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Incorporation of STP Sludge and Fly ash in Brick Manufacturing: An attempt to save the Environment

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ABSTRACT

Brick is one of the most important masonry unit as a building material due to its properties. Many attempts have been made to incorporate wastes into the production of bricks. In this paper we experimentally describe the recycling of the waste products like STP Sludge and Fly ash by incorporating them into bricks. It is a practical solution for problems like cost expenditure on waste management and its effect on environment. The STP sludge and Fly ash is extremely close to brick clay in chemical composition so, it could be a potential substitute for clay bricks. The sewage treatment process generates a sludge that must be disposed-off in an environmentally sound manner. The sludge generated in most of the treatment systems around the world is discharged into the nearest watercourse. Among all disposal options, the use of sludge in producing constructional elements is considered to be the most economic and environmentally sound option. This paper reviews the recycle of sewage treatment plant sludge and Fly ash against fired clay bricks. Bricks so formed have adequate crushing strength, hardness and water absorption.

Keywords : Incorporation, Brick, Masonry, STP Sludge, Recycling, Fly ash, Environment.

1 INTRODUCTION

For thousands of years, bricks have been made from clay. Brick is one of the most common masonry units as a building material due to its properties. Many attempts have been made to incorporate wastes into the production of bricks, for examples, rubber, limestone dust, wood sawdust, processed waste tea, fly ash, polystyrene and sludge. Recycling such wastes by incorporating them into building materials is a practical solution for pollution problem. This project reviews the recycling of different wastes into fired clay bricks. Most manufactured bricks with different types of waste have shown positive effects on the properties of fired clay bricks.

The history of brick manufacturing goes back 8000 years when the fabrication of the earliest sun dried clay bricks was discovered. Sludge generated at water treatment plants should be treated and handled in an environmentally sound manner. Coagulant sludge is generated by water treatment plants, which use metal salts such as aluminium sulphate (alum) or ferric chloride as a coagulant to remove turbidity. The traditional practice of discharging the sludge directly into a nearby stream is becoming less acceptable because these discharges can violate the allowable stream standards. The discharging of sludge into water body leads to accumulative rise of aluminium concentrations in water, aquatic organisms, and, consequently, in human bodies. Some researchers have linked aluminium's contributory influence to occurrence of Alzheimer's disease, children mental retardation, and the common effects of heavy metals accumulation. It is recognized that the disposal of aluminium-laden solids from water treatment plants will receive a closer scrutiny. The water treatment plant sludge is extremely close to brick clay in chemical composition. So, the sludge could be a potential substitute for brick clay. The water treatment process generates a sludge that must be disposed of in an environmentally sound manner. The sludge generated in most of the treatment systems around the world is discharged into the nearest watercourse. Among all disposal options, the use of sludge in producing constructional elements is considered to be the most economic and environmentally sound option[1]. One of the most common industrial wastes, which contain high silica content, and might be incorporated with sludge in brick manufacturing, is Flyash. So this trend provide an environmentally sound manner to reuse Flyash.

2 BACKGROUND

At this time India is witnessing a new phase in development. with rapid economic growth and high rate of urbanisation. Construction provides the direct means for the development, expansion, improvement and maintenance of human settlements is particular and economic growth in general. Construction activity accounts for more than 50% of the development outlays in India. Building construction costs are increasing at rates which are so per cent over inflation. This is primarily due to the increase in the cost of basic building materials like burnt brick, steel, cement, timber, etc. As a result, the cost of construction using conventional building materials and construction is very high for normal housing. Construction costs is beyond the affordable capacity of the economically Weaker Section and Low Income Group and a large cross section of the Middle Income Groups, whose income levels have not increased commensurately. This has become all the more relevant in the macro context. Due to the large volume of housing to be done in both rural and urban areas and the limited resource of building materials and finance available. According to the projections for the Ninth Five Year Plan, there will be a shortage of 6.6 million houses in urban areas and 12.76 million houses in the rural areas at the end of year 2001, inspite of all the Governmental efforts and resources.

