Sustainable Construction Practices Manufacturing of Eco-Hollow-Sludge Clay Brick

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Abstract- *Building construction is one of the fastest growing industries in India and it puts a huge burden on its limited natural resources. This research tries to highlight the use of alternative materials and how they can be modulated to suit the Indian construction industry. Sludge resulting from wastewater treatment plants creates problems of disposal. Generally, dewatered sludge's are disposed of by spreading on the land or by land filling. However, for highly urbanized cities, sludge disposal by land filling might not be appropriate due to land limitation. Incineration might be an alternative solution. However, a substantial amount of sludge will be produced after the treatment process and must be disposed of by other means. This paper presents the results of the utilization of dried sludge ash, clay and fly ash as brick making materials. The trial percentages of dried sludge ash can be mixed with clay for brick making are 5%, 10%, 15%, 20% and 25% respectively. And the trial percentage of fly ash can be mixed with clay for brick making is 12%. Another important objective of this research is to inspire and motivate architects, designers, researchers and builders to encourage and support the development of such sustainable and eco-sensitive material in construction industry.*

Keywords- Manufacturing By using Sewage Sludge Ash, Clay and Fly Ash

I. INTRODUCTION

Construction industry in any part of the world has significant positive and negative environmental, economic and social impacts on the society. Besides providing the required number of buildings and facilities to human beings, activities within construction industry provides employment opportunities to large number of people. The negative influences of construction activities include; noise, traffic congestion, dust, fumes, water pollution and waste disposal. Construction industry is now looking for most ecofriendly and more sustainable material and technologies. A large quantity of sludge is generated each year from various industries. Large amount of waste water is produced from various processes within the industry like manufacturing processes, cleaning processes, kitchen wastes etc. for discharging this waste water into the specified water bodies, certain standard specified by the regulatory authorities have to be met.

For this purpose, the wastewater has to be subjected to various treatment processes. As a result of these treatment processes, sludge is produced. Sewage sludge is being generated in an ever-increasing amount due to the urbanization and higher effluent criteria implemented in recent years. Without proper treatment and disposal, it will cause a secondary pollution problem in the environment. It contains mineral, organic, and biological impurities insoluble, soluble and colloidal form. The conventional disposal options include landfill, incineration and forestry application. The heat-treated wastes had high chemical durability and would be safe for landfill or for re-use in a number of potential applications. The disposal of sewage sludge is a very important problem in many communities that face a growing opposition to the siting of new landfills or incinerators. The quantity of sludge produced depends upon the amount of wastewater and the type of treatment adopted for treating the waste water. Common method adopted for disposing the sludge is landfilling. Landfill disposal of the sludge has drawbacks like high cost of transportation, difficulty in getting suitable sites for landfilling; heavy metal contamination of the land, emission of foul gases etc.so, disposal of sludge has become a major issue. Efforts are being made to utilize the sludge for making useful materials. In recent years, various uses of incinerator ash have been developed in order to ease the burden of the disposal. For example, the ash has been used to replace part of the Portland cement to make construction materials, e.g. brick, paving block, tile; previous studies have shown that with such treatment, heavy metal release from brick of ash considerably decreases by sintering or cement consolidation. The brick made from sewage sludge ash, clay, flyash is known as Nature's brick. This study focuses on the possibility of using sludge as a brick material and make sustainable product. The sludge for this study was collected from Sewage treatment plant Muttathara, Thiruvananthapuram Kerala.

II. OBJECTIVES

To check the feasibility of sewage Sludge as ingredient in brick making

- To examine the effect of dry sludge in brick properties
- Conservation of natural resources like clay
- To solve the problem of sewage sludge disposal in urban region
- To make eco-friendly low cost and durable construction material
- Economical design and light weight product
- Reduce pollution
- To develop buildings which use the natural resources to the minimal at the time of construction as well as operation.
- To ensure minimum negative impact on the environment by the construction and operation of a building, as operation.

III. METHODOLOGY

This chapter briefly explains the methodology adopted in this experimental work. It also includes the materials used, experimental investigation andthe mix design.

ITERATURESURVEY

The literature survey includes the thinks which has been already done on the various aspects of sewage sludge ash, clay and fly ash. The properties of the proposed material and the suggestions which were given to know the future development of the particular work isto bestudied inthereviewof literature.

COLLECTION OF MATERIALS

In this stage various materials used for making the brick such as sewage sludge, clay and fly ash are collected from different places.

TESTING OF MATERIALS

All the ingredients of brick are tested in accordance with relevant IS standards. The physical properties of materials such as specific gravity, sieve analysis, moisture content etc… are to be determined.

