UTILIZATION OF WTP SLUDGE & TEA WASTE IN BRICK MANUFACTURING

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ABSTRACT

The objective of this study is to investigate the effect of processed waste tea (PWT) and water treatment plant (WTP) sludge addition on the physical, mechanical and thermal properties of the burnt clay bricks. PWT and WTP sludge has been added to raw brick clay in the ratio of 5% by mass. Bricks have been manufactured through hand molding and burnt in kilns at a temperature of 990^{o}C. The samples were tested as per standard methods given in Indian standard codes. The compressive strength of the brick sample consisting of WTP sludge increased significantly while the compressive strength of brick samples consisting PWT decreased slightly. However, thermal insulation of PWT bricks depicted an increment when compared to the controlled bricks. As a result, WTP sludge and PWT both can be utilized for substituting clay brick by taking advantage of increased strength, increased thermal insulation, low cost and environmental benefit.

Keywords: Clay Bricks, Processed Tea Waste, Sludge, Thermal Conductivity

1. INTRODUCTION

The construction industry is a backbone to any nation. In India it is witnessing a strong growth due to huge infrastructure development. As the construction progresses rapidly, the demand of good quality construction and building materials also increases. Brick is a popular building material all over the world because of its highly economical cost, superior finish as well as high compressive strength and durability. With the onset of the industrial revolution and infrastructure development, bricks gained importance due to its fire and weather resistance as well as its property of sound insulation. Demand for bricks is ever increasing which is resulting in an escalation of cost, particularly across the Indian subcontinent. Along with an increase in the cost, brick manufacturing is also causing depletion of the top fertile clay layer in and around the kiln (a tall exhaust chimney) which is used to manufacture bricks. These problems of cost escalation and depletion of the fertile top soil layer can be tackled by substituting the primary components of common bricks with ordinarily available waste material. It will result in resource saving and also solves the disposal problem of the waste materials. Two such potential waste materials facing disposal problem and are present in bulk quantity are processed tea waste (PWT) and water treatment plant (WTP) sludge. The disposal of these materials is a matter of concern and is a burden to the growing economy.

Water treatment plants all over the world treat raw water by implementing varied techniques prevalent in that region. The plants help treat raw water to potable water with the help of various treatment chemicals. Water treatment plants produce large quantities of by-products commonly known as sludge as a result of treatment processes of raw water such as coagulation, flocculation and filtration. The problem of sludge disposal is a grave problem owing to environmental concerns, limited resources and few landfills. By replacing primary components of mud bricks with WTP sludge, we can not only solve the problem of disposal of sludge, but can also take advantage of favorable properties while minimizing the manufacturing cost at the same time.

Few studies have been performed on utilizing WTP sludge in brick making. The excavated soil, mainly clay is mixed with sludge to improve the brick properties. Five different mixing ratios of sludge at 0, 5, 10, 15 and 20 per cent of the total weight of sludge-clay mixtures were studied.The result also showed that increasing the sludge content improved workability and physical appearance (color) of sludge –clay burnt bricks (Victoria, 2013). Hence, we can use up to 15% of the WTP sludge in manufacturing of bricks. The amount of sludge can be increased above 15% but the energy consumption in firing of bricks will increases due to presence of high amount of alumina and low silica in WTP sludge (Huang et al, 2005).

