Fly Ash Utilisation for Value Added Products
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Studies on Kolaghat Thermal Power Station fly ash with a view to set up a mechanised brick plant

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ABSTRACT

This paper describes some of the efforts in finding means to put fly ash to some use in producing value added products. Some trials with fly ash from Kolaghat Thermal Power Station were undertaken at CGCRI, Calcutta by the author's firm and a Japanese company to establish the possibility of putting up a mechanised brick plant, utilising clay and fly ash in different proportions which are briefed in the paper. From the studies, it is revealed that a mechanised brick plant, by replacing clay with flyash of similar characteristics as that of Kolaghat Thermal Power Station, to an extent of 50% can easily be installed. It also reveals that a plan for producing 50,000 bricks or more per day will be a very attractive proposition. One could even consider a 25,000 bricks per day plant with some simplications while selecting the equipments.

Key words : *Fly ash utilisation; Kolaghat Thermal Power Station; Mechanised brick plant; Building materials*

1.0 INTRODUCTION

It is estimated that 65 to 75 million tonnes of fly ash is generated from the thermal power plants operating in India.

With the industrialisation of the country, it is but natural that the power generation should also increase. As thermal power generation is more than 70% of total power generated in the country, more and more fly ash will be generated.

Continuous generation of this solid waste creates problem regarding its disposal. continuous research is going through out the world for its disposal and utilisation.

2.0 FLY ASH IN THE WORLD

Though in many of the western countries, power generation is much more than in India but as the ash content in their coal is 6-10%, compared to 30-40%, the generation of fly ash compared to power generation is much less. However, in most of these countries, the utilisation of fly ash is much more than in India.

Table 1 gives an indication of fly ash generated and its utilisation.

Table 1 : Fly ash generation and its utilisation all over the world

Country	Fly Ash Generated Million tonne/annum	Utilisation %
India	65	2
U S A	90	15
China	100	30
U K	20	25
Germany	40	15
World	500	-

3.0 FLY ASH GENERATION IN INDIA

Not very consistent figures are available regarding fly ash generation in the country.

It is obvious that though data of power generation is available, the generation of fly ash is estimated, taking the following factors into consideration.

- Plant load factor
- Calorific value of coal, i.e. coal consumption
- Ash content

These data are not always available and may not be consistant and hence there is inconsistency in giving these figures. Table 2 gives some of the figures mentioned by some authors while presenting/publishing papers during 1997-98.

Table 2 : Fly ash generation in India

	Authors (S)	Organisation Fly	Ash generation in India Million tonnes/annum
1.	S. Kumar, K. K. Singh and P. Ramachandra Rao	NML	75
2.	S. Raghuveer	ITC Bhadrachalam Paper Boards Ltd	75
3.	A. K. Mukherjee, T. K. Chakravorty & A. K. Das	SAIL	65
4.	L. B. Gupta	Punjab SEB	65-70
5.	S. K. Paliwal, P. K. Gupta & B. Sengupta	CPCB	40
6.	A. Trechan, R. Krishnamurty & A. Kumar	NTPC	55-60
7.	G. Singh, PSM Tripathy, R. C. Tripathy & S. K. Das	CERI	40-50
8.	S. S. Dasgupta	SDG MET. Project Pvt. Ltd.	40

Whatever the figures may be, but it is obvious, that the fly ash generated from the thermal power projects pose an enormous national threat.

Before going into the problem of its utilisation and disposal, one has to study the generation of fly ash in future, say for the next millenium.

3.1 Projected power generation

It is necessary to study the growth of power in the country and with that the share of thermal power to forecast generation of fly ash.

A forecast till 2020 is shown in fig 1. However, as indicated in Table 2, it may vary to a large extent. Nevertheless this national problem will remain.

Union power minister P. R. Kumarmangalam mentioned recently, that the additional power generation in the country by the end of 9th Five year plan will be 30,000 MW and another addition of 15,000 MW by the end of 10th Five Year Plan. Though the generation through hydel route will increase, the share through thermal route will remain between 70 and 80%

Thus, the problem of fly ash utilisation/disposal will grow menancingly unless steps are taken to increase the utilisation from 2% to atleast 15%, if not more.