However, it also needs to be recognized that construction is also adversely affect the environment, through physical disruption. The depletion of key renewable resources like fertile top soil, forest cover and excessive consumption of energy. Therefore, there is a strong need to adopt cost-effective, environmentally appropriate technologies by up- gradation of the traditional technologies and also using local materials as well as using appropriate and intermediate technologies using modem construction materials with efficient, effective technology inputs. Building materials is an area where enormous amount of innovation for cost reduction can be achieved. May bricks being the most important area for innovation as the total demand of clay bricks, as an challenged walling material in India, is estimated at 180 billion per annum causing the depletion 540000 metric tonnes of fertile soil[2].

In the above, Sludge and Flyash, basically a waste material, has a clear edge over the other construction material as these can be converted to a resource with minimum amount of investments. Further, it can help to increase the speed and quality of construction and thereby helping in enhancing the efficiency of housing delivery mechanism.

2.1 STP Sludge

Sludge refers to the residual, semi-solid material left from industrial wastewater, or sewage treatment processes. It can also refer to the settled suspension obtained from conventional drinking water treatment, and numerous other industrial processes.

The term is also sometimes used as a generic term for solids separated from suspension in a liquid; this 'soupy' material usually contains significant quantities of 'interstitial' water.

Table 1 :
Major constituents of STP Sludge[1]

Item	$Si0_2$	Fe_20_3	Al_20_3	Ca0	Mg0	Na_20	L.o.I
%	43.12	5.26	15.97	5.56	0.85	0.52	26.79

2.2 Fly ash

Fly ash, also known as flue-ash, is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal.

Table 2 :
Major constituents of Flyash [1]

Item	$Si0_2$	Fe_20_3	Al_20_3	Ca0	Mg0	Na_20	L.o.I
%	27.88-59.4	1.21-29.63	5.23-33.99	0.37-27.68	0.42-8.79	0.20-6.90	0.21-28.37

2.3 Related Works

Several trials have been reported in Taiwan, UK, USA, Egypt, and other parts of the world to use water treatment sludge in various industrial and commercial manufacturing processes. Studies have been carried out on using sludge in brick, artificial aggregate, cement, and ceramic making. Also, some trials have been conducted to use sludge in land application. Due to the similar mineralogical composition of brick clay and water treatment plant sludge, the use of water treatment sludge in brick manufacture has been highly encouraged.Several trials have been reported in this purpose.

In a study that was conducted in the Netherlands, the researchers have manufactured bricks from clay to which water sludge was added (Feenstra, L., et al., 1997). The bricks were assessed in terms of production technique and environmental impact. The results of the study were then taken as a basis for closer evaluation of the feasibility of this option. As a result, the process has now become reality. A research carried out in the UK, investigated the incorporating of two waste materials in brick manufacturing. The study used waterworks sludge and the incinerated sewage sludge ash as partial replacements for traditional brick-making raw materials at a 5% replacement level (Anderson,M., et al., 2003).In another study that was carried out in Taiwan, researchers blended the water treatment sludge with the excavation waste soil to make bricks. The conclusion of the study indicated that 15% was the maximum water treatment sludge addition to achieve first-degree brick quality (Chihpin, H., et al., 2005). In Egypt, similar studies investigated the use of sludge as a complete or partial substitute for clay in brick manufacturing (Hassanain, A.M., 2008; Ramadan, M.O., et al., 2008; Hegazy, B.E., 2007). In this trend, different series of sludge and clay proportioning ratios were tried, which involved the addition of sludge with ratios between 50 and 100 % by weight. Each series was fired at different temperatures between 950 and 1100 ^oC. The physical properties of the produced brick were then determined and evaluated[1].

For other eminent works done in this field see [2], [3], [4], [5], [6] and [7], [8], [9], [10] .

3 EXPERIMENTAL ANALYSIS

Our experimental analysis focuses on different proportions of Sludge and Flyash. Firstly the XRF analysis of Sludge and Flyash is performed in order to know the chemical composition of them. There after brick cubes have been made of different proportions and their testing is conducted.

3.1 Collection of Waste materials

Waste materials i.e Sludge and Flyash has been collected. Sludge was taken from Daulatganj STP , Lucknow and flyash was taken from NTPC, Unchahar, Raibareilly.

3.2 XRF analysis of waste materials

In order to know the chemical composition of Sludge and Flyash, XRF analysis was carried out.The XRF analysis of

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Sludge and Flyash has been done in CSIR Lab, Delhi.

