ISSN 2229-5518

Novel Green Bricks manufactured from Textile ETP Sludge

Ravikrishnan.S[1], Dr.S.SenthilSelvan[2]

Abstract— Textile industry being second largest sector in India after sugar industry is facing problems regarding sludge disposal. *Tiruppur* and *Erode* districts in *Tamilnadu* were the top contributors in the textile industries in India for the past three decades. Common method adopted for disposing the sludge is land filling and polluting in the river beds. The disposal of sludge has become a major issue. So there is a strong demand for environmentally safe reuse of sludge and effective disposal methods for textile effluent sludge. The textile effluent water treatment plant sludge taken from *Pallipalayam* area in *Erode* and from some areas in *Tiruppur* is extremely close to brick clay in chemical composition. So, the Effluent Treatment Plant (ETP) sludge could be a partial replacement for brick clay. Use of sludge as construction and building material converts the waste into useful products that can alleviate the disposal problems. In this study an investigation to incorporate the sewage sludge waste in the manufacture of *unburnt* bricks is carried out. The soil is partially replaced with sludge percentage which is varied from zero to twenty-five percent by weight and the bricks are *compressed* at high pressure and manufactured. Firing is not done in the manufacture of bricks. In this research work, an experimental study on the strength characteristics of GREEN bricks is done and it is compared with the conventional bricks.

Index Terms— *Compression, Conventional, Effluent water treatment plant sludge, Green bricks, Sludge waste, Unburnt brick.*

1 Introduction

Textile industry being second largest sector in India after sugar industry has problems regarding sludge disposal. As per the records in Tamil Nadu State Pollution Control Board (TNPCB), there are more than 1030 large units engaged in textile industrial processes in Tirupur and Erode alone. These industries have established eight Common Effluent Treatment Plants (CETPs) and several individual Effluent Treatment Plants, which are subjected to treat about 75,000 m^3 of effluent wastes per day generated by textile industries. These effluents are coloured, alkaline, high in suspended solids and temperature and contains BOD, COD, Nitrogen, Phosphate, Toxic chemicals, oil and grease etc. In Tiruppur region, the treated effluents from the textile processing industries are discharged into natural river streams, particularly into the Noyyal River. Hence, entire Tiruppur environment was found to be polluted by means of water, land and air due to the industrial process of the textile industries. Due to the disposal of ETP sludge in the non engineered landfills, the ground water level and soil in Tiruppur and Erode district were polluted. So, disposal of sludge in Tiruppur region is a major problem existing today. The surface water in those areas was also found to be much affected. The drinking water for Tiruppur region is pumped from river Cauvery, which is flowing through Erode district.

Several researches and studies have shown that sludge or sludge ash could blend with clay to produce brick or other building materials. K. Y. Chiang, et.al (2000) found that light-weight bricks have been produced by sintering mixes of dried water treatment plant sludge and agricultural waste. Samples containing up 40 percent by weight of rice husk have been sintered using a heating schedule that allowed effective organic burn-out. Deng-Fong Lin, et.al (2001) investigated on the brick manufactured from incinerated sewage sludge ash and clay. The appropriate percentage of ash content for producing quality bricks was in the range of 20 to 40% by weight with a 13 to 15% optimum moisture content prepared in the moulded mixture burning at 1,000°C for 6 hours. The 10% ash content, ash clay bricks exhibited higher compressive strength than normal clay bricks. This study showed that the pulverized sludge ash could be used as brick material. The bonding strength can be further enhanced by controlling operating conditions. Anyakora Nkolika Victoria (2012) investigated on the sludge collected from Lower Usuma Dam Water Treatment Plant (LUDWTP), Abuja, Nigeria was investigated for use as brick material. The reuse of sludge as brick material is a long-term approach to sludge disposal for economic and environmental sustainability. 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. Badr El-Din E. Hegazy, et.al (2012) investigated the complete substitution of brick clay by water treatment sludge incorporated with rice husk ash (RHA). In this study, three different series of sludge to rice husk ash (RHA) proportions were studied, which exclusively involved the addition of sludge with ratios of 25, 50, and 75% of the total weight of sludge-RHA mixture. Each brick series was fired at 900°C, 1000°C, 1100°C, and 1200°C. The produced bricks properties were obviously superior to the clay control-brick and to those available in the Egyptian market. Shrikant S Jahagirdar, et.al (2013) investigated the effect of textile mill sludge addition in burnt clay bricks. Sludge percentage is varied from zero to thirty-five percent by weight. The burning

- *Ravikrishnan.S is currently pursuing M.Tech degree program in Structural Engineering in SRM University, Kattankulathur - 603203, Kancheepuram, Tamilnadu, India, E-mail: ravee07@gmail.com*
- *Dr.S.SenthilSelvan is a Professor in the Department of Civil Engineering, SRM University, Kattankulathur - 603203, Tamilnadu, India. E-mail: ssenthils@gmail.com*

ISSN 2229-5518

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. Higher firing temperature and firing period gives 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.

