strength as 1.6 to 4.3 N/mm.sq., having a water absorption of 19 to 32%.

Bose M.C.[1] (1984) mentioned that 10% lime plus 10% sand plus 80% flyash with 0.2% accelerator, pressed at 15.75 N/mm.sq., bricks were moulded and steam cured, meeting the code requirements. The costing worked out to be Rs 600/1000 bricks and they are approved by West Bengal/Tamil Nadu State Governments.

Neyveli Lignite corporation, Tamil Nadu prepared bricks (size 225 x 112 x 75mm) and blocks (size 390 x 190 x 190 mm) with flyash-lime-gypsum proportioning are 92-4½-3½% volumetrically. The compressive strength will be 3.5 MN/m.sq. with 28 days wet and 30 days air curing and the cost price will be Rs 200/1000 bricks. They had built their complete township with these blocks as well as flooring and observed satisfactory performance since a decade.

Authors have summarized[12] a series of experimental work in Table-4

Table 4:–

Size of Block 200 x 100 x 100 mm

Sr No.	%Proportion by volume Lime	Gypsum	Flyash	Water Additon %	Bulk Density (KN/m³)	Apparent Porousity %	Compressive Strength (MN/m²)	Efflorescence	Cost of 1000 Blocks Rs
1	22	13	65	29	9.72	19.62	8.2	Moderate	282
2	17	13	70	30.5	9.65	21.81	7.3	Moderate	238
3	15	10	75	31.5	9.62	24.16	6.9	Moderate	221
4	12	8	80	33	9.54	24.77	6.2	Moderate	191
5	10	5	85	34	9.47	26.41	5.4	Moderate,	169
6	8	4	88	35.5	9.51	27.71	4.6	Heavy	137
7	6	3	91	36	9.58	27.93	4.2	Heavy	123
8	3	2	95	38	9.42	29.11	2.9	Heavy	81

Note: Except for Sr. No. 7 and 8 the dimensional tolerances were within limits. Curing by sprinkling water for 1 week and then water curing for 3 weeks.

5.2 Flooring, Roofing Tiles

Authors have reported that flooring/roofing tiles are prepared with volumetric proportion as ½ : ½: 1:1 of cement: lime: flyash: fine sand and obtained flexural lot of upto 460 N. The tiles were pressed and water cured for 3 weeks and air curing for 2 weeks. The cost of such unit will be 155 Rs/ brass. An accelerator was used for quick demoulding process.

5.3 Mortars/Finishing/Panelling

Authors have executed mortars/panelling work of proportioning 1:8 to 1:10 as cement, flyash volumetrically which showed significantly well performance.

As an appropriate technology to rural regions, authors have produced blocks with unskilled labour and indigenous technology. For mass production of such flyash blocks, adopting either CINVA-RAM block press or Elson's wire cut block making machine having a capacity of 20000 blocks per day.

6. Conclusions

Utilization of flyash in building components is an activity of pollution control and producing cheap/durable elements. A kiln process (used for production of burnt clay bricks) is totally eliminated and the flyash structure are very light weight. Use of flyash and gypsum, both bye-products whose prices are going to remain unchanged for a few years into the future should be accepted as basic materials for urban/rural dwellings on a self help basis. Construction amongst the binders, lime needs longer curing and extension search is for cheap accelerator to gain quicker bond.

Sense of Thanks

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Development of flyash composites for building elements

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ABSTRACT: India's major source for power supply is thermal power plants which has produced millions of tonnes of Ashland by 1990, the annual production might reach 12 million tonnes per year. The disposal without pollution of land and air is critical problem.

The need for housing in India is enormous. This would mean demand for building materials like bricks, blocks, panel walls etc has been summarised. The extension work was carried out to evolve a polymer flyash composite (PFC) which can be used for casting building elements and sanitary fittings (substituting Chinawares). The literature is reviewed. Flyash is used as filler phase of composite. The matrix material thermoplastic polyester (a product of petrochemical industries, now growing fast in India) was selected as it has cross links between long chain molecules. As theoretical approach is yet to be evolved, the trial mix empirical approach was adopted and specimens were casted with different proportions for preliminary estimates of engineering properties. Isophthalic grade polyester resin made locally with methyl - ethyl ketone as catalyst, cobalt naphthenate solution as accelerator and styrene as monomer has been selected for study.

The composite PFC specimens were casted for the four different proportions of ingredient and the specimens have been tested for compressive, split tensile, flexural, hardness and durability tests.

The properties of composites are compared with Indian code requirements for floor materials, structural components, repairs jobs, sanitary equipments and pipes.

The work has established the technical feasibility of PFC as an alternative material for housing. Economics will change from time to time and place to place.

1 PRESENT SCENE

India, a fast developing country, has 60 major thermal power stations to generate 734×10^{5} MWh (1982) electricity. The need for power is rapidly increasing and present production of 19 million tons of flyash is expected to reach 33 million tons. This fine dust produced is a waste creating land and air pollution.

Most of the cases partial disposal to lagoons and keeping it wet is estimated to cost Rs.300 million every year at current rate of Rs.4/-per MWh power produced.(2) The agricultural lands required to dump ash, estimated at 3.15×10^{-6} hectares/1 MWh/year, is 2×10^{3} hectares/year. The pollution consciousness, enforcement of act, inflation in economy and non availability of waste land for disposal of ash has brought out need for finding alternati systems. The use of ash must be such instead of spending millions in partia disposal, it must create products whic could generate wealth.(8)

2 WASTE MATERIAL

There are two major waste products: as coal lignite (Neyveli) in India. The is collected and disposed of in most o plants by wet process. Dry process is The bottom ash and ash from precipitat are mixed with water to form a slurry is pumped to lagoons.

The ash collected from electro stat precipitators is finer than bottom ash

First hopper collects coarser fraction with higher carbon content. The fineness of ash in each succeeding stage is increasing with carbon content decreasing. The lagoon sample of ash is a mixture of all ashes, sedimented in irregular stratifications. The material is fine grained non plastic soil for all practical purposes.

3 PHYSICAL CHARACTERISTICS

The samples from lagoons and different stations exhibit very wide range of properties but in all the cases of major plants the ash confirms to IS 3812.[4]

The major fraction passing is 45 micron with 20% retained on 75 micron sieve. It has bulk density of 1.2 t/m³, specific gravity 2.25, Lime reactivity 42 kg/cm² (dry ash from height shows 60 kg/cm²) and 30 days drying shrinkage 0.07%.

Chemically ash excluding from legnite has SiO_2 45 to 60%, Al_2O_3 10-20%, Fe_2O_3 (4 to 6%); LOI 0.3 to 15% and small percentage of Calcium, Magnesium, Alkalies, and sulphates. The glass content of Indian flyash is reported to be only 20 to 30% as against 80% in ashes from USA and France. Hence lesser reactivity is expected.

4 BULK USAGES

Desai M.D.[3] has reviewed the extensive work done starting with Comar ('74), the contributions of Gardine M.D. (E'78), Shastri V.R.(8), N.B.O.('85) Recently central fuel research institute ('86), Sharma C.L.(6), Alluwalia S.C.(1) and Sinha B.P.(7) have evaluated bulk use of ash for making housing elements.

The uses cover technology for producing bricks, blocks, hollow blocks, roofing and flooring tiles, replacement of cement in ..., fill material for Embankments - highways and dams. The industry has yet to overcome inertia to adopt new technological options.

The main thrust has been to develop bricks-blocks with cement (5-10%) or lime (10-12%) or cement and lime as binder with 0.2% accelerator. The blocks are air dried for 2 hrs and then either cured under water for 10 days or steam cured for 5-8 hrs.

The main justification for the development is estimated shortage of 25,000 million bricks as per the findings of All India Bricks & Tiles Federation. The present market prices for bricks are Rs.700/- per thousand in most of urban growth centres. The poor shape, 15% breakages, high water absorbtion are added disadvantages. The cost of rendering is also high.

Thus industry was forced to search alternatives. The present production of 20 million tons of ash is ... shortage of bricks. Th... by Central Fuel Researc... and Neyveli plant have produced bricks at marketable rates of 700/- Rs., 200/- Rs. per 1000(2). These blocks do not have most of the disadvantages of bricks cited earlier.

Neyveli project has succeeded in producing insulation bricks for intermediate lining using flyash lime and foaming agent (Alluminium powder) which can stand 800°C. The cost is half of conventional alternatives.

Though uses in small quantities of flyash are reported in canal linings, dams cellular concrete, light weight aggregates, R.C.C. Still percentage utilisation is insignificant. (1)

5 IMPACT ON ECONOMY

Housing sector in India has vast potential for growth.(3) The demand is ever increasing and hence cost escalation is logical consequence. The targets for low law cost rural and urban housing could be attained by flyash bricks and blocks. In continuation of work (Desai 1981-87) further work on blocks and hollow blocks with present cost is shown in (TABLE : 1) photo plate shows solid and hollow flyash blocks.

The use of total flyash will provide savings of Rs.300 millions on disposal cost and save another Rs.300 million or more by cutting down cost of bricks from Rs.700 to Rs.450, at least, per 1000 bricks. These flyash hollow bricks with low moisture absorbtion and better finish, now designed, can save on plaster as well. Economics, at cost of living today, may jusify brick plant as a part of thermal power project.

6 POLYMER-FLYASH COMPOSITE

Technically applications of ceramics and polymers almost unknown until 1900AD, have increased several folds. The advancement in polymer technology is tremendous. The new polymers are suitable to form composite materials. The flyash waste material is studied as filler phase of a composite. To develop compatible phase with flyash the matrix material must have link between long chain molecules of epoxy, polyester. These two are selected under availability and curing at room temperature.