3.2 Areas of possible utilisation

The fly ash can be used for various ways. Some of the possible uses are mentioned in Table 3.

Table-3 : Fly ash utilisation in "Nut shell"

Low value (category A)	Medium value (category B)	High value (category C)
1. Mine Fills/Embankments	1. Portland Cement Clinker	1. Extraction of Alumina
2. Use in Road Construction	2. Portland Pozzolana Cement	2. Extraction of Magnetite
3. Lime Fly-Ash Stabilized Soil	3. Masonry Cement	3. Extraction of Cenospheres
4. Lime-Fly Ash Concrete	4. Oil well Cement	4. Floor & wall Tiles
5. Lean Cement Fly-Ash Concrete	5. Fly Ash Building Bricks	5. Acid Resistant Bricks
6. Lime-Fly Ash Bound Macadam	6. Fly Ash Blocks	6. Insulating and Semi insulating.
7. Cement-Fly Ash concrete	7. Pre-Cast Fly Ash Building units	7. Fly Ash Building Distemper
8. Partial Replacement of Cement in Mortars and Mass Concrete	8. Lime-Fly Ash Cellular Concrete	8. Domestic cleaning powder
9. Reinforced Fly Ash	9. Cement-Fly Ash Concrete & Ready mixed Fly-Ash Concrete	9. Soil Amendment Agent
10 Fly Ash in Grouting Cement Concrete	10. Sintered Fly Ash Light Weight Aggregate and Concrete.	
11. Air Tight Concrete		

NTPC has tried to forecast the possible areas of utilisation of fly ash by the year 2010. This is presented in Table 4.

Table-4 : Forecasting the possible areas of fly ash utilisation by the year 2010

Item	Million Tonnes/yr	%
1. Fly Ash likely to be generated by 2010	110	100
2. Bricks/Blocks, Cellular Concrete, Bldg. blocks/slabs	75	68
3. Reclamation of low lying land, old mines etc	20	18
4. Construction of roads, highway etc	5	4.5
5. Cement, Concrete and cement products	4.5	4
6. Others (Balance)	5.5	5.5

From the above table, it is evident, that the main thrust-area should be the manufacture of bricks, blocks, tiles etc and most of the research should be aimed towards these products. This paper thus deals with the manufacture of such products.

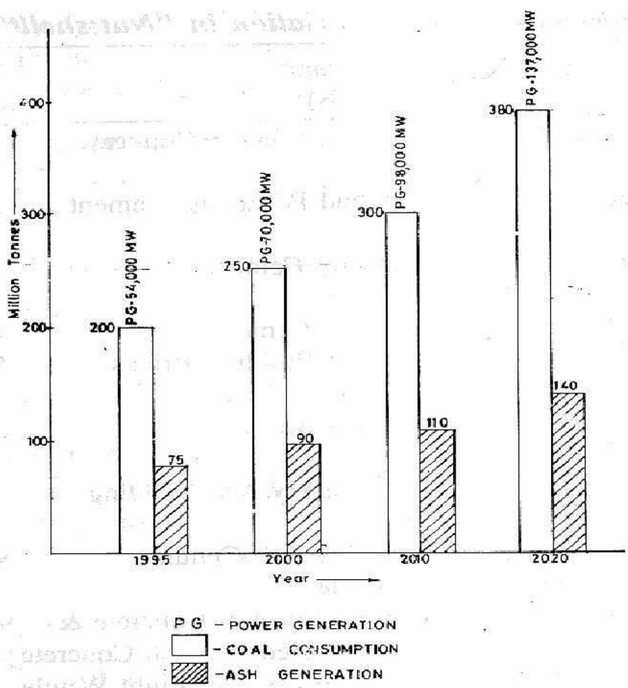

Fig. 1 : Ash generation from 1995 to 2000

4.0 MANUFACTURE OF BRICKS, BLOCKS, TILES etc.

The manufacture of these products can be achieved by various processes, viz

1. Clay, Fly ash : fired
2. Clay, Fly ash, Lime : Steam curing
3. Clay/Sand, Fly ash, Lime : Pressed.

Here it is dealt with the first process (St. No. 1) because of various advantages, viz

- Its colour is red and thus acceptable to buyers, unlike other processes, which gives a grey colour (Sl No. 2 and 3)
- No boiler is used (Sl 2)
- The production with the use press only (Sl No. 3) cannot be very high.