2 Materials and Methods

2.1 Clay

Clay is defined as a stiff, sticky fine-grained earth that can be moulded when wet, and is dried and baked to make bricks, pottery, and ceramics. For this research work, clay is procured from places near Chengalpattu and Maraimalai Nagar areas in Kancheepuram district. The collected soil samples are dried and then used for the manufacturing process.

2.2 ETP Sludge

Sludge refers to the residual, semi-solid material left from industrial wastewater, sewage treatment processes. From the Textile industries in Tiruppur and Erode alone about 200 tons/day of textile sludge are generated. The textile ETP sludge used in the present investigation was taken from CETP, Tiruppur. The wet sludge was collected from the CETP and then dried. The dried sludge was then sieved for removal of dusts. It is then pulverized to powdered form using soil pulverizer as depicted in fig. 1.2 and used for mixing with the soil sample.

The Textile Effluent Treatment Plant (ETP) sludge as shown in fig. 1 has a high calcium and magnesium content, which comes mainly from coagulating chemicals (magnesium salt and lime) used in ETP.

Fig. 1 Collected ETP sludge

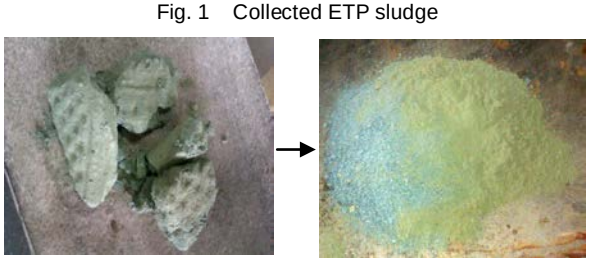


Fig. 2 ETP Sludge before and after pulverization

2.3 Lime

Lime has been used as a primary ingredient in masonry mortars for centuries, and this important use continues to the present day in both historic and contemporary applications. The lime reacts with silica and provides high dimensional stability for bricks. The lime is purchased from Super chemicals in Park town, Chennai. Calcium Hydroxide traditionally called as hydrated lime. It is a free flowing fine powder available in different grades. It has varied uses in many industries.

3 Basic Material Testing

3.1 General

Basic material testing is carried out using the instruments and equipments in the Soil Mechanics Laboratory, Department of Civil Engineering, SRM University. The equipments and instruments are used to understand the practical behavior of the materials evaluating the physical properties, mechanical properties, suitability of material for use in construction, material selection and codal provisions, etc.

3.2 Properties of specimens

The test results for clay and sludge are tabulate below in table 1

TABLE 1
Physical Properties Of Clay and Sludge

SL.NO	TEST	SLUDGE	SOIL
1)	Liquid Limit	36 %	29.15 %
2)	Plastic Limit	Non-plastic	22.22 %
3)	Plasticity Index	-	Medium Plasticity
4)	Shrinkage limit	8.77 %	14.32 %
5)	Proctor Compaction Test • O.M.C • Dry density	 35.6% 0.947 g/cm^3	 19 % 1.796 g/cm^3

3.3 Preliminary test

A total of 108 Trial Specimens of Sizes 50 cm x 50 cm were prepared with the following mix proportions.Lime is used with mix proportions of 0, 2, 4, 6, 8, 10 % and ETP Sludge is used with the increment of 5% for the mix proportions.

TABLE 2
Mix Proportions For Intital Test Specimens

SYMBOL	SOIL (%)	ETP WASTE (%)	LIME (%)
M1	90	0	10
M2	85	5	10
M3	80	10	10
M4	75	15	10
M5	70	20	10
M6	65	25	10

The initial test specimens of size 50mm x 50mm were prepared. The Trial cubes with the mix proportion were casted as shown in fig. 2. It is observed that the maximum percentage of sludge addition to the soil was found to be less than 25% since

ISSN 2229-5518

the compressive strength gets reduced upon addition of 10 % of Industrial waste. Since the industrial waste is not adhesive to soil we come to the use of lime for effective bonding between them and a constant amount of 10% is added to the mixes as shown in table 2.