The results of XRF analysis of Flyash are as following:

Table 3 :

XRF analysis of Flyash, Tested in CSIR lab Delhi

Elements	Result %
Sio_2	54.34%
Al_2O_3	24.19%
Fe_2O_3	4.42%
CaO	1.48%
TiO_2	1.36%
K_2O	1.15%
Na_2O	0.72%
MgO	0.64%
P_2O_5	0.59%
SO_3	0.58%
SrO	0.19%
BaO	0.18%
ZrO_2	0.14%
MnO	0.06%
Cr_2O_3	0.02%
ZnO	0.02%
Y_2O_3	0.01%
CuO	0.05%
CO_2O_3	0.10%
PbO	0.00%
GeO_2	0.02%
Nio	0.40%
Rb_2O	0.01%
Other	9.33%

The results of XRF analysis of Sludge are as following:

Table 4 :

XRF analysis of Sludge, Tested in CSIR lab Delhi

Elements	Result%
SiO_2	57.4
Al_2O_3	7.8
CaO	7.4
Mg	3.2
K_2O	1.6
P_2O_3	1.2
Na_2O	0.6
Br	0.3
Zn	0.4
Fe_2O_3	0.7
Others	1
L.O.I	18.4

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3.3 Proportioning of materials:

In order to know the best proportion of sludge and fly ash, we make six different test cubes of bricks of dimension 7x7x7 cm. The different six proportions are as following:

Table 5: Different Sludge and Proportions of Flyash

Trials	SLUDGE %	FLYASH %
T1	20	80
T2	30	70
T3	50	50
T4	80	20
T5	90	10
T6	100	0

3.4 Making of Bricks

Following steps are taken for making of bricks:

Step 1: Crushing of STP Sludge in Los Angeles machine to powder of it.

Step 2: Sieving of sludge from 75 micron sieve to finely divided sludge particles.

Step 3: Mixing the sludge and flyash

Fig 1: Hand Mixing of Constitents

Step 4: Moulding
The paste of sludge and flyash is filled in the brick mould and compacted.

Fig 2 : Moulding

Step 5: Taking out the raw brick from the mould and keep that in sunlight for proper weathering. After weathering , the final appearance of raw brick is below:

Fig 3: Raw Brick

Step 6 : Firing of raw brick in Muffle furnace at 1000^{o}C for 4 hours.

Fig 4: Muffle Furnace

After firing the appearance of final brick is as shown below

Fig 5: Fired Brick

3.5 Testing of Bricks

Following tests are performed on different specimens of bricks:

3.5.1 Water absorption test:

- Note dry weight of brick.
- Immerse in water for 16 hours.
- Weighed again.
- Difference in weight indicate the water absorbed.
- In no case it should not be greater than 20% by dry weight of brick.

Table 6:
Results of Water Absorption Test

Trials	Proportion (Sludge : Fly ash)	Water absorption %
1	20:80	51.3
2	30:70	43.2
3	50:50	32.6
4	80:20	19.4
5	90:10	26.9
6	100:0	34.7

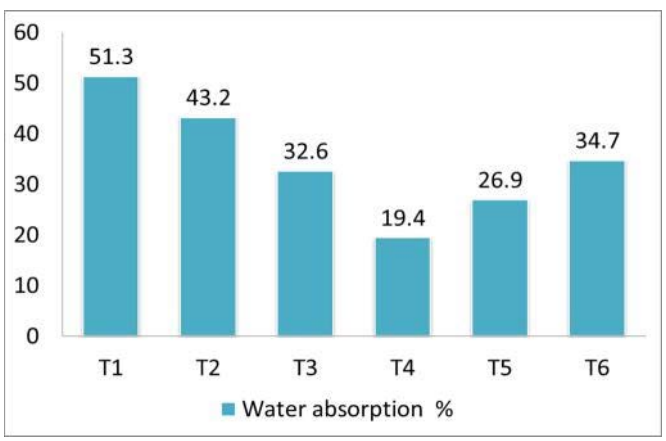

Fig 6: Water absorption Graph

3.5.2 Crushing strength test:

- Test using compression testing machine
- Brick is compressed till it breaks
- Max load at which the brick crush is noted.
- Crushing strength = Maximum load / Area of the bearing face
- Minimum compressive strength of the brick is 3.5N/mm^2