A simplified flow sheet is indicated in Fig. 2.

Table-5 : Analysis of clay and ash

Composition	Pond Ash (%)	Clay (%)
Moisture	6 - 30	22 - 24
Ignition loss	8.5 - 19.0	4.5 - 6.0
SiO_2	46 - 57	63 - 66
Al_2O_3	12 - 22	14.0 - 15.5
Fe_2O_3	4 - 7	5.5 - 6.3
CaO	0.8 - 1.2	0.50 - 0.65
MgO	0.7 - 1.1	1.6 - 1.74
Na_2O	0.10 - 0.17	1.25 - 1.70
K_2O	0.8 - 1.0	2.5 - 2.8
SO_3	0.10 - 0.14	0.12 - 0.18
P_2O_5	1.1 - 1.6	0.40 - 0.55
TiO_2	1.4-2.3	1.0 (Approx)
Li_2O_2, V_2O_5	0.04 (max)	0.02 (max).

Measured volume of clay is fed to a conveying system through a box feeder and the required quantity of fly ash from a silo is fed to the conveyor. The mixture is then mixed thoroughly in a pan mill and an edge runner. It then passes to an extruder and extruded through a die over a roller conveyor. An automatic cutter cuts the pieces into required length and through a series of conveying system loaded to dryers, which are heated through the waste heat of Hoffman kiln and/ or through a hot air generator/auxiliary furnace.

After the bricks have been dried at 100°C, they are stacked in Hoffman kiln, which is fired by a spray of pulverised coal from the roof of the kiln.

To achieve productions of 25,000 bricks per day or 50,000 per day or 100,000 per day, the plant can be run in various combination as indicated in Fig. 2. The mechanical lines generally operate for one or two shifts only. On the other hand, the dryer and Hoffman kiln operate round the clock.

The Chinese also have similar plants for bricks production, viz clay and fly ash but the flow sheet is in a little variance with the Indian plants mentioned in Fig 2. The flow sheet adopted by the Chinese is indicated in Fig 3, the main difference being :

- The Coal is mixed in the initial stages, instead of charging at Hoffman kiln.
- The mixture of fly ash, clay and coal is mixed with water and cured for 3 days, which makes it a batch process, unlike in India.
- In place of tunnel dryer and tunnel kiln, chamber dryer and Hoffman kiln can be used.

It appears, that same Indian companies are considering to put up plants based on Chinese technology.

