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Study of Effective Utilization of WTP Sludge and Fly Ash in Brick Manufacturing

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Abstract – Bricks are one of the most important construction material which are highly durable and used for the purpose of creating partition walls and have been used in the construction industry since thousands of years. The researches carried out in the past have witnessed making changes in the properties of bricks by making use of different foreign materials and to make the brick manufacturing process as sustainable and cost effective as possible. An attempt has been made in the following research to incorporate the use of WTP sludge and fly ash as an alternative material in the brick manufacturing process and observing the different properties of bricks and assessing the suitability of such bricks as per relevant codes of practice. Studies have revealed that the WTP sludge and fly ash have properties resembling to the clay used for manufacturing of traditional clay bricks. The disposal of WTP sludge and fly ash is done in an unscientific manner causing harmful effects on the environment. The utilization of WTP sludge and fly ash in manufacturing of bricks is an environment friendly solution and cost-effective. The combination of WTP sludge, fly ash and clay in manufacturing of bricks has shown promising results conforming to the relevant codes of practice.

Key Words – Brick, Construction, Fly Ash, WTP sludge.

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INTRODUCTION

Brick is a versatile construction material used as structural as well non-structural element in various construction activities such construction of masonry wall, pavement floors, construction of arches and cornices, construction of masonry retaining structures in road constructions, in waterproofing of terrace slabs, washrooms, etc. Earlier the bricks were also used in the construction of load bearing structures in which they acted as the member responsible for taking different types of loads acting on the structures. The history of manufacturing of bricks goes thousands of years back which began with making use of mud or soil or clay which advanced making use of various materials such as rubber, limestone dust, wood sawdust, processed waste tea, fly ash, polystyrene, sludge, etc. As per the reports published by Central Pollution Control Board the sludge generated in waste water treatment plants is generally disposed off in an entirely unscientific and environmentally unfriendly nature by dumping it directly into the nearest water bodies thereby disturbing the characteristics of the water body. While sewage sludge contains nutrients and organic matter that are beneficial for the soil, it also contains contaminants such as heavy metals, organic compounds and pathogens. The evidences have revealed that improper disposal of sludge leads to concentration of heavy metals inside the human as well as in the aquatic organisms. Fly ash is composed of tiny, airborne particles and is thus considered to be a type of particulate matter or particle pollution. It can cause various problems related to health including breathing problems and also some carcinogenic effects. When ash is disposed in landfills or wet ponds there are environmental effects such as leaching, groundwater contamination. It is recognized that the WTP sludge and Fly ash have chemical properties resembling to brick clay and could act as a substitute to it thereby acting as an environmentally sound process.

LITERATURE REVIEW

Sandeep Yadav, Suyash Agnihotri, Shivam Gupta, Rishabh Kumar Tripathi in their research paper **Incorporation of STP Sludge and Fly ash in Brick Manufacturing: An attempt to save the Environment International Journal of Advancements in Research & Technology, Volume 3, Issue 5, May-2014 138 ISSN 2278-7763** found out in their experimental analysis included that the most successful composition of Brick is Sludge: Fly ash 80:20 and the crushing strength to be 6.4 N/mm2. The water absorption was observed to be 19.4% which was conforming to the IS 3495 and it also successfully passed the soundness and hardness test. After carrying out the cost analysis of

the experimentally manufactured bricks it was observed to be Rs.0.64 which was very less in comparison with the standard Ist class bricks and the benefit cost ratio was observed to be 1.5625 which was more than 1 so it was very profitable and feasible to implement the experimentation practically on larger scale.

Hegazy B.E., Fouad H.A. and Hassanain A.M,, (2012), in their research paper **"Brick Manufacturing From Water Treatment Sludge And Rice Husk Ash " Australian journal of basic and applied sciences Vol. 6, No. 3 pp 453-461 (2012)** In their study they investigated the complete substitution of brick clay by WTP sludge with rice husk ash with various ratios. Chemical analysis of WTP sludge, rice husk ash and clay were determined according to ASTM C114-00 by using X-ray fluorescence spectrometer. The results of chemical composition show that WTP sludge and rice husk ash has similar chemical composition as clay. In WTP sludge silica content was slightly less than that of clay on the other hand silica content in rice husk ash was more than clay, Four batching proportion of clay, WTP sludge and rice husk ash were used. In first proportion (control brick) , only clay was used and in other three proportion (series A, B and C) WTP sludge and rise husk ash were taken in varying proportion of 1:3, 1:1 and 3:1 by weight respectively. Each brick series were fired at four different firing temperatures of 900°C, 1000°C, 1100°C and 1200°C. Engineering properties like water absorption, efflorescence and compressive strength were analyzed according to Egyptian standards. Compared to control bricks in which 100% clay was used, all of the sludge-RHA brick types exhibited higher water absorption at lower firing temperature. At firing temperature of 1100°C and 1200°C exhibited water absorption equal to clay brick. The specific gravity of control clay bricks ranged between 1.84 to 1.95 and specifc gravity of sludge-RHA ranged between 0.78 and 1.46. Compressive strength of control clay brick ranged between 58.09 and 69.44 kg/cm2 and of sludge-RHA ranged between 28.78 and 79.96 kg/cm2 with the increase in the firing temperature compressive strength increases ensures the completion of the crystallization process. At the same firing temperature sludge-RHA achieved higher compressive strength than that of controlled clay bricks.