Table 7:
Results of Crushing Strength Test

Trials	Proportion (Sludge : Flyash)	Crushing Strength (N/mm^2)
1	20:80	1.2
2	30:70	1.7
3	50:50	3.8
4	80:20	6.4
5	90:10	5.0
6	100:0	3.1

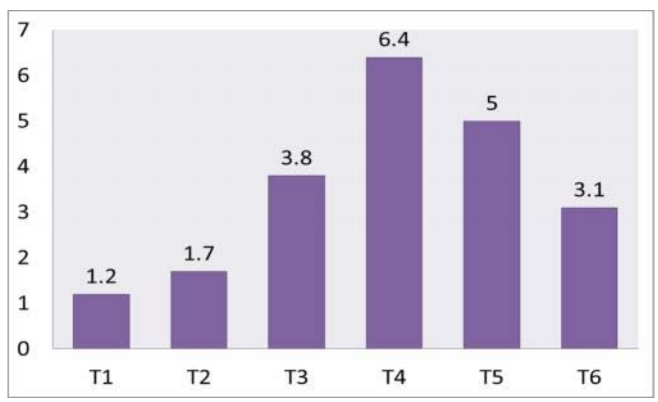

Fig 7: Crushing strength (N/mm^2) Graph

3.5.3 Hardness test:

- Scratch is made on the brick surface with the help of finger nail.
- If no impression on the surface, the brick is sufficiently hard

Table 8:
Results of Hardness Test

Trials	Proportions (Sludge: Fly ash)	Result
1	20:80	×
2	30:70	×
3	50:50	×
4	80:20	✓
5	90:10	✓
6	100:0	×

3.5.4 Soundness test:

- Two brick stuck with each other.
- Brick of good quality should not break and produce the ringing sound.

Table 9 :
Results of Soundness Test

Trials	Proportions (Sludge: Fly ash)	Result
1	20:80	×
2	30:70	×
3	50:50	✓
4	80:20	✓
5	90:10	✓
6	100:0	×

4 COST ESTIMATION

Total Weight of One Brick = 1.8 kg
For % Proportion of SLUDGE : FLYASH = 80 : 20
Weight of Sludge = 1.44 kg, Weight of Flyash = 0.36 kg

- Cost of flyash (including Transportation)
  = Rs 500 / Ton
  = Rs 0.5 / kg
  =0.5*0.36
  =Rs 0.18 per Brick

- Cost of Sludge (Including Transportation)
  = Rs 0 per Brick
  (According to Indian Government Provisions it is mandatory for Authorities of STP to dispose off Sludge free of cost at required places)
- Cost of Labour
  = Rs 300 / 1000 bricks
  = Rs 0.3 per Brick

- Cost of Coal = Rs 8000 per Ton
  = Rs 8 per kg

Amount of Coal = 2 Ton / 100000 bricks
= 0.02 kg / Brick
So , Cost of Coal = 8 *0.02
= Rs 0.16 per Brick

- Total Cost = Cost of (flyash + Sludge+ Labour + Coal)
  = 0.18+0+0.3+0.16
  = Rs 0.64 per Brick
  = Almost under Re 1.00

5. BENEFIT COST RATIO ANALYSIS

Manufacturing cost per Brick = Rs 0.64
Let Selling price per Brick =Re 1
Benefit Cost Ratio = 1/0.64
= 1.5625
> 1
Hence it is very Profitable .

6 . FEASIBILITY ANALYSIS

6.1 Economic Feasibilty

It utilizes waste material such as sludge & flyash whose management leads to expenditure of millions of fund by the Indian government.
Since BCR = 1.5625 >1
Hence Economically Feasible.

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6.2 Environmental Feasibilty

Sludge and Flyash both harm the environment in number of ways. Such as flyash causes pulmonary diseases and sludge causes sewage sickness of land. Since this project utilizes use of both wastes in making of Brick which is non harmful in nature. Hence Environmentally Feasible.

6.3 Technical feasibility

Sludge Bricks can be made just like Clay Bricks i.e no additional technology is required.
Hence Technically Feasible.

7. RESULT AND CONCLUSION

- The most successful composition of Brick is
  Sludge : Flyash = 80:20
- Crushing strength = 6.4 N/mm^2
- Water absorption = 19.4 %
- Successfully passed the hardness and soundness test.
- Manufacturing Cost =Rs 0.64
- BCR = 1.5625

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