PROPORTIONINGOFSAMPLES

In this investigation brick mix design is carried out according to IS code 1077:1992 and IS 3495(part1):1992 for the conventional brick. From the obtained mix proportion clay is replaced by sewage sludge in percentages of 5%, 10%, 15%, and 20% also fly ash is added by 12% of the concrete and also add 3or 4 small chiseled rock pieces (1cm thickness) to the center portion of the brick.

CASTINGOFSPECIMEN

All the mixes will be prepared by hand mixing along with water. For compressive strength studies cube specimens of size (19cm*9cm*9cm) will be studied.

TESTINGOF SPECIMEN

The specimen will be tested for determining the compressive strength, water absorption, efflorescence, hardness, soundness etc.

RESULTSANDDISCUSSION

The results of the strength properties will be tabulated

IV. ANALYSIS AND RESULTS

TESTING OF MATERIALS SLUDGE

SPECIFIC GRAVITY TEST ON SEWAGE SLUDGE

Determination of the specific gravity of dry sludge particles

Procedure:

- Dry weight of pycnometer (w1)
- Oven dried sludge passing through 4.75mm sieve is filled in the pycnometer up to one-third of its volume and weighted (w2)
- Add sufficient water to cover the sludge and shake it well to avoid. Note down its weight(w3)
- Fill the pycnometer completely with water and weigh(w4)
- Specific gravity of sludge= (w2-w1)/ ((w4-w1)-(w3-w2))

Determination No	1	2
Weight of pycnometer (W1) in g	33.91	33.91
Weight of pycnometer + soil (w2) in g	44.36	47.82
Weight of dry soil (ws) in g	10.45	13.91
Weight of pycnometer +soil + water (w3) in g	92.36	94.30
Weight of pycnometer + water (w4) in g	89.39	89.39
specific gravity of sewage sludge	1.32	1.38

Specific gravity of sewage sludge is 1.38

SEIVE ANALYSIS

Procedure:

- Bring the sample to an air condition and weight it.
- Clean the sieve to be used and record the weight of each sieve and the pan.
- Arrange the sieves to have the largest mesh size at the top of the stack. Pour carefully the soil sample into the top sieve and place lid over it.
- Sieve the dry sludge sample successively for 10 minutes. Remove the stack and re- weight each sieve and the bottom pan with the soil sample fraction retained on it.
- Draw the graph using semi logarithmic graph sheet with % weight passing on y axis and sieve size on x axis
- Initial mass of soil sample taken for analysis (kg) = 0.250 kg.

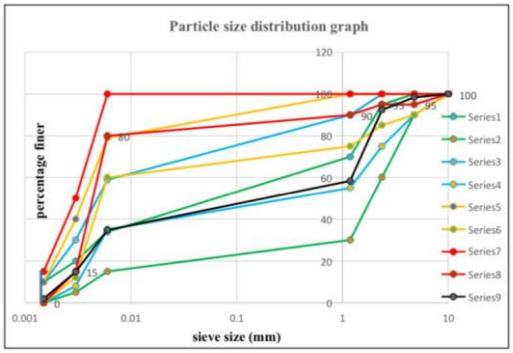


Fig 5.4 Particle size distribution graph of clay

Table 5. 3 Sieve analysis of sewage sludge

Sieve size	Weight retained in each sieve	% weight retained in each sieve	Cumulative % weight retained (c)	% weight passing (100-c)
4.75	4	1.6	1.6	98.4
2.36	15	6	7.6	92.4
1.18	85	34	41.6	58.4
600 micron	59	23.6	65.2	34.8
300 micron	50	20	85.2	14.8
150 micron	32	12.8	98	2
Pan	5	2	2	0

TESTS CONDUCTED ON CLAY

SPECIFIC GRAVITY TEST ON CLAY

Procedure:

- Dry the specific gravity bottle thoroughly and weigh, with its cap screwed on (w1).
- Oven dried soil passing through 4.75mm sieve is filled in the pycnometer up to 1/3rd of its volume.
- Take the weight of the pycnometer along with the soil (w2).
- Add sufficient water to cover the soil and shake it well to avoid air bubbles and note its weight (w3).
- Then the pycnometer is filled with water and its weight (w4) is noted.
- Specific gravity of sludge= (w2-w1)/ ((w4-w1)-(w3-w2))

Table 5.4 Specific gravity of clay

Determination No	1	2
Weight of pycnometer (w1) in g	33.91	33.91
Weight of pycnometer + soil (w2) in g	64.43	63.84
Weight of dry soil (ws) in g	30.65	30.06
Weight of pycnometer +soil + water (w3) in g	107.62	105.34
Weight of pycnometer + water (w4) in g	89.39	89.39
specific gravity of clay	2.46	2.34

Specific gravity of clay is 2.46

PROCTOR COMPACTION TEST

Procedure:

- Take about 3 kg of soil passing through 4.75 mm sieve in a mixing tray.
- Weigh the mould with base plate and apply grease lightly on the interior surfaces.
- Fitthe collar and place the mould on a solid base.