Shrikant S Jahagirdar, S. Shrihari, B Manu 1 NITK, Surathkal, India "Utilization of Textile Mill Sludge in Burnt Clay Bricks" International Journal of Environmental Protection May. 2013, Vol. 3 Iss. 5, PP. 6-1 in their investigation of the effect of Textile mill sludge addition in burnt clay bricks is done under this study. Chemical composition of sludge and soil samples was analyzed by ICP-AES, SEM and XRF facilities. Sludge percentage is varied from zero to thirty-five percent by weight. Firing temperature and firing period are varied to understand the variations in characteristics of burnt bricks. Parameters such as compressive strength, density, water absorption, efflorescence and ringing sound are studied as per BIS (Bureau of Indian Standards) procedures. Density of bricks, compressive strength and ringing sound reduces as sludge content in bricks increases whereas water absorption and efflorescence increases. Higher firing temperature and firing period i.e. 8000C and 24 hours give good results in terms of compressive strength with same percentage of sludge as compared to other temperature and firing period combinations. Textile mill sludge up to 15% can be added so as to get compressive strength greater than 3.5 N/mm^2. The study demonstrates that textile mill sludge can be used as partial replacement for clays in burnt clay bricks. Textile mill sludge can be used up to 15% without compromising on the compressive strength of 3.5 N/mm2 and water absorption of 20% as per the IS code requirements. Organic matter present in the sludge gets burnt at temperature more than 5500C, because of which large number of voids are created in the body of the bricks. This makes bricks porous resulting in lesser compressive strength and greater water absorption capacity. TG-DTA analysis shows there is decrease in weight of sludge with increase in temperature because of burning of organic matter present in the sludge. Due to which large number of voids are created in the body of the bri

Jagadish KS,Venkatarama Reddy, Nanjunda Rao, (2013), "Altematjve Budding Materials & Technologies", New Age International Pvt. Ltd, Inc., 2013 found out thatt embodied energy of Building materials is presented. The energy intensity is calculated as per the data collected from manufactures in and around Bangalore City. Building materials include natural material, processed materials and Building elements. Embodied energy for alternative building materials and building elements is also presented. This results in porous brick structure and lesser compressive strength and increased water absorption

OBJECTIVES

[1] To prepare environment friendly and cost effective alternative to traditional bricks.

[2] To arrive at ideal or optimal mix of Clay, WTP sludge and Fly Ash for manufacturing of burnt clay bricks.

[3] To evaluate engineering properties of bricks as per IS: 3495 produced using Clay, WTP sludge and Fly Ash.

[4] To evaluate the cost required in manufacturing of the Clay, WTP sludge and Fly Ash bricks.

METHODOLOGY

The experimental process involved analysis of various engineering properties of conventional bricks and understanding the process of testing of bricks.

After the detailed study of various engineering properties the materials required for manufacturing of bricks such as clay, WTP sludge and fly ash was completed. The clay was collected from nearby fields satisfying the requirements of clay required for manufacturing burnt clay bricks. The WTP sludge was collected from waste water treatment plant located at Satara and fly ash was collected from nearby industry. The size of the bricks used for manufacturing was 190mmX 90mmX90mm (conventional size of bricks).The proportioning of materials was done as shown in Table no.1. The proportioning was done by keeping the percentage of fly ash as constant and varying the proportions of clay and WTP sludge. After the proportioning of various materials manufacturing of bricks was done following all the processes at a nearby brick manufacturing plants as per IS 1077-1992. After the manufacturing of bricks the tests conducted on fly ash bricks were compressive strength, water absorption, efflorescence and size and shape. The representation of all the engineering properties required for classification of first class bricks was done and results were interpreted in tabular as well as graphical format. The cost analysis was conducted for all the proportions taking into consideration various factors affecting the entire process of manufacturing.