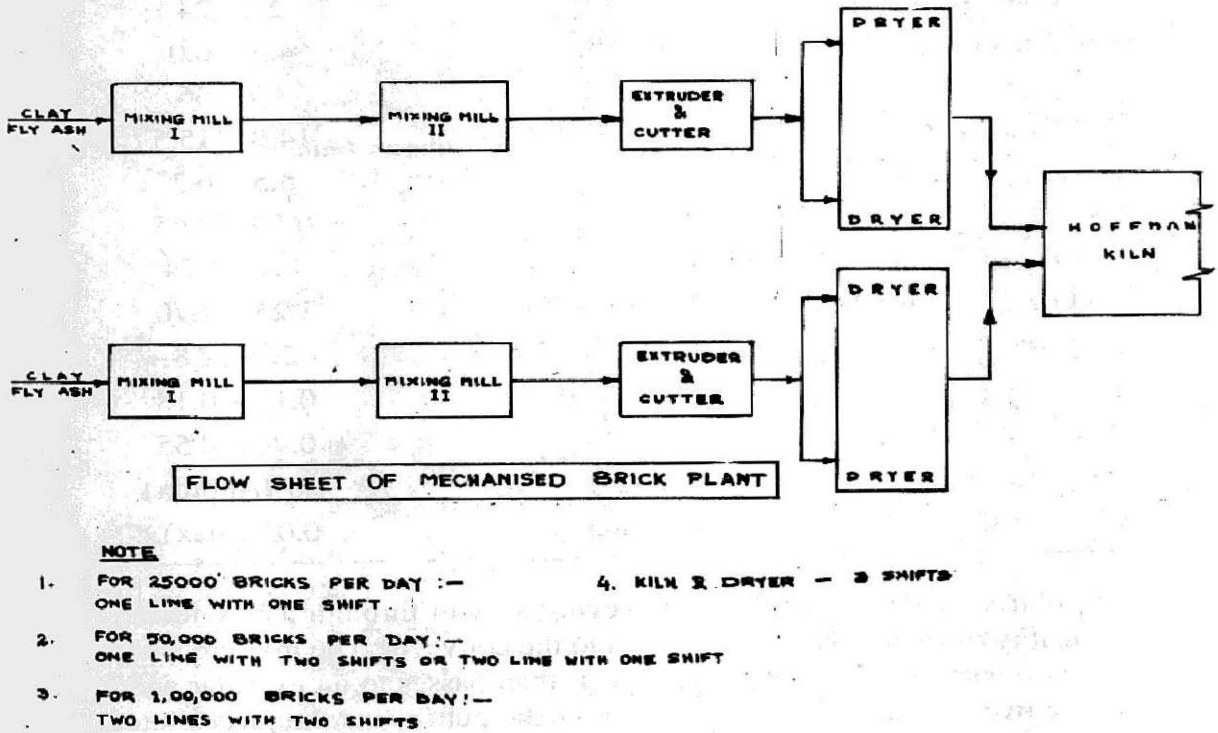

Fig. 2 : Flow sheet of mechanised brick plant

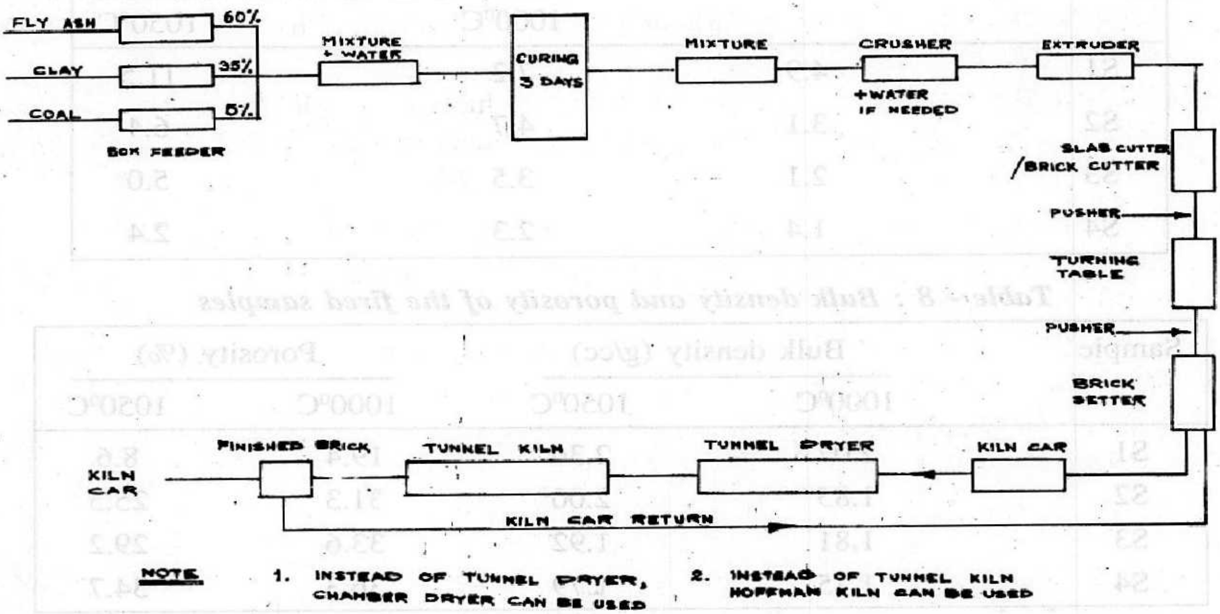

Fig. 3 : Flow sheet for brick production in China

4.1 Mechanised brick plant with fly ash from K T P S

Some studies were made, in which the author was very closly associated, with fly and bottom ash of kolaghat Thermal power Plant.