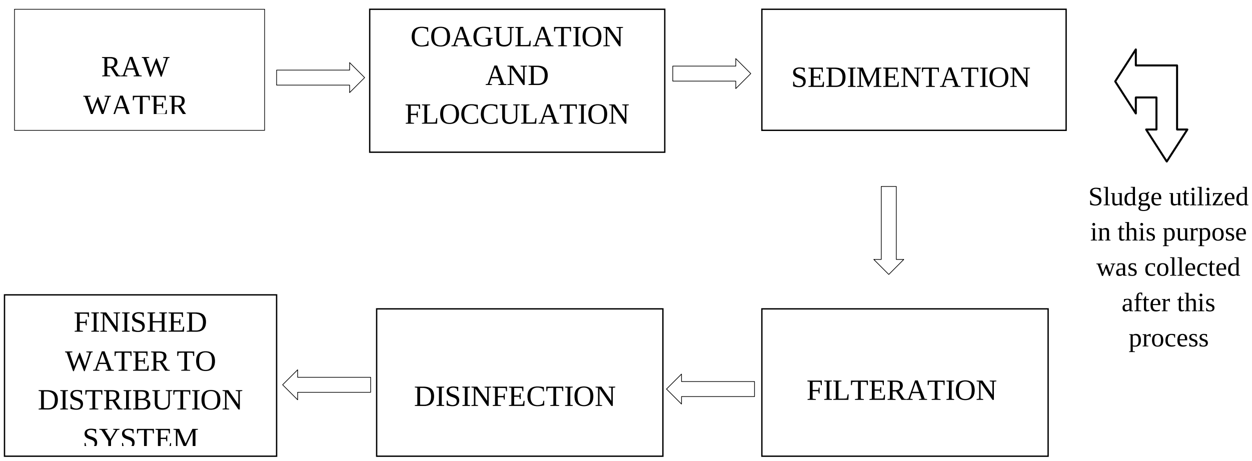
Tea is a beverage, known for its medicinal properties, which is being consumed worldwide for centuries. Tea consists of alkaloids, tannins, catechin and polyphenols which are revealed on phyto-chemical screening of tea (Archana et al., 2011). In India, yearly production of tea is approximately 857,000 tones which is 27.4% of total world production (Wasewar, 2010). The waste which is produced after the preparation of tea is termed as processed tea waste (PTW) or tea dust which is organic in nature. In order to enhance the properties of bricks PTW can be added to raw material. Addition of PTW will increase the porosity of bricks which ultimately enhances the thermal insulation property of the burnt bricks (Demir, 2006).

Hence the purpose of the present work is to replace the depleting clay with household tea waste and WTP sludge in brick manufacturing. Experiments have been performed to study the effect of 5% clay replacement with PWT and WTP respectively.

II MATERIALS

2.1 WTP Sludge

Raw water to be treated is initially passed through screens, which are kept inclined at about 45’-60’, in order to remove the big visible objects such as trees, dead animals etc. Then this water is allowed to pass through coagulation and flocculation tanks where colloidal matter and suspended solids are removed. In order to remove the colloidal matter and very fine suspended mud particles, coagulants (alum in this case) has been added and thoroughly mixed to form a gelatinous precipitate termed as floc which are large enough to get settled under the effect of gravity. This process is known as coagulation and flocculation. The flocculated water is then passed through sedimentation tank where these flocs are allowed to settle and the resulted by-product which is obtained from the base of tank is termed as sludge. The water from outlet of sedimentation tank is allowed to pass through rapid sand filter and chlorine is added to the water obtained from filtration and then this water is distributed in the city through distribution system. The clay utilized in the bricks has been replaced with tea waste by up to 5% of total clay weight i.e. 150 grams (WTPS5)



2.2 Tea Waste

The tea dust which is obtained after preparation of household tea is organic in nature and is termed as tea waste. The tea dust was collected from the cafeteria situated at ITM University Gurgaon, Haryana. The clay utilized in the bricks has been replaced with tea waste by up to 5% of total clay weight i.e. 150 grams (PTW5)

III METHODS

3.1 Compatibility Test

A good material (earth) for making bricks should have a liquid limit between 25 to 38%, plastic limit between 7 to 13% and a shrinkage limit between 15 to 25%. In order to ensure the suitability of brick earth two field tests are performed. In the first field test, the soil to be tested is transformed into the plastic mass by adding sufficient amount of water to it. Then balls of about 80mm diameter are formed from this plastic mass through hand moulding which are then left for sun drying. The dried balls are then pressed between fingers and if they crumble easily then it shows excessive sand content in the earth. Any surface cracks on drying indicate deficiency of sand content. In case of the second field test, the plastic mass prepared in first field test is transformed into threads of 3mm diameter through rolling and then allowed to dry under the sun for four days. Any surface cracks on the dried threads will indicate excessive shrinkage limit (Gurucharan, 2005).