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TABLE : 1

Design Mix for flyash blocks and costing

Sr. No.	Proportion by weight Cement:Flyash:Sand:Grit	Average Com.Stress after 35 days(kg/cm²)	% Water absorbtion	Total Cost Rs./per block*	Remarks
A 1	1 : 2 : 3 : 2	44.2	19.5	5.80	Ukai flyash from pond
A 2	1 : 3 : 2 : 3	37.1	18.9	5.55	"
A 3	1 : 3 : 3 : 2	40.0	13.5	5.42	"
C 1	1 : 3 : 4 : 4	154.6	7.3	4.44	Ukai Flyash from precipitator.
C 2	1 : 3 : 4 : 5	130.8	6.9	4.22	"
C 3	1 : 3 : 5 : 5	140.5	10.0	4.00	"
		(IS class 50) & above.	(IS limit 20%)		

* Solid Blocks of 30 cm x 20 cm x 15 cm

(Note standard bricks 19 cm x 9 cm x 4 cm (IS 1077-1975)

TABLE : 2

Curing Time for Polyester Resin (in minutes)

Catalyst	Accelerator 1%	Accelerator 2%	Accelerator 3%	Remark
1%	93	51	28	* Methylethyl ketone peroxide
2%	40	23	13	** Cobalt napthenate solution
2.5%	28	20	11	

TABLE : 3

Trail Mixes by Weight

Composite	Binder System Resin	Monomer by wt of resin	Filler Systems (by wt) F.A.	sand,Marble	grit	Binder filler
PPC 1	1	-	4	-	-	1:4
PPC 2	1	0.25	6	-	-	1.4.8
PPC 3	1	0.4	5	5	-	1.7.13
PPC 4	1	0.25	2.5	3	3.5	1.7.2

7 BINDER PHASE

The thermosetting plastic (polyester & epoxy unsaturated resins) which looses reversibility to soften on reheating, isoth-elmic resin has been tested.

8 FILLER

The filliers could be fibres, laminates or powder. The use of Quartz, Chalk, Barites, sawdust have been reported to obtain heat and acid resistant products, plasticizers, dyes, lubricants, catalysers are introduced with filler (cement Research Institute of India, New Delhi (1988)). Use of polyester resin with Benzol peroxide catalyst and styrene as copolymer agent has been studied. The properties achieved are strength, density, corrosion and alkaly resistance, poor heat conductivity.

9 LITERATURE STUDY

The polymer composite have been developed to overcome deficiency of concrete in special applications. Literature survey (9) indicates work done on polymer impregnated concrete (PIC), polymer concrete (PC), Polymer cement concrete (PCC), we will limit to PC only.

Kukacka L.E. et at ('71) has used polymer (MMA) for high strength concrete. Valore R.C. 'ANaus D.J. ('75) studied polyester bound aggregate and epoxy bound aggregate systems. Compressive strength of both decrease rapidly with increasing temperature. Kobayashi (775) found strength decreases in PC is linear for range of 20°-100°C. Inoue S ('75) discussed PC using synthetic resins for structural elements. Klocker W ('75) reported about light weight PC using polyester resins to form new building material. Use of acrl-concrete (MMA) for kerbstone, sanatory articles, staircases etc. has been discussed by Koblischeck ('75). Browne R.D. et..al ('75) have brought out advantages and disadvantages of PC for building industry. Nagaraj ('87) used sugar industries waste furfuol acetone monomers for PC.

10 POLYMER FLYASH COMPOSITE

The size, shape and particle size distribution mechanical interaction with matrix. The surface area, wetting, distribution of aggregates effect adhesion between two phases. Volume changes on curing induces transient internal stresses at particle interface.

The variables for filler phase are sand and flyash. The binding is attained by resin system which is fluid enough for penetration and which polymersies without heat or pressure. Unsaterated polyester (Isothalric resin) provided principal molecular chain and styrene used provides cross link ie. rigidity in three dimensions. For workability of few hours organic catalyst is added. The accelerators are used to initiate polymarisation.

For experimental work Isophthelic polyester resin Gletstar India Ltd. having following properties were viscocity at 25(C, poise, sp. gravity = 1.12, setting time could be adjusted by propertioning catalyst and accelerator (TABLE : 2). Cast polyester laminates shows hardness 110 (Rockwell M Scale), heat distortion 70°C, impact (Izod) 0.54 cmkg, sp. heat 0.55 cal g^{-1}, Thermal Conductivity 5 x 10^{-4} Cal Sec^{-1}, Cm^{-1} deg c^{-1} cm^{-2}.

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Filler system is flyash from pond and dry collection from hopper from Ukai power plant and fine sand from sea at Dumas. The ash had particle size 0.002 mm to 0.075 mm whereas sand had range 0.06 to 0.2 mm. proportioned amount (TABLE : 3) by weight of resin, accelerator and styrene were mixed in a container. The filler material of calculated proportions is then added until stiff constancy is attained. Catalyst is then added. After thorough blending sand was added gradually until the mixture remained workable and compatible. This blended PFC was used to cast specimens for flexure (40x15x200 mm), compression (30x30mm) 70 mm diameter and 140 mm cylinders were casted for splite tensile strength. The compaction was done by rodding. The test results for four trials are shown in Table 3 and Table 4.

10 APPLICATION OF PFC

As per the composites performance depends on characteristics and proportions of fillers and binders and adhesive forces binding the two phases. The PFC could be designed to obtain required properties for a product.

PFC could be used for floor material, structural components, repair of structures, sanatory equipments pipes etc. IS 774 (1970) specifications of absorbtion, impact strength and suitability against chemical attack could be met with by mix 'PFC 4' using marble chips as aggregate with modifications. It can also be used for a seamless flooring.

The structural components subjected to high wear and tear, high bending tensile and compressive stresses and resistance to weathering could be made from PFC without any reservation except costing. Products like washbasins, baths, kitchen platforms, stair cases, doors and window frames, architectural effects could be well planned using PFC.

The sewage or industrial waste drains, sanatory work and pipes (IS 651-1971) could be fabricated using PFC. They will be thin in section and light in weight. The material having also better bond for strengthening old concrete structures.

11 ACKNOWLEDGEMENT

The authors gratefully acknowledge the encouragement given by College authorities in this project. Also thanks to Miss P.N. Mehta who has actively assisted in preparation of paper and Shri R.T. Patel (lecturer) has been associated with experimental work.

12 CONCLUSION

In addition to introduction of flyash as a basic raw material for hollow or solid building blocks or bricks, ample scope exists in development of Polymer Flyash Concrete (PFC) composite for use in Civil Engineering. This technical feasibility, though may not prove economical for each element at present has signified potentiality to meet challenging assignments. The technology is based on waste to wealth and can be considered as a option available for exploitation.

TABLE : 4

Properties of PFC

Composite	Strength (KG/cm²)			Water absor-btion	Acid resista-nces loss % by wt.	Hardness (Rockwell Scale)	Unit weight KN/m³
	Compressive	Tensile	Flexural				
P F C 1	728	527	578	0.15	1.6	H 60	16
P F C 2	602	419	550	0.30	1.9	H 55	16.2
P F C 3	852	266	311	0.60	1.6	H 75	19
P F C 4	652	-	207	0.55	2.0	H 82	17.2

5

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Flyash Ferrocement Building Elements for Low Cost Housing

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SYNOPSIS

Flyash ferrocement beams and roofing sheets were developed to study the load-deflection characteristics and cost. The effect of parameters like, variation in shape of the cross section, number of wire mesh layers, use of skeletal steel and some replacement of cement by flyash were examined to minimise the cost without affecting the strength and durability. Eight beams of channel and I sections and twelve roofing sheets of trough, corrugated and folded plate shapes were cast and tested in flexure under one third point loading. Folded plate sheets and I beams exhibit more stiffness for same reinforcement. The number of wire mesh and skeletal steel has shown the effect only in cracked stage. Use of flyash reduces the cost by 20 percent without affecting strength. The cost of the beam is 50% less than R.C. beams, maintaining strength cost ratio same, where as the cost of sheet is 35% less and having the strength cost ratio double than the A.C. sheet.

INTRODUCTION

Housing shortage in the world is a well recognized problem. In India, by the year 2000, certain estimates put this shortage at about 18.5 million in rural areas and 6.0 million in urban areas - thus at a total of about 24.5 million [1]. Development of new materials of construction, low cost housing and accelerated construction methods are some of the different measures that research workers and engineers have been attempting towards meeting this challenge. Use of ferrocement for housing has received much attention in developing countries due to its construction being labour intensive, and due to the economy, strength, durability and lightweight characteristics.

The conventional asbestos and galvanised iron roofing sheets are uneconomical to the poor as they are having high basic cost, high maintenance cost and require stiff supports and costly fastenings. Similarly conventional R.C. beams and columns need replacement to optimise the cost where high strength is not the criteria in a single storeyed shelter. Many times R.C. lintels also become uneconomical as they need more construction period which may stop the progress of the masonry work. All these gave adirection to authors to check the feasibility of ferrocement with respect to strength and cost and to study the application of flyash - the waste material of thermal power plants.

REVIEW OF FERROCEMENT BEAMS/LINTELS

Based on the experimental evident of the crack pattern, methods were proposed for computing cracking and ultimate moment in flexure for flat, trough, channel, I and hollow box beams [2,3,5]. Ferrocement is considered as a hybrid material between reinforced concrete (material exhibiting cracking etc.) and steel (an elasto-plastic homogeneous material with large ductility and resilience). Addition of steel fibres in ferrocement increases the strength and energy absorption capacity significantly [6]. Brick infill in precast ferrocement inverted channel exhibits better resistance to cracking and deflection [6]. The cost of ferrocement lintels having spans of 0.6 to 1.8 m is 12 to 23 percent less than R.C. lintels of both channel and rectangular sections [7].

REVIEW OF FERROCEMENT ROOFING ELEMENTS

Ferrocement is an excellent material, particularly for roofing, because of its low cost, durability and weather resistance. It can span long distances and reduce the need for costly supports [8]. Precast corrugated roof units reinforced with local fibres comparable to asbestos cement and galvanised iron sheets have been developed in Australia, Indonesia, Israel, Italy, Peru and Zimbabwe [9]. The strength of ferrocement corrugated sheets was found half that of asbestos sheet, whereas strength to cost ratio was same [10]. Ferrocement folded plate V and trough type sections are found economical having thickness up to 50 mm and span up to 5 m [11]. In California, Thailand and Bangladesh, the cannel section (width 304 mm, length 2.44 m, thickness 12.5 mm and weight 390 N) was found versatile and economical [12].