A Japanese company clectrical power job by West Bengal Power Development Corporation was assigned of finding ways and means of utilising fly ash from KTPS to value added products. For fly ash-clay bricks, EPDC worked closely with my company SDG Met. Project Pvt. Ltd.

Table - 6 : Proportion of ash and clay

Sample Code	Canal silt (Parts by wt.)	Pond ash (Parts by wt.)
S1	100	0
S2	70	30
S3	60	40
S4	50	50

Table - 7 : Shrinkage of the dried and fried samples

Sample	Green to dry Shrinkage (%)	Green to fired shrinkage (%)	
		1000°C	1050°C
S1	4.9	7.2	11.5
S2	3.1	4.7	6.4
S3	2.1	3.5	5.0
S4	1.4	2.3	2.4

Table - 8 : Bulk density and porosity of the fired samples

Sample	Bulk density (g/cc)		Porosity (%)	
	1000°C	1050°C	1000°C	1050°C
S1	2.07	2.36	19.4	8.6
S2	1.85	2.00	31.3	25.5
S3	1.81	1.92	33.6	29.2
S4	1.75	1.79	36.3	34.7

Table - 9 : Water absorption and compressive strength of the fired samples

Sample	Water absorption (%)		Compressive Strength (kg/cm^2)	
	1000°C	1050°C	1000°C	1050°C
S1	9.4	3.7	285	260
S2	16.9	12.8	275	250
S3	18.6	15.2	260	235
S4	20.7	19.3	250	225

Samples of fly/bottom ash were collected from KTPS and tests were conducted at CGCRI In which fly ash and clay were mixed in different proportions and fired at 1000 and 1150°C and the product was tested for various properties, viz.

- Shrinkage
- Bulk density
- Porosity
- Water absorption
- Compressive strength.

The following tables give information of the tests conducted.

Table	*Description*
5	Composition of Ash and Clay
6	Proportion of Ash and Clay by weight
7	Shrinkage of the dried and fired samples
8	Bulk density & Porosity of the fired samples
9	Water absorption and compressive strength of the fried samples

The brick-samples with various proportions of fly ash and clay were designated as S1, S2, S3 and S4. It is but natural, that the properties of S1 were best and S4 worst.

The properties were better with 1050⁰C fired samples compared to that at 1000⁰C, except for compressive strength, which was better at 1000⁰C.

For determing the quality of bricks, the two important properties to be considered are water absorption and compressive strength. Fig 4 indicates graphically variance of these two properties for S1, S2, S3, S4 at 1000 and 1050⁰C.