3.2 Manufacturing of bricks

First of all the raw material (soil) was collected and spread on a levelled surface after sprinkling sand on it. The waste material (WTP sludge or PTW) was then mixed with the raw material (5% of total weight). Water was then added to the mixture in an appropriate amount so that the mixture would be workable and bricks after burning process would gain sufficient strength. Moulding of this mixture was then done with the help of wooden moulds (22.4*11.6*7.5 cm in dimension). Sand was sprinkled on every face of the mould and the mixture was then pressed and put into the mould through the hands. The mixture was then pressed by frog ,attached to a wooden plate, from open face of the mould. These moulded bricks were allowed to get sun dried in drying sheds for 3 to 5 days, so that bricks could get some strength and these dried bricks could easily undergo the burning process. In the burning process, dried bricks were burnt in the kilns at a temperature of 990'C for 2 to 4 days. Kilns are rectangular burning chambers were the temperature was raised up to 990'C with the help of thermal energy. Burnt bricks were then allowed to get cooled for 3 to 4 days. After a cooling period, burnt bricks could be tested and checked against Indian standards and according to the results obtained these bricks would be used for various construction purposes.

3.3 Testing of bricks

The compressive strength of the bricks were determined(IS 3495:1992, Part I) with the help of universal testing machine (UTM). The sample of brick to be tested was prepared by filling the frog and the voids with cement mortar and placing these bricks in a wet jute bag for 24 hours. After 24 hours, sample bricks were kept immersed in water for 3 days. These bricks were then tested using UTM keeping the face having mortar filled frog in the upward direction. Burnt bricks were also tested for water absorption capacity (IS 3495:1992, Part-II). In this test, burnt bricks were first weighed on a balance and then kept immersed in water for 24 hours. After 24 hours, bricks were weighed again on the same balance and by using the formula (IS 3495:1992, Part II) the percentage water absorption was calculated. Burnt bricks were also tested for efflorescence and warpage (IS 3495:1992, Part III-IV). Field tests were also conducted on the burnt bricks in which the first test was done by striking two burnt bricks with each other and examining the sound created by their strike. Second field test was conducted to determine hardness of bricks by scratching bricks by finger nail. The third field test was to drop the burnt brick from 1 meter height on a leveled ground surface. Thermal insulation of the burnt bricks was also tested with the help of simulated Lee's- Disk apparatus. Three samples of burnt bricks were tested in each case and the mean result of three bricks was reported (IS SP: 41, 1987 Part I-IV)

IV RESULTS AND DISCUSSIONS

4.1 Compatibility tests of WTP Sludge and Processed Tea Waste

Table 1 shows the characteristics of physical compatibility tests of WTP Sludge mixture and Processed Tea Waste (PTW) mixture respectively. The field tests performed exhibited satisfactory results which lead us to manufacture bricks of a fixed proportion (5% waste, 95% Clay).

S.No	Property	WTP Sludge	PTW
1	Homogeneity	Satisfactory	Satisfactory
2	Field Test Procedure		
2.1	• Balls of 80 mm diameter	Satisfactory	Satisfactory
2.2	• Threads of 3 mm diameter	Satisfactory	Satisfactory

Table I- Physical Compatibility Tests

Plate I and II show wet WTP Sludge and PTW and plate III and IV show dry & crushed WTP Sludge and PTW.

4.2 Physical attributes of manufactured bricks

Table II shows the mean physical characteristics of WS5 and TW5 bricks. The mean weight of brick samples ranged from 2743 grams to 2945 grams with the TW5 brick being the lightest.