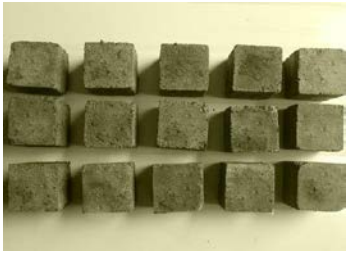


Fig. 2 Casted cube specimens

TABLE 3
RESULTS OF INITIAL TEST SPECIMENS

SYMBOL	AVERAGE LOAD TAKEN BY 3 SPECIMENS (kN)	AVERAGE COMPRESSIVE STRENGTH AT THE END OF 28 DAYS (N/mm²)
M1	9.67	3.86
M2	11.33	4.53
M3	**12.67**	**5.06**
M4	10.33	4.13
M5	10	4
M6	9.33	3.73

The cube specimens prepared were tested to find their compressive strength by using the compression testing machine and the results from the table 3 indicate that the M3 mix shows higher compressive strength of 5.06 N/mm² compared to all the other mixes.

3.4 Objective, Scope and Work methodology

a) *Objective:* To manufacture un burnt bricks using clay, ETP sludge and lime and to study the strength characteristics of partial replacement of clay using ETP sludge for manufacturing of bricks.

b) *Scope:* To introduce the sludge ash waste as a replacement material with clay in manufacture of bricks and to obtain un burnt bricks with equivalent or higher characteristics of conventional bricks by partial replacement by sludge waste.

c) *Methodology:*
- In this research work, a total of 125 number of unburnt compressed bricks as shown in fig. 3 of size 22.5 x 10.5 x 7 cm with the mix proportions of clay soil, sludge, lime, are manufactured and the study of physical and mechanical properties of GREEN bricks are being carried out.
- It is observed that the maximum percentage of sludge addition to the soil was found to be less than 25%.
- Tests for the GREEN bricks are done.
- The mix proportion of soil, ETP waste, lime adopted for casting of bricks is shown in table 4.

TABLE 4
FINAL MIX PROPORTION

SYMBOL	SOIL (%)	ETP.W (%)	LIME (%)
M1	90	0	10
M2	85	5	10
M3	80	10	10
M4	75	15	10
M5	70	20	10
M6	65	25	10

Fig. 3 Casted bricks

4 TECHNICAL TESTING

4.1 Laboratory Tests

The following laboratory tests were conducted on bricks
- Visual Tests
- Compressive strength Test
- Water absorption Test
- Efflorescence Test

4.2 Visual tests

It is observed that all the test results as shown in table 5 have been passed by GREEN bricks.

TABLE 5
VISUAL TEST RESULTS

Sl.No	TESTS	Y/N
1)	The bricks should be well finished, smooth and are free from cracks.	Yes
2)	They should posses sharp and square edges.	Yes
3)	They are of uniform color, shape and size as per standard.	Yes
4)	When the bricks are struck with each other, they should produce clear ringing sound.	Yes
5)	Fracture of good bricks showed uniform and bright compact structure without any voids.	Yes
6)	Bricks should not be broken down when dropped from 1m height.	Yes
7)	The water absorption should not be more than 20 % when immersed in water for 24 hours.	Yes

ISSN 2229-5518

4.3 Compressive Strength Test

The block specimens are measured for its weight and dimensions. The specimens are placed in compression testing machine as shown in fig. 4 with 8 mm plywood plate bottom of it to get uniform load on the specimen. Then load is applied axially at a uniform rate. The crushing load is noted. Then the compressive strength is the ratio of compressive load to the area of brick loaded.