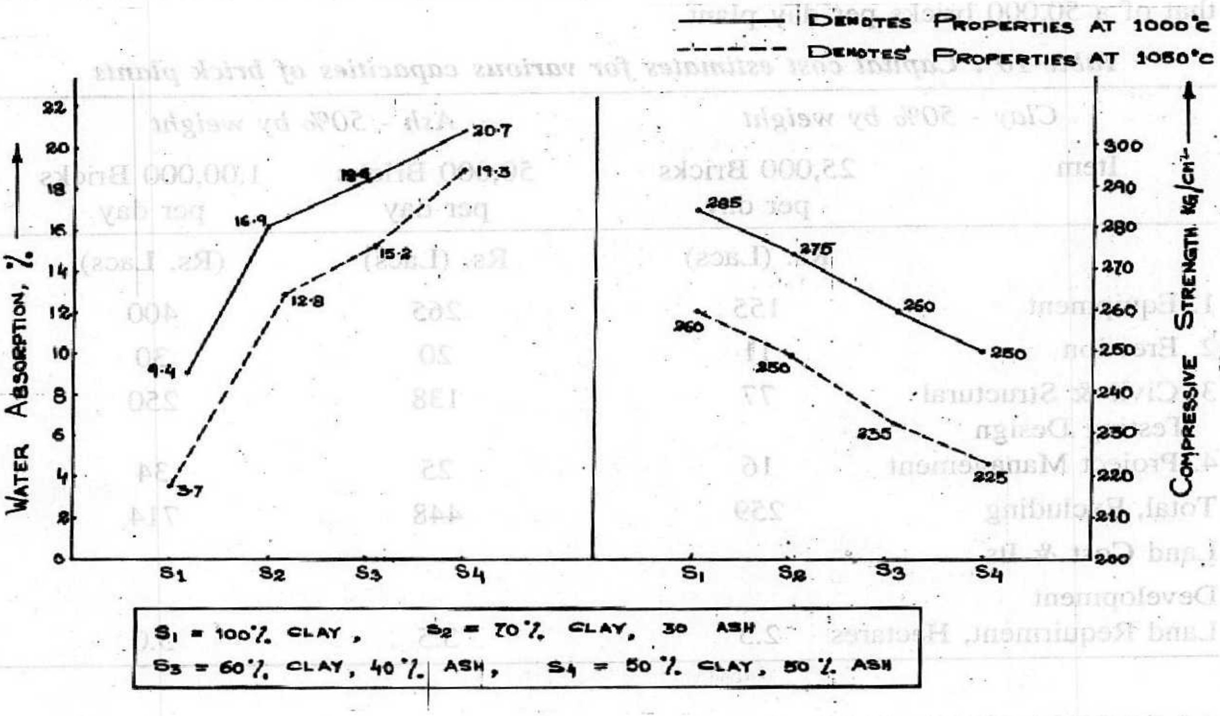

Fig. 4 : Water absorption and compressive strength of brick with various mix

4.2 Economics

In the particular study, the sample S4 was considered, i.e where clay and fly ash were mixed equally by weight (50:50).

The study also involved plants with capacities of producing bricks as follows :-

25,000 bricks per day

50,000 bricks per day

1,00,000 bricks per day

5.0 CAPITAL COST

The capital cost estimates for various capacities of brick plants are given in Table 10.

For arriving at the cost of equipment it has been assumed that except for the extruder and cutter all the items will be indegenously procured/fabricated/manufactured.

It has been assumed that the driers are of chamber type and the kiln is hoffman kiln. From box feeding to drier unloading will be more or less mechanised.

One can see that the cost of a 50,000 bricks per day plant is 73% more than a 25,000 bricks per day plant. On the other hand a 100,000 bricks per day is only 60% more than that of a 50,000 bricks per day plant.

Table-10 : Capital cost estimates for various capacities of brick plants

Clay - 50% by weight		*Ash - 50% by weight*	
Item	25,000 Bricks per day	50,000 Bricks per day	1,00,000 Bricks per day
	Rs. (Lacs)	Rs. (Lacs)	(Rs. Lacs)
1. Equipment	155	265	400
2. Erection	11	20	30
3. Civil & Structural Testing Design	77	138	250
4. Project Management	16	25	34
Total, Excluding Land Cost & Its Development	259	448	714
Land Requirment, Hectares	2.5	3.5	5.0

6.0 PRODUCTION COST

For working out the cost of production, the following assumptions have been made :

- Cost of clay has been taken at Rs. 30 per tonne, considering excavation and transport.
- Fly ash will mostly be available free of cost, so only transport cost of Rs. 25 per tonne has been considered.
- The cost of coal has been considered as Rs. 2000/t.
- The cost of power has been considered as Rs. 3.50/Kwh, taking into account all the factors.

The cost of production for the plants of three different capacities works out to Rs. 1225, 1140 and Rs. 1040 per 1,000 bricks respectively.

The consumption of various items and unit costs has been indicated in Table 11.