Table 1 : Proportions of the mix for the modified bricks

Sr. No.	Sludge (%)	Fly Ash (%)	Clay (%)
1	10	10	80
2	20	10	70
3	30	10	60
4	40	10	50
5	50	10	40
6	60	10	30
7	70	10	20
8	80	10	10
9	90	10	00

TESTS AND RESULTS

1. ***Compressive Strength Test:*** The test is conducted using compressive strength testing machine until the sample breaks. The compressive strength is given by formula,

$$\text{Compressive Strength} = \frac{\text{Maximum Load}}{\text{Surface Area}}$$

2. ***Water Absorption Test:*** Water absorption is one of important characteristics in masonry. If the water absorption of a brick is high, then the brick will absorb water from the mortar upon stacking. This stack will reduce the hydration of the mortar and the bonding between the brick and mortar will be weak. The water absorption test was conducted by first weighing the bricks and immersing them for 24 hours in water and weighing them again. Following are the results of water absorption test

3. ***Efflorescence***: The ends of the brick are kept in a 150 mm diameter porcelain or glass dish containing 25 mm depth of water at room temperature (20 o -30 o C) till the entire water is absorbed or evaporated. The water is again filled to 25 mm depth in the dish and allowed to be absorbed by the brick or evaporated.

Table No. 2: Results of Engineering Properties of Modified Bricks

Sr. No.	Proportion	Compressive Strength (N/mm²)	Water Absorption (%)	Efflorescence
1	10:10:80	4.3	15.22	Nil
2	20:10:70	3.7	14.33	Nil
3	30:10:60	3.4	15.96	Nil
4	40:10:50	3.6	18.67	Nil
5	50:10:40	2.4	20.88	Nil
6	60:10:30	2.3	22.12	Nil
7	70:10:20	1.1	22.36	Nil
8	80:10:10	0.9	24.66	Nil
9	90:10:00	0.8	23.52	Nil

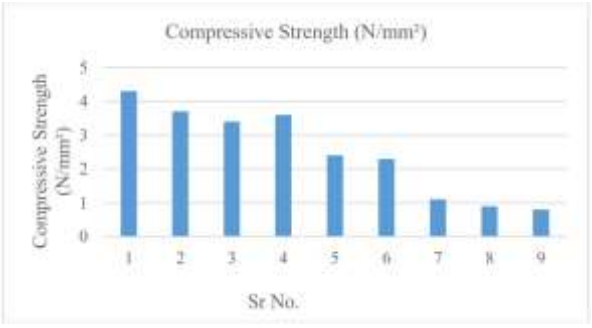

Fig 1: Graphical Representation of Compressive Strength of Modified Bricks

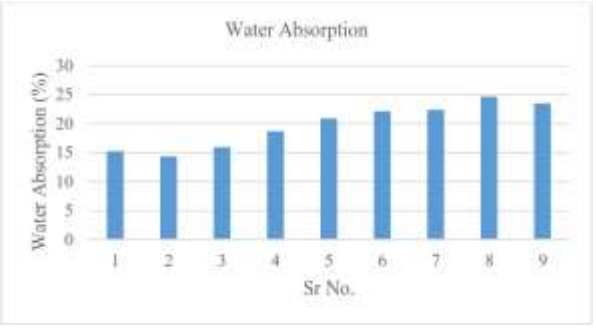

Fig 2: Graphical representation of Water Absorption of Modified Bricks

1. Economic Analysis:

A. Quantity of Materials required for 40:10:50 Proportion and labours required:

i. Quantity of Clay: 300 gm

ii. Quantity of WTP Sludge: 240gm

iii. Quantity of Fly Ash: 60gm

iv. Quantity of Coal: 50gm

v. Quantity of baggase: 10gm

vi. Number of labours required: 4

B. Cost of Materials and labours:

i. Cost of Clay: Rs.5/kg = 5*0.3 = Rs 1.5

ii. Cost of WTP Sludge: Nil

iii. Cost of Fly Ash: Rs.1.4/kg = 1.4*0.06 = Rs.0.084

iv. Cost of Coal: Rs.4/kg = 4*0.05 = Rs.0.2

v. Cost of Baggase: Rs 5/kg = 5*0.01 = Rs.0.05

vi. Labour Charges: Rs.300/500 Bricks = 0.6*4 = Rs.2.4

vii. Equipment Charges: Rs.500/500 Bricks = Rs.1

Total Cost Required = Rs.5.234= Rs.5.5/Brick.

CONCLUSION

1. It is observed that when the proportion of sludge and fly ash increases the compressive strength decreases and water absorption increases.

2. The bricks manufactured with 40% WTP sludge, 10% fly ash and 50% clay gives strength of 3.6N/mm² and water absorption of 18.67% which is satisfying the requirements of IS:1077:1992.

3. The cost of the bricks thus manufactured with 40% WTP sludge, 10% fly ash and 50% clay is Rs.5.5/brick which is less than conventional bricks.

FUTURE SCOPE OF STUDY

The percentage of Fly Ash in the manufacturing can be increased or decreased in the manufacturing of modified bricks and the changes in the properties of bricks thus manufactured can be observed.

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