EXPERIMENTAL PROGRAM

Flyash Ferrocement Beams

Total eight beams were cast, out of which four of I section and four of channel section. The cross section detail and photograph is shown in Fig. 1 and Photo. 1 respectively. The reinforcement consists of two or three layers of hexagonal chicken wire mesh (0.466 mm ϕ, 12.5 mm c/c) with or without skeletal steel wires (3.25 mm ϕ). The cement-flyash-sand matrix ratio was kept 1:0.75:3 by weight with a water cement ratio 0.55. The beams were tested in flexure under universal testing machine by applying one third point loadings. The

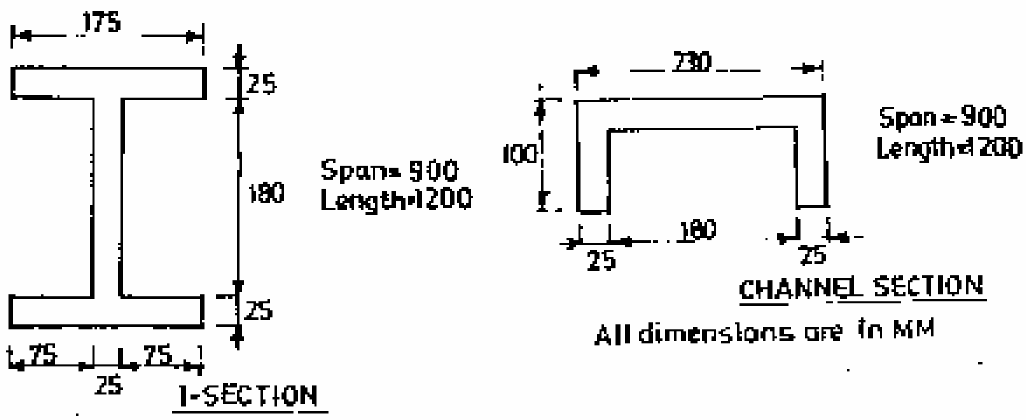

Fig. 1 : Cross Sections of Flyash Ferrocement Beams

Photo. 1 : Flyash Ferrocement Beams after testing

deflection was measured maximum up to 5 mm at the mid span with a dial gauge (0.01 mm) and then the beams were tested for ultimate load.

Flyash Ferrocement Roofing Sheets

Trough, corrugated and folded plate type sections were selected for the test. Total twelve sheets were cast, four of each shape. The cross section detail and photograph is shown in Fig. 2 and Photo. 2 respectively. The reinforcement consists of three layers of

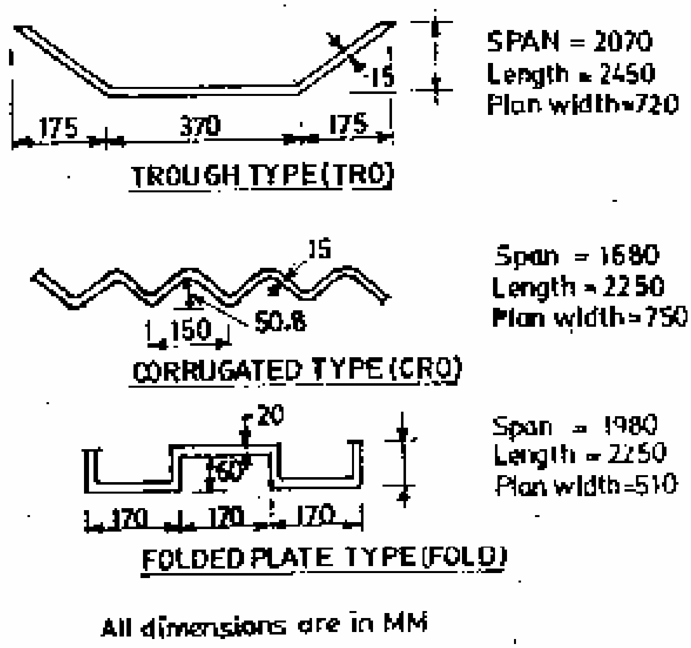

Fig. 2 : Cross Sections of Flyash Ferrocement Sheets

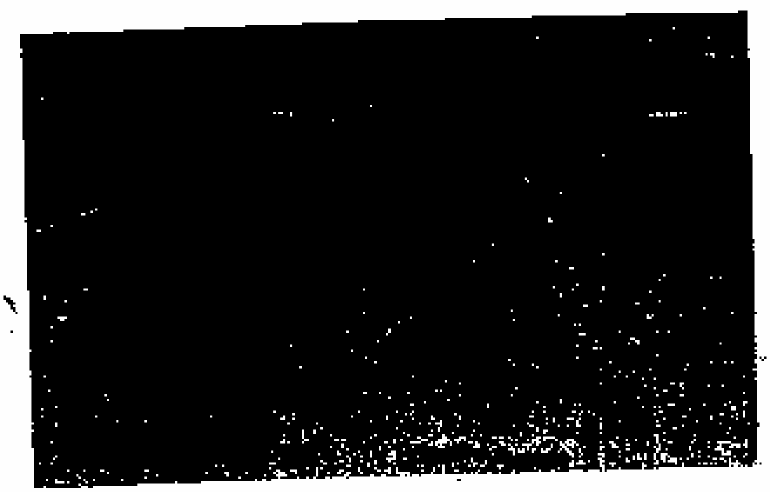

Photo.2 : Flyash Ferrocement Sheets (Category 2)-Trough, Corrugated, Folded plate type.

chicken mesh or two layers of chicken mesh plus three wires (3.25 mm ϕ) or two layers of chicken mesh plus nine wires (3.25 mm ϕ) plus three bars (6 mm ϕ). In all except category 2, the cement flyash-sand matrix ratio was kept 1:0.75:3 by weight with water cement ratio 0.55. In category 2, no flyash was used keeping the cement-sand and water-cement ratio 1:2 and 0.40 respectively. The sheets were tested in flexure under specially made platform as shown in Photo. 3.

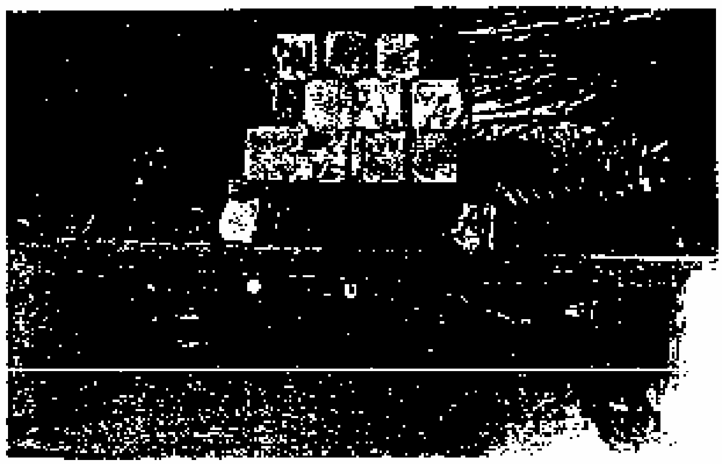

Photo. 3 : Test set up for Roofing Sheets (Trough type sheet under testing).

DISCUSSION OF TEST RESULTS

Flyash-Cement-Sand Matrix

A direct replacement of a part of cement with flyash in cement mortars adversely affects the strength and other properties. To get the equal early strength, 19.1 percent cement was replaced by adding flyash of about three times the replaced cement by weight. The compressive strength of this flyash cement sand matrix was same that of no flyash mortar. These details are shown in Table 1.

Table-1

Mix proportion by Wt. Cement:Flyash:Sand	Qty.of Materials Reqd. for 1 m^3 mortar			Comp. Strength (N/mm^2)		Saving in cement
	Cement (N)	Flyash (N)	Sand (N)	3 days	7 days	
1 : 0.0 : 3	4200	00	12600	3.13	5.67	-
1 : 0.75 : 3	3400	2550	10200	3.19	6.81	19.1%

Flyash Ferrocement Beams

It has been observed that the flexural behaviour of these elements are similar to that of steel. The general shape of the load-deflection curves are shown in Fig. 3. They could be idealised by

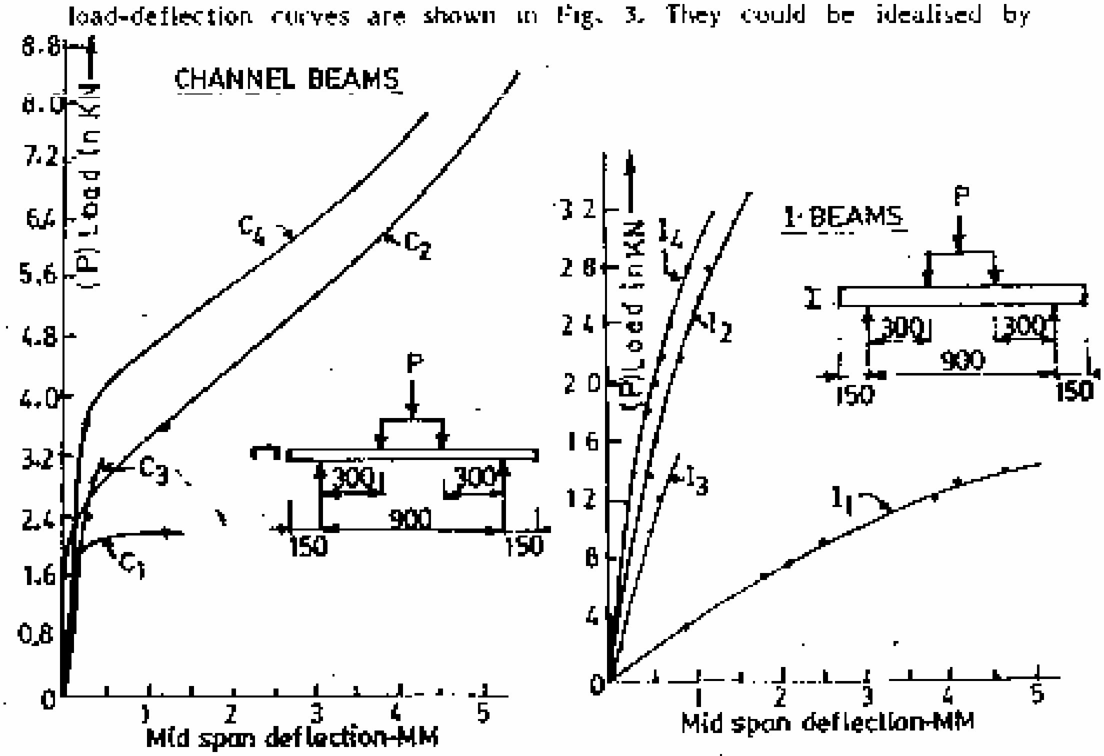

Fig. 3 : Load deflection curves for Beams (Effect of variation in reinforcement for same section)