Table-11 : Basis of production cost estimate

Item	Unit Cost	Consumption / Day		
		Plant-I	Plant-II	Plant-III
Clay	Rs. 30/t.	60 T.	120 T.	240 T.
Coal	Rs. 2000/T.	8.5 T.	15 T.	28 T.
Power	Rs. 3.5/Kwh	1800Kwh	3500Kwh	650Kwh
Labour	Ls	Rs. 3000	Rs. 6500	Rs. 9500
Maintenance Expenditure	3.5% of total	Rs. 1036	Rs. 1660	Rs. 2536

Plant - I : 25,000 Bricks/day
Plant - II : 50,000 Bricks/day
Plant - III : 1,00,000 Bricks/day

7.0 PROFITABILITY

The cost of product and profitability have been worked out for all the three plants and presented in Table 12.

The following assumptions have been made :

- Equity : Debt is taken as 1: 2
- Interest on loan on capital cost and on working capital has been taken at 16.5% p.a.
- Depreciation has been accounted at 5% on capital cost on straight line method.

Fig. 5 gives the comparative values of sales, product and profit before tax of the plants of three capacities.

Fig 6 indicates the return on investment and pay back period for the 3 plant.

Table -12 : Cost of product and profitability per annum

		Plant-I	Plant-II	Plant-III
1.	Sales value (Rs. 2400/1000 bricks) Rs. lacs	192	384	768
2.	direct production cost, Rs. lacs (Table-XI)	98	182.4	332.8
3.	Interest & depreciation, Rs. lacs.	40.2	71.6	118.41
4.	Product cost (2+3+4) Rs. lacs.	138.2	254	451.21
5.	Profit before tax (1-4) Rs. lacs	53.8	130	316.79
6.	Return on *I*nvestment %	20.2	28.5	44.32
7.	Pay back period, years,	5.08	3.65	2.4

Plant - I : 80,00,000 Bricks/annum
Plant - II : 1,60,00,000 Bricks/annum
Plant - I : 3,2,00,000 Bricks/annum
No of Working Days : 320/annum