- Add water to the soil to bring its moisture content to about 6% and then mix it thoroughly using the trowel until the soil gets a uniform color.
- For light compaction, compact the moist soil in three equal layers using a rammer of mass 2.6 kg.
- Distribute the blows evenly and apply 25 blows in each layer.
- Rotate the collar so as to remove it, trim off the compacted soil flush with the top of the mould, and weigh the mould with soil and base plate.
- Extrude the soil from the mould and collect soil samples from the top, middle and bottom parts for water content determination.
- Place the soil back in the try, add 3% more water based on the original soil mass, and re mix as in step 3.
- Repeat steps 4 and5 until a peak value of compacted soil mass is reached followed by a few samples of lesser compacted soil masses.

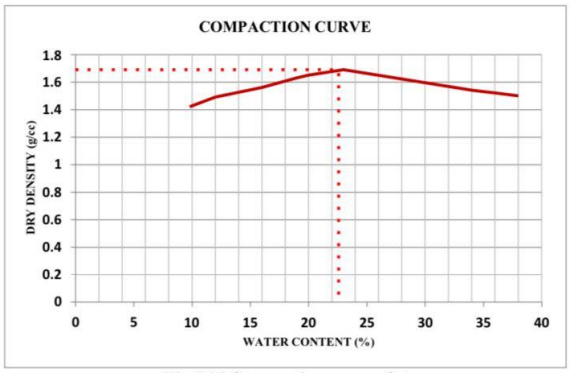


Fig 5.16 Compaction curve of clay

Table 5.7 Compaction test for clay

No	1	2	3	4	5	6	7	8	9	10
Wt+mould+soil in g	5500	5600	5700	5800	5900	6000	6100	6100	6000	5900
Wt. Compacted soil	1500	1600	1700	1800	1900	2000	2100	2100	2000	1900
Wet density in g/cc	1.56	1.67	1.77	1.88	1.98	2.08	2.18	2.18	2.08	1.98
Container no	57	1	102	5	29	3	7	N21	710	1A2
Wt. Container in g	27.41	32.83	30.26	33.37	30.98	29.60	36.20	27.43	40.82	28.75
Wt. container + wet soil in g	71.02	67.85	68.86	63.01	65.63	69.20	66.85	67.68	86.30	69.84
Wt. container+ dry soil in g	67.11	64.12	63.63	58.23	59.68	61.74	58.95	57.20	74.20	58.6
Wt. water in g (Ww) in g	3.91	3.73	5.23	4.78	5.95	7.46	7.9	10.48	12.1	11.24
Wt. dry soil in g (Ws)	39.7	31.29	33.37	24.86	28.7	32.14	22.75	29.77	33.38	29.85
Water content (w) in %	9.8	12	16	19	20	23	34	35	36	38
Dry density in g/cc	1.42	1.49	1.52	1.57	1.65	1.69	1.62	1.61	1.52	1.50

TEST CONDUCTED ON FLY ASH

SPECIFIC GRAVITY TEST

Procedure:

- Dry the specific gravity bottle thoroughly and weigh, with its cap screwed on (w1).
- Sample is passing through 4.75mm sieve is filled in the pycnometer up to 1/3rd of its volume. Take the weight of the pycnometer along with the soil (w2).
- Add sufficient water to cover the soil and shake it well to avoid air bubbles and note its weight (w3). Then the pycnometer is filled with water and its weight (w4) is noted.
- Specific gravity of flyash = (w2-w1)/ ((w4-w1)-(w3-w2))

Table 5.9 Specific gravity of fly ash

Determination No	1	2
Weight of pycnometer (w1) in g	33.91	33.91
Weight of pycnometer + soil (w2) in g	53.13	58.76
Weight of dry soil (ws) in g	19.22	24.85
Weight of pycnometer +soil + water (w3) in g	99.47	102.68
Weight of pycnometer + water (w4) in g	89.39	89.39
specific gravity of fly ash	2.10	2.14

Specific gravity of fly ash= 2.14

MANUFACTURING OF BRICKS AND TESTING OF BRICKS

Brick is one of the oldest building materials and it is extensively used even at present because of its durability, strength, reliability, low cost, easy availability etc. bricks are obtained by moulding clay in rectangular blocks of uniform size then by drying and burning these blocks in brick kilns.