trilinear curves-uncracked stage, cracked stage and ultimate stage. The number of wire mesh layer and skeletal steel has no significant effect on flexural rigidity in uncracked stage. The increase in skeletal steel in the tension flange and number of wire mesh layers in the cross-section has the effect of increasing the flexural rigidity in the cracked stage only. The ultimate load carrying capacity was increased from two to four times by providing skeletal steel wires (3.25 mm ϕ). For same reinforcement, the ultimate strength of I section is four times higher than channel section. The weight, ultimate load and cost of beams are shown in Table 2.

Table-2

Notation		Reinforcement		Unit Weight of Composite (N/m^3)	Experimental Ultimate Load (KN)	Cost of beam (RS/m^3)
		Chicken mesh (0.46 mm ϕ)	Skeletal steel (3.25 mm ϕ)			
I SECTION	I 1	2 layers	—	29025	20.00	4421
	I 2	2 layers	9 Nos.	31780	34.50	4893
	I 3	3 layers	—	32283	13.50	4824
	I 4	3 layers	9 Nos.	32868	31.00	5296
CHANNEL	C 1	2 layers	—	29026	2.25	3781
	C 2	2 layers	6 Nos.	29580	9.00	4202
	C 3	3 layers	—	30193	3.00	4912
	C 4	3 layers	6 Nos.	30737	7.80	5333

The cost of this channel and I beam is Rs. 45/- and Rs. 70/- respectively, which is 20 to 35 percent less than the R.C. beam of both channel and I section and 50 percent less than the conventional R.C. lintels. The strength cost ratio approaches the same as that of R.C. beams.

Flyash Ferrocement Roofing Sheets

The load deflection curves are shown in Fig. 4 for same shape of sheets having variation in reinforcement. Three distinct linear ranges are evident.

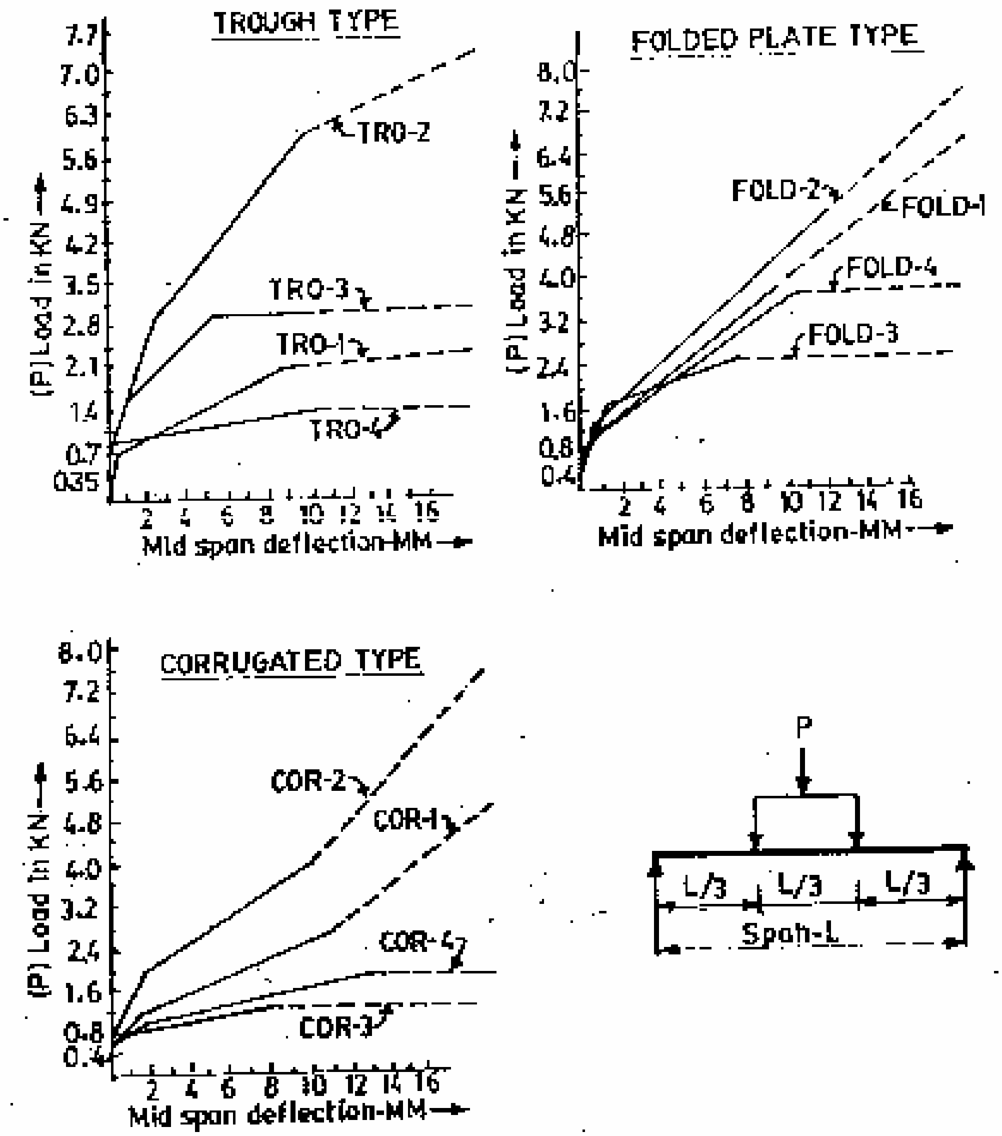

Fig. 4 : Load deflection curves for sheets (Effect of variation in reinforcement for same shape of sheet)

The stiffness of the sheet increases with the use of skeletal steel in the valley portion. Increase in the number of chicken wire mesh layers does not affect much the ultimate load carrying capacity. The effect of shape on the stiffness is not very clear at lesser loads, but higher stiffness was exhibited at higher loads by folded plates rather than the trough and corrugated sheets. Skeletal steel (3.25 mm ϕ) were started yielding first followed by zipper action of chicken wire mesh. Sheets of category-2 having no flyash and cement sand ratio 1:2, exhibit only 20 to 30 percent increase in strength compared to sheets of other categories having cement-flyash-sand ratio 1:0.75:3. Ultimate moment capacity and strength cost ratio is shown in Table 3.

Table-3

Notation		Reinforcement: Chicken mesh (0.46 mm ϕ)	Reinforcement: 3.25 mm ϕ skeletal steel	Reinforcement: 6 mm ϕ skeletal steel	Unit Weight of composite (N/m^2-cm)	Experimental Ultimate Moment (N.m)	Strength Cost Ratio
TROUGH	TRO-1	2 layers	9 Nos.	3 Nos.	303	860	1.6
	TRO-2*	2 layers	9 Nos.	3 Nos.	378	2550	4.7
	TRO-3	3 layers	-	-	351	1060	2.6
	TRO-4	2 layers	3 Nos.	-	272	500	1.3
CORRUGATED	COR-1	2 layers	9 Nos.	3 Nos.	520	1500	2.7
	COR-2*	2 layers	9 Nos.	3 Nos.	336	2000	3.7
	COR-3	3 layers	-	-	245	380	0.9
	COR-4	2 layers	3 Nos.	-	269	530	1.3

FOLDED	FOLD-1	2 layers	9 Nos.	3 Nos.	460	2190	2.8
	FOLD-2*	2 layers	9 Nos.	3 Nos.	357	2590	3.4
	FOLD-3	3 layers	-	-	265	800	1.4
	FOLD-4	2 layers	3 Nos.	-	287	1220	2.2
A.C.Sheet		-	-	-	267	700	1.1

*Without flyash having cement-sand ratio 1:2

The cost of flyash ferrocement sheet of category 1 was Rs. 45/m^2 whereas that of 3 and 4 was Rs. 34/m^2. The cost is 35 percent less than the A.C. sheet (Rs. 63/m^2) and the strength cost ratio is more than double. Strength of category 2, having no flyash, is more than the required which becomes uneconomical for low cost housing.

CONCLUSIONS

Based on the experimental results, the following conclusions may be drawn:

1. Cement-sand matrix of 1:3 in ferrocement construction can be replaced by cement-flyash-sand matrix of 1:0.75:3 without affecting the early strength. Thus 19.1 percent saving in cement and hence reduction in cost up to 20 percent is possible by utilising a thermal waste product-flyash.

2. Increase in the number of wire mesh layers and skeletal steel has no significant effect on flexural rigidity of flyash ferrocement flexural elements in uncracked stage. It has more effect of increasing flectural rigidity in cracked stage only.

3. Ultimate load carrying capacity can be increased more by providing few number of skeletal steel wires in tension zone of the beams and valley portion of the roofing sheets rather than providing more number of chicken mesh layers.