TABLE 6
COMPRESSIVE STRENGTH TEST RESULTS

SYMBOL	7 DAY COMPRESSIVE STRENGTH N/mm²	14 DAY COMPRESSIVE STRENGTH N/mm²	28DAY COMPRESSIVE STRENGTH N/mm²
M1	4.33	4.23	4.37
M2	2.16	3.08	4.68
M3	**2.31**	**3.22**	**5.27**
M4	1.45	2.92	4.41
M5	1.38	2.82	4.26
M6	1.33	2.68	3.91

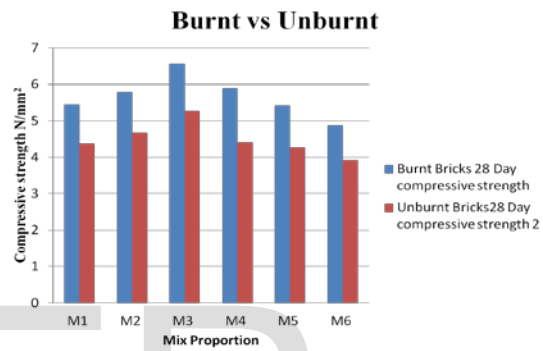
The 7 day, 14 day and 28 day strengths for the various mix proportions were found out and Average of three specimens is taken for each mix and the mean compressive strength for 7,14, and 28 days is mentioned in table 6.

Fig. 4 Compression Test

From the table 7 and chart below it is found that the compressive strength at the end of 28 days gradually increased and then decreased after reaching the optimum amount of ETP sludge waste and it's found to be 10%. Comparing all the mix proportion with conventional bricks, M3 mix proportion gives better strength in both cases and its found that un burnt bricks attain 80.33 % of strength when compared with the burnt bricks.

TABLE 7
COMPARISON BETWEEN BURNT AND UNBURNT BRICKS

SYMBOLS	BURNT BRICKS 28 DAY COMPRESSIVE STRENGTH N/mm²	UNBURNT BRICKS 28 DAY COMPRESSIVE STRENGTH N/mm²
M1	5.45	4.37
M2	5.79	4.68
M3	6.56	5.27
M4	5.89	4.41
M5	5.42	4.26
M6	4.87	3.91



4.4 Water Absorption Test

Brick specimens are weighed dry. Then they are immersed in water for a period of 24 hours. The specimens are taken out and wiped with cloth. The weight of each specimen in wet condition is determined. The difference in weight indicates the water absorbed. Then the percentage absorption is the ratio of water absorbed to the dry weight multiplied by 100. The average of three specimens is taken.

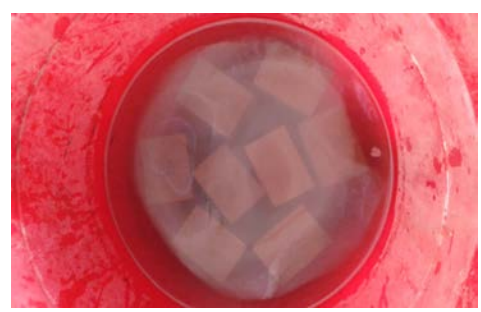


Fig. 5 Water Absorption test

The Specimes are kept inside a bucket containg water as shown in fig. 5. From the table VII it is observed that, when the mixture contains a rather high percentage of ETP sludge waste, the adhesivity of the mixture decreases, but the internal core of the brick increases. As a result the quantity of absorbed water also increases.

ISSN 2229-5518

TABLE 8
RESULTS OF WATER ABSORTION TEST

SYMBOL	UN BURNT BRICKS 24 hrs WATER ABSORPTION	BURNT BRICKS 24 hrs WATER ABSORPTION
M1	14.73	3.56
M2	13.2	3.89
M3	**14**	**4.42**
M4	14.46	5.20
M5	15.67	5.81
M6	16.86	6.34

It is found from the chart that the water absorption property of all proportions of GREEN Brick is lesser than the water absorption of normal good quality burnt clay bricks which is maximum of 20%.

4.5 Efflorescence Test

The presence of salts in brick is not desirable because they form patches of grey powder by absorbing moisture. The brick specimen is placed in a tray containing distilled water to a depth of 25mm in a well ventilated room. After all the water is absorbed or evaporated again add water for a depth of 25 mm. After second evaporation observe the bricks for white/grey patches.

TABLE 9
Efflorescence Test Results

No	OBSERVATION	MIX PROPORTION
a)	**Nil:** No patches	M1 and M2
b)	**Slight:** 10% of area covered with deposits	M3
c)	**Moderate:** 10 to 50% area covered with deposit but unaccompanied by flaking of the surface.	M4, M5 and M6.
d)	**Heavy:** More than 50 per cent area covered with deposits but unaccompanied by flaking of the surface.	-
e)	**Serious:** Heavy deposits of salt accompanied by flaking of the surface.	-

The table 9 represents the mix proportion and the category the bricks fall due to the presence of alkalies.