Plate I- WTP Sludge

Plate II-Wet PTW

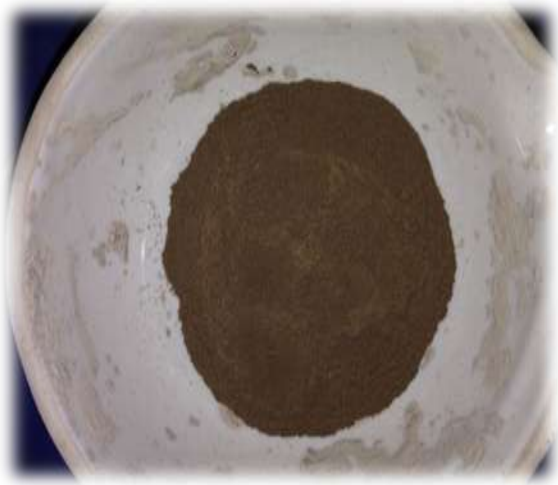


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Plate III- Crushed WTP Sludge **Plate IV- Crushed PTW**

S.No	Character	WS5	PTW5
1.	Length (mm)	217.00	218.50
2.	Width (mm)	108.00	107.50
3.	Height (mm)	76.00	76.60
4.	Weight (g)	2945.00	2743.00

Table II- Physical Attributes

4.3 Mechanical attributes of bricks

Table III shows the mean compressive strength of WS5, TW5 and controlled bricks. Compressive strength determines the applicability potentials of the bricks, which is affected by the composition, moisture content and type of crystallization. Table III also depicts mean water absorption of brick samples. Water absorption is a key factor that affects the durability of bricks, thus lesser the water infiltrating into the brick, the more durable is the brick. The results of water absorption test ranged between 13.84 and 19.25 percent. The efflorescence test was performed in accordance with (IS 3495 Part III). The efflorescence test results mentioned in Table III showed that efflorescence was of “Nil” class for all of the clay brick types, which comply with the requirements of the (IS 3495 Part III). This result could be considered as an indicator for the very low values of soluble salts content of the brick. All the three categories of brick further satisfied the warpage (IS 3495 Part IV). The bricks also exhibited satisfactory results for the field tests of soundness, hardness and drop. Plates V and VI depict the compressive strength test and drop test being performed.

S.No	Property	WTPS5	PTW5	Controlled Bricks	Permissible Range
1.	Compressive Strength (N/mm^2)	14.47	04.68	10.28	10-15 (Class AA) 3-7 (Class B)
2.	Water Absorption	13.84%	19.52%	17.21%	<20%
3.	Efflorescence	Nil	Nil	Nil	Slight
4.	Warpage	Negligible	Negligible	Negligible	-
5.	Soundness	Satisfactory	Satisfactory	Satisfactory	-
6.	Hardness	Satisfactory	Satisfactory	Satisfactory	-
7.	Drop Test	Satisfactory	Satisfactory	Satisfactory	-

Table III- Mechanical Attributes

Plate V- Compressive Strength Test **Plate VI- Drop Test**

4.4 Thermal conductivity of bricks

Table IV depicts the mean results for the thermal conductivity test performed on the brick samples. The results of thermal conductivity test ranged from 0.11 for PTW to 0.15 W/mK for controlled bricks. The thermal conductivity for PTW5 came out to be the lowest among the lot.

S.No	Property	WS5	PTW5	Controlled Bricks
1.	Thermal Conductivity (W/mK)	0.132	0.11	0.15

Table I- Thermal Conductivity

V CONCLUSIONS

The present study reveals that both the wastes (WTP sludge and PTW) can be used as a substitute of raw material used for brick manufacturing. Based on the result analysis following conclusions can be made:

1) The addition of WTP sludge (5 % by weight) will increase the compressive strength of bricks.

2) The addition of PTW (5% by weight) will increase the thermal insulation property of the bricks, but will increase the water absorption capacity of the bricks.

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