4. Flyash ferrocement I beams and folded roofing sheets have more flexural strength. The same elements can be used as column and wall panels in the construction of low cost housing. The dimensions of these elements are designed in such a way that they require very less or no fixures.

5. The cost of flyash ferrocement beam is 20 to 33 percent less than the R.C. beam of both channel and I section and 50 percent less than conventional R.C. lintels. The strength cost ratio is same that of R.C. beams.

6. The cost of flyash ferrocement roofing sheet is 35 percent less than the A.C. sheet and the strength cost ratio is also more than double.

7. Unit weight of flyash ferrocement element is higher than the conventional elements (R.C. beam or A.C. sheet). This can be reduced by using mechanised process of construction for reducing the thickness.

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FLYASH BLENDED PORTLAND POZOLONA CEMENT
AN ENVIORMENT FRIENDLY PRODUCT

A thought paper by Dr. M. D. Desai

1. Cement in present context must be selected taking pollution of ground water, environment and air. Strong concrete need not be durable. Apart from cost many factors govern selection of cement. Thanks to 50 years of forward march of country that we have "choice" of cement.

2. Baroda and South Gujarat have industrial growth. Air and water pollution are by product of past 10 - 15 years. High sulphates, chlorides and Mgo in ground coastal region. pH of subsoil and ground water, intrusion of salinity due to ground water lowering poses new range of problems never faced in past.

3. Days of OPC-grade one type cement and scarcity are over. Now marketing and consultancy services are offered for product. R & D is constant process in product development for better and cost effective production. OPC, PPC, SRC, masonry cements with range of admixtures are available.

4. Higher grade cements are used as competitive characteristic. The requirements of minimum cements contents and practice of using mix proportions (not design mix) has neither utilized high strength nor encouraged designers to economise the structural sections by and large

5. Reduced columns or footings, reduced shuttering times saving in cost are more advertised than practiced in majority of projects. In very little time bound problems rate of construction has to be very fast. For such problems accelerator has it benefit.

6. Alluvial and sea deposited regions random samples shows sulfates 0.2 to 0.5% in soil. Very high chlorides contents in ground and water is widely observed. Cyclical humidity, splashing rains and winds are problems of recent origin. Ukai, Narmada, Mahi, Damanganga reservoirs have added ponds, green zones and has changed local wind patterns and changed soil condition

7. Good concrete must have impermeability. Non-cracking, non-segregated well graded well cured concrete with adequate cover over steel is good concrete. The cement, which resists heat, cyclical reversals of humidity, salinity, pollution of ground water with lower heat of hydration performs better over life span of the structure (durability).

8. In 50th year of independence engineers with social responsibility shall keep environment aspects at all cost in mind.

9. We can not do without power. Major source being thermal power plants - by 2000 AD 33 million tons of ash will create air, land, ground pollution in the country. We shall have worst effect in Gujarat. Cost of dust proofing @ Rs.600 million / year and loss of good land 2 million hectare per year (used for dumping) must be saved. This waste Fly ash - end product of power plant can be converted into asset for the nation. If we can not do it we may support it by insisting use of products made out of it.

10. Power plants have ESP and Flyash now available in fine (45/u passing) powder of active silica and Alumina. This ash mixed with high grade clinker under controlled condition and pulvarised. The addition of gypsum required is decided by controlled tests. The output is blended cement having all properties of OPC 43 grade or more.

11. Advantages are low thermal conductivity, capacity to absorb extra time to form silica gel, lighter in weight and more flexibility for the same strength. The strength gain continues up to 365 days. The cement is more resistant to sulfates, SO_2 low pH solution and cycles of drying and wetting. Flyash blended Cement has more fineness (3600 cm^2/g), setting time initial 120 – 150 min and final 250 min. the strength after 3 days is 200 to 300 kg/cm^2 against 160 kg/cm^2 for OPC 33 grade. It is matching to grade 43 and almost to 53. Old Phobia of PPC - a poor grade cement must be wiped out from the mind of users. This blended cement being light in volume, yield of concrete / bag of cement is more.

12. The Tata Sudh or blended cement using a fly ash a end product of national pollutant has been manufactured by a technology to provide 43 to 53 grade OPC.

13. In 50th independence year can we resolve to use a cement which will encourage use of end product Flyash. This use will partly help reducing pollution of air, land ground and water of 2000 AD The consumption of clay and energy we preparing clunker are saved

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FEASIBILITY REPORT ON UTILIZATION OF ASH, FOR THE PROPOSED 240 $\pm$ 5 % COAL BASED CAPTIVE POWER PLANT OF ESSAR STEEL LTD.

CLIENT:
ESSAR STEEL LIMITED,
HAJIRA, 394 270,
DIST: SURAT (INDIA)

FEASIBILITY REPORT ON UTILIZATION OF ASH, FOR THE PROPOSED 240 ± 5 % COAL BASED CAPTIVE POWER PLANT OF ESSAR STEEL LTD.

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FEASIBILITY REPORT ON UTILIZATION OF ASH, FOR THE PROPOSED 240 ± 5 % COAL BASED CAPTIVE POWER PLANT OF ESSAR STEEL LTD.

1.0 INTRODUCTION:

A 240 ± 5% MW pulverized imported coal based thermal captive power plant is proposed at ESSAR Steel – Hajira. The summary of project report by DE Tox Corporation for environment impact assessment forms basic data.

The plant will generate fly ash (dry – hopper), bottom ash and mixed ash in the pond. The relevant data is summarized below:

2.0 (1) Location at Hajira.26 villages fall in 15 km radius.

(2) Proposed coal source: imported from Australia. Indonesia, South Africa, China (Maximum lump size 100 mm)

(3) Coal pre scanned by magnetic separator to remove heavy metals.

(4) Ash handling is covered Conveyor, Silo, and Slurry pumps.

(5) The ash generated will be

a) Bottom ash

b) Fly ash (coarse and fine)

The ash will be conveyed to slag bath.

The mixture of ash and water is diverted to grinder.

The bottom ash is stored in hopper or mixed with F.A.and water and pumped to ash pond.

(6) The plant plans to store F.A. for first year in ash pond. Then it is Planned to employ agency to consume 10% of total ash produced in 2nd year.

(7) The total ash generated in 18 years will be stored in 12-hectare pond. The maximum height of pond is 5m.

(8) ESSAR proposes supply of fly ash free to producers of ash based products for 10 years.

(9) The disposal ~~layout~~ planned shows layout of Ash pond, Settling pond and recycling of water. The ash pond plot is

12 hectare area for settling and stilling pond. The entry / exit for buyer of ash has been planned outside security requirements.

(10) DATA:

Coal consumed:	45 TPH / unit
Ash content of coal:	Max.13.6% (Adopted 10%)
Dry Density of FA:	0.75 T / m^3
Dry Density of Pond Ash:	1.00 T / m^3
Bulk Density of Pond Ash:	1.6 T / m^3

Bottom Ash, 20% of total Ash.

Coarse Fly Ash, 4% of total Fly Ash.

Fine Fly Ash, 90% of total Fly Ash.

Fly Ash 100% dry, ash storage in silo for Fly Ash.

Unused Fly Ash has option of wet disposal.

Storage of Fly Ash for 12 hours operations.

Ash at point of generation,

Bottom Ash 48 TPD ——— Fly Ash 192 TPD

(11) Storage of Bottom Ash for 18 years in disposal area.

Fly Ash shall be used for manufacture of bricks, cement, concrete, hollow blocks, in phased manner with 10% in 2^{nd} year. The increase will be 10% per year. By 6^{th} year 50% utilization is proposed.

(12) Expected Characteristics of Fly Ash generated is shown in Table: 1.

(13) Based on general information, the bottom ash (48 TPD) has range of grading as shown in Fig: 1.

Particle Size:	%Passing:	
10 mm	90%	Clay: 0%
5 mm	40%	Silt (0.002-0.075mm): ~~50~~ 10 to ~~70~~ 16 %
1 mm	20%	Sand (0.075-4.75 mm): ~~30~~ 80 to ~~46~~ 90 %
0.1mm	5%	Uc=1.5 to 3.7, Cc=0.9

It is equivalent to poorly graded silty fine sand. It is planned to store 100% dry ash in separate silo. The physical properties are: SP. gravity=2.3 to 2.4 g / cc, OMC=~~30-45~~ 30-40 %. At MDD Bottom ash will be expected to have coefficient of permeability 6.2 x 10^{-3} cm/sec. The compacted sand could be considered as c=0, ϕ =34°, shear parameters under drained condition.

(14) The characteristics of Fly Ash likely to be available are reproduced in Table: 1, using Table: 3.3 of Executive Summary report and IS 3812.The fly Ash (coarse and fine) meets all limits for use as pozolonic materials (except SO_3 content which is not critical). (The mineral present will be CaSO4, or MgSO4)

The fly ash (composite) of similar coals shows the following physical properties.

- Specific Gravity G =2.2 ± 0.2
- Clay fraction :0%
- Silt (0.002-0.075mm) :50-60%
- Sand (0.075-4.750mm) :30-46%
- Uc=1.5-1.75, Cc 1.0
- Modified proctor MDD =1.2 g/cc

  OMC =32-35% (To be checked in trial embankment for roller & thickness)
- Shear Parameters c= 0.2 to 1.0 kg/cm^2

  (Cu) @ OMC, MDD ϕ = 27°
- Permeability coefficient = 10^{-6} to 10^{-5} cm / sec.
- Specific Surface = 3200 m^2 / g
- Lime reactivity =20 to 40 kg / cm^2

(15) FEASIBILITY FOR USES:

15.1 Though there are many applications for above (FA & BA) materials. A realistic planning must consider adjoining area, industries of building materials bricks, tiles, cement and the projects planned in decade (2002-2012).