From the table 9 and fig. 6 it is concluded that when the sludge ash percentage increases the efflorescence also increases and M3 comes under 'Slight' Category and M4, M5, M6 are in 'Moderate' zones. Efflorescence goes on increasing i.e. no efflorescence for 0% sludge to slight to moderate efflorescence for increasing sludge percentage up to 25%. In case of bricks with 0%, 5%, 10% sludge addition very less efflorescence is observed.Thus the presence of alkali has been determined by this test.

Fig. 6 Efflorescence Tested Specimens

The observation is reported as 'nil', 'slight', 'moderate', 'heavy' or 'serious' to mean. Hence to determine the presence of alkalies this test is being performed.

5 CONCLUSION

The characterization and tests of GREEN bricks, ETP sludge waste and its incorporation into clay material used for brick manufacturing, led to the following conclusions.

a. ETP Sludge can be a successful partial replacement material for clay soil in the manufacture of bricks.
b. Green coloured clay bricks have been manufactured in the industry.
c. Unburnt bricks are manufactured thereby reducing the air pollution to the environment.
d. The manufactured GREEN bricks strength observed to be above the minimum recommended compressive strength value of 3.5 N/mm^2.
e. Comparing the mix proportion with conventional bricks, M3 sample gives better compressive strength of 5.27 N/mm^2.
f. The water absorption property of all proportions of GREEN Brick is lesser than the water absorption of normal good quality burnt clay bricks which are maximum of 20%.
g. It is found, when the ETP Sludge waste percentage increases the water absorption also increases.
h. From the results of technological tests, it is suggested that ETP Sludge wastes can be incorporated up to 25% by weight of clay materials for the production of bricks and the optimum amount of ETP Sludge waste was found to be 10% by weight of clay which gives better bonding, higher compressive strength and lower water absorption.
i. The possibility to use the Textile effluent treatment plant wastes as an alternative raw material in the production of clay-based products will also induce a relief on waste disposal concerns.
j. The ETP Sluge can also be extended and used for the manufacture of paver blocks and footpath constructions etc.
k. Thus the use of ETP Sludge reduces the both the land and air pollution problems and its environmentally effective.

REFERENCES

[1] Anyakora Nkolika Victoria., (2012) ''Characterisation And Performance Evaluation Of Water Works Sludge As Bricks Material'', International Journal Of Engineering And Applied Sciences, May 2013. Vol. 3, No. 3, pp. 69-79.

[2] Badr El-Din., Hegazy E. and Fouad H.A. (2012), ''Incorporation of water sludge, silica fume, and rice husk ash in brick making'', Advances in Environmental Research, Vol. 1, No. 1, pp. 83-96.

[3] Baskar R., Begum K. and Sundaram S. (2006), ''Characterization and reuse of textile effluent treatment plant waste sludge in clay bricks'', Journal of University of Chemical and metallurgy. Vol. - 41(4): pp. 473-478.

[4] Deng Fong Lin. and Weng C.H. (2001), ''Use of sewage sludge ash as brick material'', Journal of Environmental Eng. Vol. - 127(10), pp. 922-928.

[5] Shrikant S Jahagirdar., (2013) ''Utilization of Textile Mill Sludge in Burnt Clay Bricks'', International Journal of Environmental Protection, , Vol. 3, Iss. 5, pp. 6-13.

[6] Singh M. and Garg M. (2008), ''Utilization of waste lime sludge as building material''. Journal of Science and Industrial Res. Vol. – 67, pp. 161 – 166.

[7] IS: 2720 (Part-VII) (1980),''Code of practice for Methods of Tests for soils'', Bureau of Indian Standards, New Delhi, India.

[8] IS: 3495 (Part-I to IV) (1992),''Code of practice for Methods of Tests of Burnt Clay Building Bricks'', Bureau of Indian Standard, New Delhi, India.

[9] IS: 2117 (1991), ''Guide for Manufacture of Hand-Made Common Burnt-Clay Building Bricks'', Bureau of Indian Standards, New Delhi, India.

[10] IS: 1077 (1992),''Code of practice for Common Burnt Clay Building Bricks'', Bureau of Indian Standards, New Delhi, India.