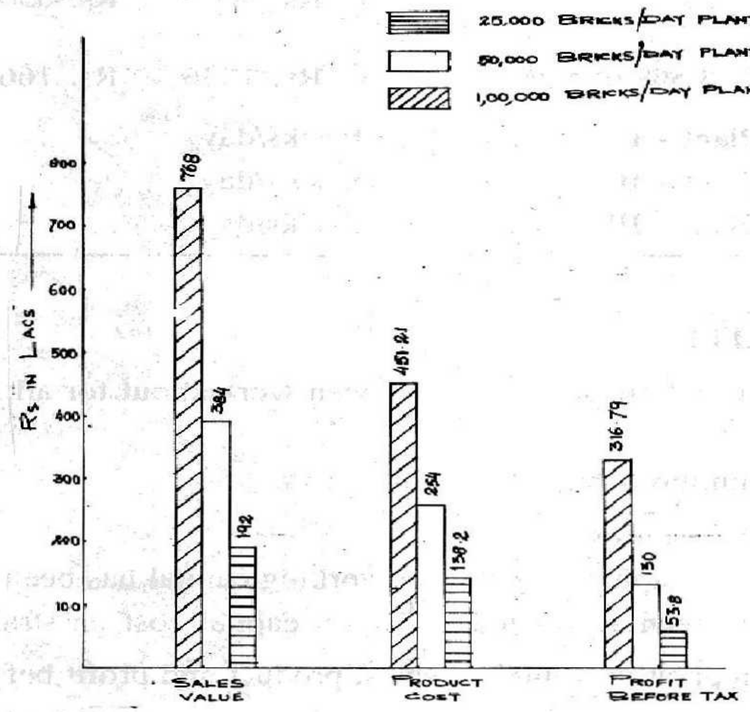

Fig. 5 : Economic study of brick plants

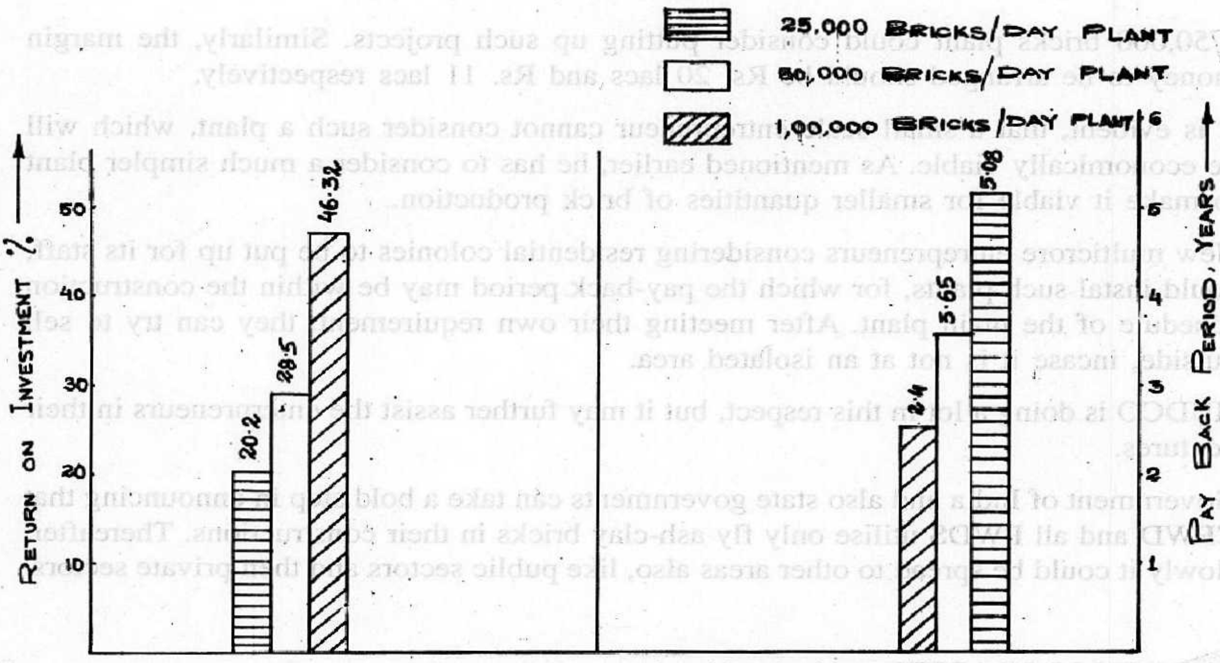

Fig. 6 : Economic study of brick plants

8.0 OBSERVATIONS

From Table 12 the following ovservations can be made.

1. A modern mechanised brick plant utilising fly ash is not economical for a 25,000 bricks per day plant, even if cost of sale of 1000 bricks is kept at Rs. 2400. At many places it is cheaper. However, in and around metropolitan cities, first class bricks are selling at Rs. 3000 per thousand bricks.
2. A 50,000 bricks per day plant can give a profit above 25% whereas 1,00,000 bricks per day plant will be highly profitable. Return on investment will be 44.3% and pay back period $2^1/_2$ years.
3. To make a 25,000 per day brick plant profitable, the capital cost will have to be reduced substaintially. This will bring down the interest burden and depreciation cost. This may be achieved by the following methods.
   a) Manual mixing of clay and fly ash as first stage instead of mechanical mixing.
   b) Partly sun drying, partly natural drying in a shed, using chamber drying, mostly during monsoon.

9.0 DISCUSSION AND CONCLUSION

From the above studies, it is evident, that only larger investors, who can arrange equity to the extent of Rs. 238 lacs for a 1,00,000 bricks per day plant and Rs. 150 lacs for a 50,000 bricks plant could consider putting up such projects. Similarly, the margin money to be arranged should be Rs. 20 lacs and Rs. 11 lacs respectively.

It is evident, that a small scale entrepreneur cannot consider such a plant, which will be economically viable. As mentioned earlier, he has to consider a much simpler plant to make it viable for smaller quantities of brick production.

New multicrore entrepreneurs considering residential colonies to be put up for its staff, could instal such plants, for which the pay-back period may be within the construction schedule of the main plant. After meeting their own requirement, they can try to sell outside, incase it is not at an isolated area.

HUDCO is doing a lot in this respect, but it may further assist the enterpreneurs in their ventures.

Government of India and also state governments can take a bold step in announcing that CPWD and all PWDS utilise only fly ash-clay bricks in their constructions. Thereafter, slowly it could be spread to other areas also, like public sectors and then private sectors.

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