The consumers of fly ash are grouped as:

a) Burnt clay Bricks manufactures: conventional & manual technology. (Bhathha)

b) Manufacturers of products made ~~with~~ of Fly Ash – Bricks, Tiles, Concrete, Pozolonic additive to cement for plaster and subgrade for roads in expansive soils area.

c) Contractors Supplying Fill material in construction of:

- Road embankment
- Dykes for pond for Ash.
- Fill material for wasteland.
- Grout for the ONGC dead wells
- Fill in mined areas (Eroded land scapes)
- Plinth fill for housing, factory, tank Pad foundation, backfill of retaining walls.

15.2 Immediate market (Burnt clay Brick works): Bhaththa.

There are plenty clay brick manufacturing units around Surat. The survey done by Local Agencies has identified 200-300 Nos of units making approximately 10 x 10^7 bricks / year on average in Surat district alone. (Table: 3). There may be many units around which are not covered by survey. The overall deficiency in supply of bricks is 25 to 50%. Quality of bricks made from local saline expansive soil is poor. They have high percentage of breakages. The process involves pudling of clay, with water, addition of Rice husk and admixtures, mould it manually, air dry and fire. The rejection of over-underburnt bricks is considerable.

Fly Ash and Bottom Ash in proper proportion (say 3 FA: 1 BA by weight), depending upon characteristics of clay, can be used as admixture in above process. The material replacement of clay could be 30 to 50%. The soil will loose its high plasticity and its high swell and shrinkage. (R & D will be required for optimum percentage of fly Ash that could give best bricks). The marketing will require demonstrating improvement in size (± 10 mm to ± 2mm or so), reduction of water absorption and improvement in strength of burnt clay bricks. The use of fly ash will also reduce fuel consumption for firing process as it is by product of firing. The envirofriendly aspect is saving 20% of agricultural land - soil used in brick making.

Organized days workshop. with some R & D results, will attract the mostly uneducated manufactures to adopt such new material. The use of cash is not altering the present working system.

In machine made bricks, soil is pulverized, blended with binders, made mixed with water. Adding of fly ash will be made at pulverizing stage easily. These bricks are fired in kiln under controlled conditions. (CBRI technology)

Estimated Use Of Fly Ash In Burnt Clay Bricks:

• No of Local Bhathhas making bricks	: 200 Nos
• Average production	: 10,000 bricks / day
• Fly Ash consumed by 10,000 Bricks @ 0.7 kg / brick [Wt. Of brick 2.3 kg 30% Ash = 0.7 kg]	: 7 T / unit / day
• Even if 30% of users adopt F.A.technology	: 60 x 7 = 420 T/day
• ESSAR can market by stages	
1st year by conveying 10 units	: 70 T/day
2nd year 15 "	: 100 T/day
3rd year 22 "	: 150 T/day

Thus from first year itself there is potential to dispose of 70 T/day ash which will be much more than required by DOEF. (Free delivery may attract consumers in 1st year)

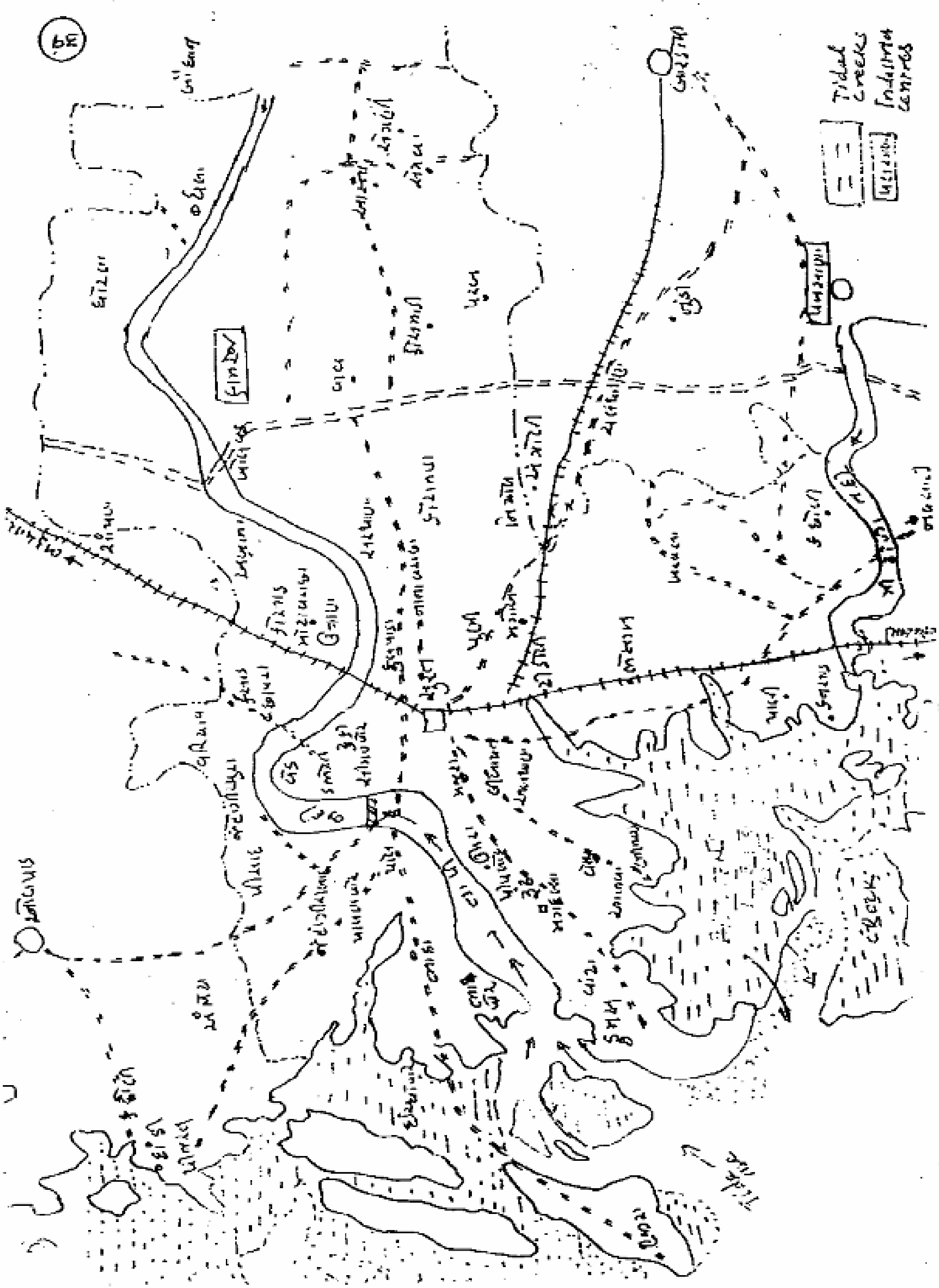
15.3 Use in Machine made stabilized FA bricks:

There are 4 plants. semiautomatic, making Fly Ash Lime Gypsum, Fly Ash cement bricks and tiles. The materials consumed per such brick will be minimum 80% F.A. & B.A. + (15 + 5% sand) + binder (cement/ lime/ gypsum/ polymers etc.)Such products per brick will consume about 1.8 kg of FA and BA. These products, in the market, are known for high strength, perfect shape, low breakages and low absorption of moisture. Total production now may be around 30,000 bricks / day consuming about 54 TPD of FA and BA. Proper marketing and strategy of R & D can create a market of 10 TPD ash in first year increasing at the rate of 20% per year in future. The technology, acceptibity of products, economic viability has been established beyond doubt. These bricks have high strength of 100 kg / cm^2, lower thermal conductivity and higher abrasion resistance. It is replacing hollow CC blocks for housing.

The feasibility of putting up a plant to convert 60 T of FA & BA (dry) in automatic plant using cement / lime and chemical as additive could be worth examining. The saving in cost of stocking and disposing ash could be invested in making bricks for self-use & marketing in Hajira belt. A 30,000 brick auto plant with a blender, water sprayer, mixture, press, conveyor and steam curing chamber could be estimated to cost around 300 lacks. The infrastructure, land & steam are available economically. Such a plant will reduce disposal of ash by 60 T/day & provide excellent strong, proper construction material for housing, paving & expansion programs of industries. Recovering plant cost in 6 years. Cost of lime & chemicals, power may not cost more than 1.0 Rs / brick of strength 100 kg / cm^2 or more. The decrease in storage cost of 60 T/day & fulfillment of use stipulated by Govt. Dept. of Environment projects a strong case for project prima faci. Present market price of such bricks is Rs 1.50 (min). Marketing at Rs 1.70 could be feasible. Strong cement based bricks could be produced for structures where plaster may not be required (cement content 15%)

15.4 Use As Soil:

Recently for major Earthwork at Calcutta (Corridor PM Road) And backfill on metro rail tunnel Delhi, extensive R & D have promoted use of fly ash and bottom ash alone or with admixture of soil as a fill material. IS Code 10153 and CRRI have recommended use as fill material in embankment construction. The material properties for composition expected fly ash & bottom ash (Para 14) indicate extensive potential for use as fill material for dyke and embankments for flood and roads / reclamation of "khar land" or tidal wet lands. The physical and engineering properties permit use of soil as impervious with high shear resistance, lower compressibility and better drainage characteristics. The lower density after compaction imposes lower stresses on soil and retaining walls. The long-term pozolonic activity



(subject to testing of lime reactivity) shows improved resistance with time.

The map enclosed shows massive evasion of tidal flow, which has to be countered by dykes and massive fills. It is possible to reclaim land and use it extensively. The pana fill now used in Hajira coastal belt could be replaced by 50% sand ash + 50% fly ash. Around 10 TPD fly ash and bottom ash could be utilized in Hajira Olpad esuary areas.

15.5 Use As Road Sub Grade:

For the roads in South Gujarat region, (predominantly expansive top clay area) roads fail by swelling and shrinkage with rains and summer.

The technology used by SMC to minimize this problem is to plough the clay, break clods by disc harrow, add fly ash & lime (1 lime: 4 fly ash by weight) around 20% by weight, replough, add optimum moisture, cure for 72 hours and roll it by heavy roller. Such a treatment is reported to:

1) improve soaked CBR of soil (subgrade) from 2 to 12 min (range of 16 to 28 %)
2) Reduce pavement thickness by 300 to 400 mm.
3) Make sub grade impervious and non-expansive thereby not allowing cracks and seepage of rainwater.
4) The sub grade is flexible.
5) The IRC provision of 700 to 1000 mm CNS soil layer cap in expansive soil is eliminated.

The type of work has been advocated by SMC & IRC 88 recommended practice for lime fly ash stabilized base / sub base in pavement construction.

The pavement thickness and hence cost can be compared as under:

Practice	Stabilized New Practice
• Traffic E	Traffic E
• Soak CBR 2	Soaked CBR (FA+lime treated) 12
• Pavement thickness: 600mm	Pavement thickness: 250mm
• For swelling soil add CNS	No Special Treatment – 1000 mm

The major users are GIDC, SMC, PWD, Hajira Industrial Internal roads etc.

15.6 The design of ash pond for this project could be made using Fly Ash & Bottom Ash (Now RCC) dyke. The ash dyke per m length on periphery of ash pond will consume 30 to 40% of ash (length of dyke approximately 1400 m.

The tentative design alternatives of dykes are shown in Fig: 2, 3. The materials are FA, BA, & Stone or slag if tests are affirmative.

16.0 Conclusion:

1.0 For proposed captive power plant at ESSAR, the utilization of by product (Fly Ash) with imported coal can be conveniently used upto 100 T/day or 150 T/day as shown below. Marketing strategy and R&D workshop – seminars to educate users & manufacturers of bricks, of course, is a must.

2.0 The ash could, to start with be free & even transport upto 20km in 1st & 2nd year could be arranged free.

3.0 Alternative study of economic feasibility of FA-cement or lime products manufacturing plant which can latter be developed for making insulating bricks using FA for on line use of 60 to 100 T Fly Ash could be assessed. The need of good brick for Hajira belt with ESSARs own needs for construction, availability & cheaper blinder & steam, saving in stocking of 60 T/day ash points to a economical viability at first sight. The technology options are established & available. only R&D with product ash for a given coal will be required.

4.0 The proposal to change over to dyke for ash pond, replacing RCC structure, using ash & slag needs to be considered as excellent option of using ash from day one.

PLANNED USE OF ASH

Source		Consumption (Avg. for a year)	Remarks
15.2	Mannual brick makers	70 T/day	Within 20 km radius
15.3	Stabilized FA bricks / tiles/ pavers blocks.	10 T/day or Own plant 60T/day	Capital Rs 3 Crores
15.4	Use as Soil.	10 T/day	--
15.5	Use as Road Sub grade	5 T/day	SMC
		5 T/day	Other Roads (Hajira)
	Total consumption:	100 T/day or 150 T/day	

Encl: Table: 1, Characteristics of Fly Ash to be generated at ESSAR. With Average F.A. from Indian Literature.

Table: 2, Expected physical properties of ESSAR F.A. based on the similar Ash.

Table: 3, Data of brick manufacturers in 50 km radius.

Fig 1: Grading and properties of Bottom Ash (expected)

Fig 2: Dyke section for proposed Ash pond at ESSAR of FA & slag or rock dyke. Alternative I.

Fig 3: Dyke section for proposed Ash pond for ESSAR with FA, Bottom Ash and Georope gabbions holding slag - to be constructed in stages over 2 to 3 years. Alternative – II.

Table: 1 **Characteristics of Fly Ash to be generated at ESSAR. With Average F.A. from Indian Literature.**

Parameters	Expected Value (Ref. Executive Summary Table 3.3)	Average Literature Value For Indian F.A. (CBRI Bomi)	Code requirement IS 1489(PPC) 3812-1981 (Pozzolana)
% SiO_2	41.5	55.0	Min 35% } Total 70% Min
% Al_2O_3	30.8	23	
% Fe_2O_3	4.8	9	
% CaO	8.7	3	-
% MgO	2.2	2	(Max) 6
% Na_2O	0.2	--	-
% K_2O	0.3	--	-
% TiO_2	1.0	--	-
% P_2O_3	1.0	--	-
% SO_3	7.6	0.9	(Max) 2.75
Base / Acid Ratio	0.22	--	-
Loss on ignition(%)	5	6	(Max) 12
Fineness(cm^2/g)	3200		* (Min) 3000
Sound ness (Autoclave)	—		** (Max) 10
Lime reactivity kg/cm^2	40		Δ

	Grade I	Grade II
*	3200	2500
**	0.8%	0.8%
Δ	40	30
C type / F type		

Table: 2 **Expected physical properties of ESSAR Ash based on the similar Ash.**

Sr. No.	Property	ESSAR Ash	
		Fly Ah	Bottom Ash
1	Grain Size:		
	Clay (%)	0	0
	0.002-0.075 mm (%)	50-70	10-16
	0.075-4.750 mm (%)	30-46	80-90
	> 4.75 mm (%)	0	0
2	Uc	1.5 to 1.75	2.7 to 3.7
3	Cc	1.0	0.8 to 1.2
4	MDD	1.2	1.0
5	OMC	32-35	30-40
6	G	2.4 ± 0.2	2.2 ± 0.1
7	k (cm / sec)	10^{-4} to 10^{-5}(silt)	2 x 10^{-4} (silt)
8	c (kg / cm^2)	0.2 to 1.10	0
9	ϕ	27°	34°

Table: 3 **Data of brick manufacturers in 50 km radius (basic panchayat Olpad, Brick manufacturers Association& traders like Jalaram Traders, Karanj)**

Sr.No.	Area	Bricks produced / year	Kilns (Nos)	Mannual Bhathi (Nos)
1	Olpad Taluka	60×10^6	10 to 15	100 to 200
2	Upeleta	20×10^6		
3	Palsana Valeswar	10×10^6		
4	Mahuva	10×10^6		
	Total:	100×10^6		

Note: Machine Made F.A. lime brick producers -- 3 to 5 (Gurjari Blocks, Olpad, BBC (Vesma), Desai Construction (Valsad))

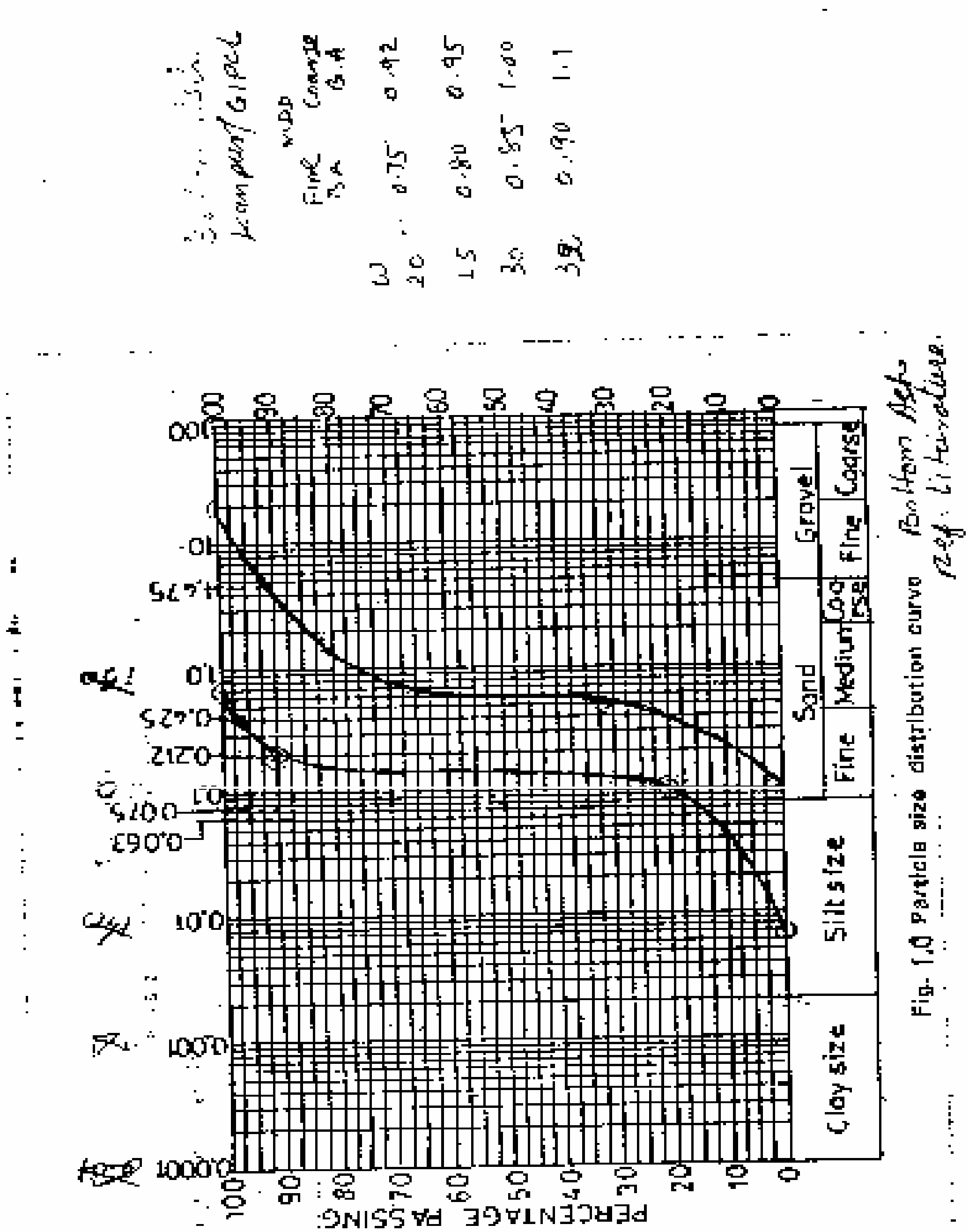
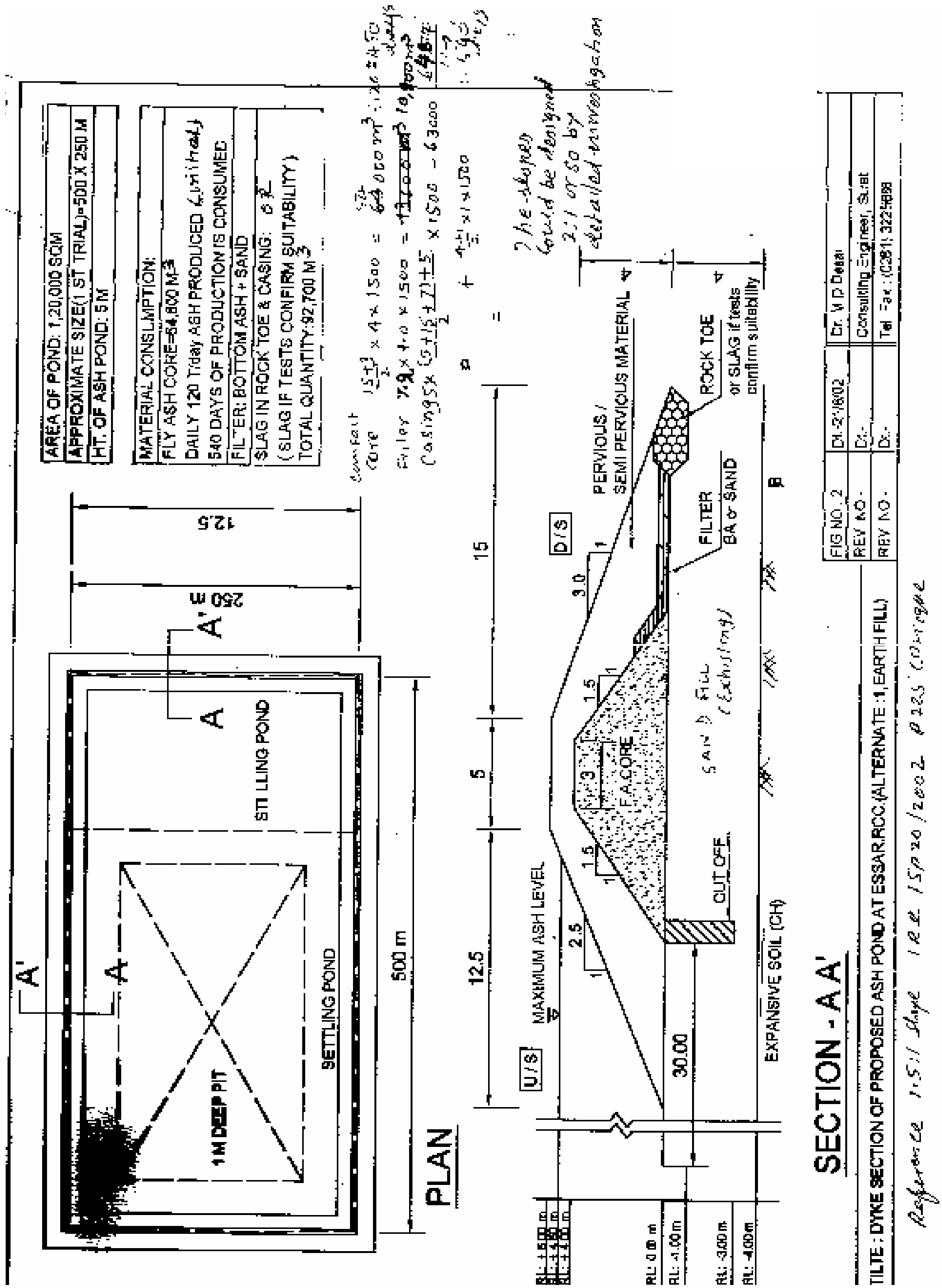


Fig- 1.0 Particle size distribution curve


AREA OF POND: 1,20,000 SQM
APPROXIMATE SIZE(1 ST TRIAL)=500 X 250 M
HT. OF ASH POND: 5M
MATERIAL CONSUMPTION:
FLY ASH CORE=64,800 M3
DAILY 120 T/day ASH PRODUCED
540 DAYS OF PRODUCTION IS CONSUMED
FILTER: BOTTOM ASH + SAND
SLAG IN ROCK TOE & CASING
(SLAG IF TESTS CONFIRM SUITABILITY)
TOTAL QUANTITY:92,700 M3
PLAN
1 M DEEP PIT
SETTLING POND
STILLING POND
500 m
250 m
12.5
SECTION - A A'
U/S
D/S
MAXIMUM ASH LEVEL
F.A.CORE
CUT OFF
EXPANSIVE SOIL (CH)
PERVIOUS / SEMI PERVIOUS MATERIAL
FILTER
BA or SAND
ROCK TOE
or SLAG if tests confirm suitability
TILTE : DYKE SECTION OF PROPOSED ASH POND AT ESSAR,RCC.(ALTERNATE :1,EARTH FILL)
FIG NO. 2
REV NO -
Dr. M D Desai
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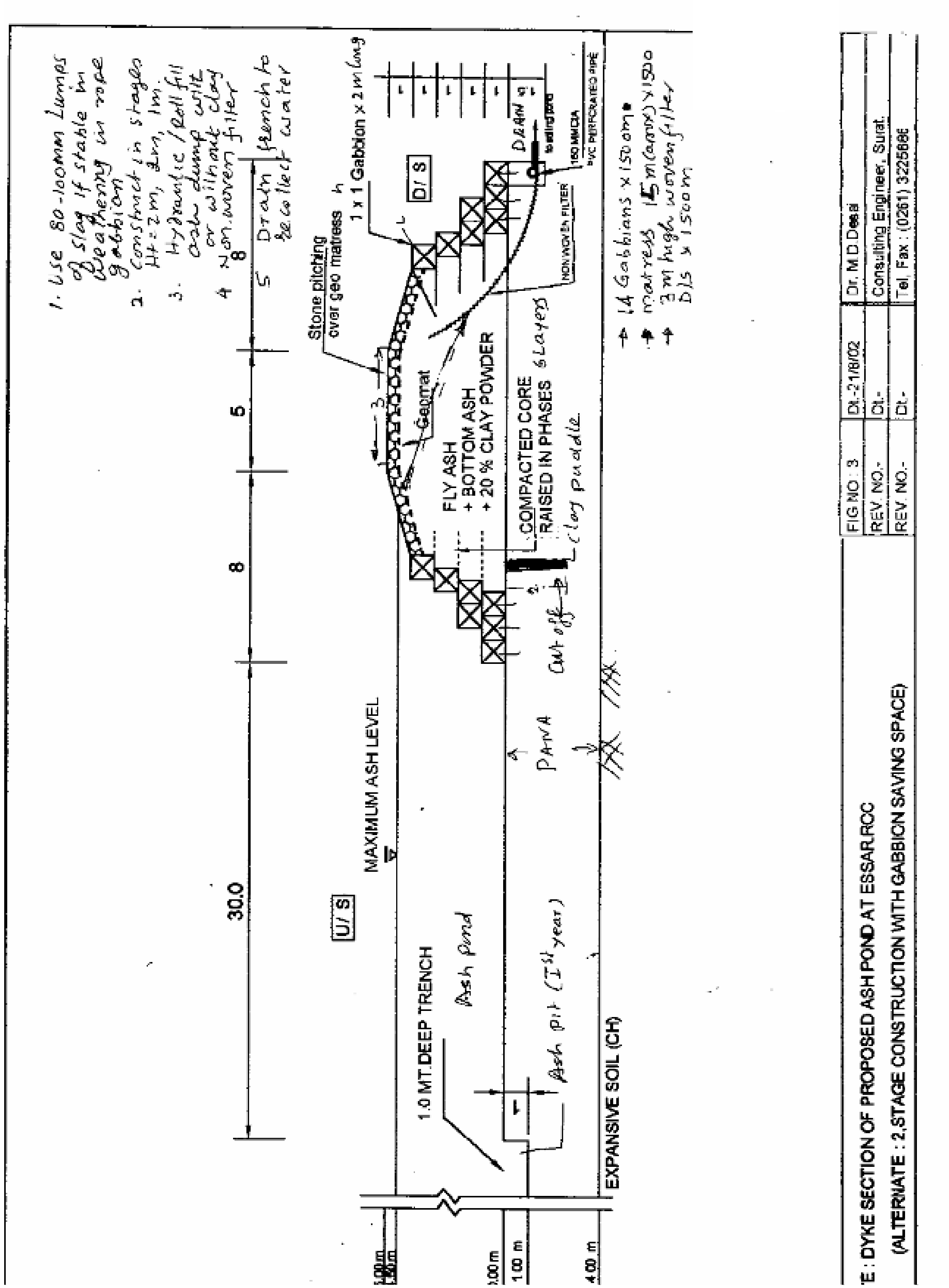
E : DYKE SECTION OF PROPOSED ASH POND AT ESSAR.RCC
(ALTERNATE : 2,STAGE CONSTRUCTION WITH GABBION SAVING SPACE)
FIG NO : 3
Dt.-21/8/02
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Tel, Fax : (0261) 3225666
MAXIMUM ASH LEVEL
U/ S
D/ S
1.0 MT.DEEP TRENCH
EXPANSIVE SOIL (CH)
FLY ASH
+ BOTTOM ASH
+ 20 % CLAY POWDER
COMPACTED CORE
RAISED IN PHASES
Stone pitching
over geo matress
Geomat
1 x 1 Gabbion x 2 m long
NON WOVEN FILTER
150 MM DIA
PVC PERFORATED PIPE
DRAIN
30.0
8
5
8
Ash pond
Ash pit (Ist year)
Cut off
clay puddle
5 layers
1. Use 80-100mm Lumps of slag if stable in weathering in rope gabbion
2. Construct in stages H=2m, 2m, 1m.
3. Hydraulic/Roll fill ash dump with or without clay
4. Non woven filter
5. Drain trench to collect water
14 Gabbians x 1500m
matress 15m(appx) x 1500
3m high woven filter
D/S x 1500m