COMPOSITION OF GOOD BRICK

A good brick should contain clay and sand in such a way that when water is added, it can be easily moulded and dried without cracking. Following are the main constituents of good brick earth:

- Silica: 50% to 60% by weight. Presence of these constituents prevents cracking, shrinking and warping of raw bricks. It imparts uniform shape to bricks. If silica is in excess, it makes the brick brittle.
- Alumina: 20% to 30% by weight. It imparts plasticity to earth so that it can be moulded easily. If alumina is present in excess, raw bricks shrink and warp during drying and burning.
- Lime: 2% to 5% by weight. Lime causes the grains of sand to melt and bind the particles of clay together. It

prevents shrinkage of raw bricks. If lime is excess, it will cause the brick to melt and hence shape is lost.

- Iron oxide: 5% to 6% by weight. Iron oxide act as a flux to cause the grains of sand to melt and this helps to bind the particles together. It imparts red color to brick on burning. Excess amount of iron oxide makes the brick dark blue.
- Magnesia: less than 1% by weight. It imparts yellow color t brick and it decreases shrinkage. Excess magnesia leads to decay of bricks.

TYPES OF BRICKS

- Common burnt clay bricks: clay bricks are fired bricks. These are formed by pressing in moulds or by an extrusion and wire cutting process. Then these bricks are dried and fired in a kiln.
- Sand lime bricks (calcium silicate bricks): these bricks are mixtures of sand and hydrated lime pressed in moulds and cured in a high-pressure steam autoclave.
- Concrete bricks: concrete bricks are mixtures of cement, sand and aggregates vibrated in moulds and steam cured.
- Fly ash clay bricks: fly ash is used along with clay in these bricks. Fly ash is obtained from boilers of thermal power stations.
- Fire clay bricks: fire clay exists at much depth below the surface and is usually mixed. Generally, fire clays contain metallic oxides less than surface clays and have more uniform chemical and physical properties.

STANDARD SIZE AND WEIGHT OF BRICKS

- Size of standard bricks is 19x9x9 cm. Such brick is known as Modular bricks.
- The size of bricks including mortar thickness is 20x10x10cm.
- Average weight of brick is about 3 to 5 kg.

MANUFACTURING OF ECOBRICKS

The process of manufacturing of bricks from sewage sludge ash, clay and fly ash involves preparation of clay, molding and then drying and burning of bricks. The bricks do not require any dressing and brick laying is very simple compared to stone masonry.

Table 6.1 Proportioning of samples in Eco bricks

Sl. No	Clay (%)	Different % of sludge ash	Fly ash (%)	Water
1	83	5	12	As per requirement
2	78	10	12	
3	73	15	12	
4	68	20	12	
5	63	25	12	

There are four different operations involved in the process of manufacturing of bricks ;

1.Preparation of meterials
2. Mixing of meterials
3. Placing
4. Drying
5. Burning

Various types of tests on bricks are conducted to check the qualities of bricks for construction purposes. Tests on bricks are conducted at construction site as well as in laboratory. Bricks are oldest and important construction materials because of their durability, reliability, strength and low cost. To produce good quality of structure, good quality materials are required. To decide the quality of the materials some tests are to be conducted on bricks.

TEST ON BRICKS

Following tests are conducted on bricks to determine its suitability for construction work.

1. Compressive strength test (as per IS-3495(Part1):1992
2. Water Absorption test (as per IS-3495(Part2):1992
3. Soundness test.

4. Presence of soluble salts (Efflorescence Test) (as per IS-3495(Part3):1992
5. Hardness test
6. Color test.

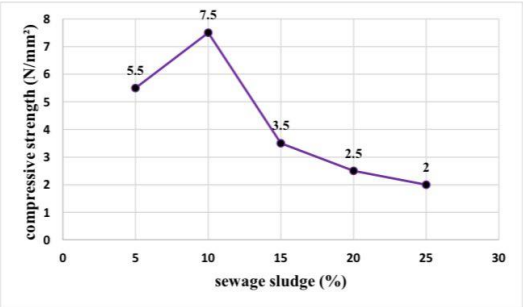
COMPRESSIVE STRENGTH TEST

The compressing test is the most important test for assuring the engineering quality of a building material. The strength of brick is greatly dependent on the amount of sludge in the brick and the firing temperature.

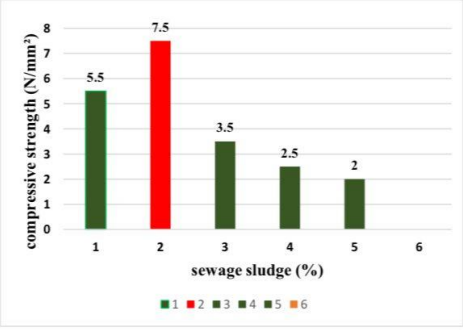
- Placing the brick in compression testing machine testing machine.
- Apply load axially at a uniform rate of 14N/mm2 per minutes till failure occurs and
- note the maximum load at failure.
- Minimum crushing strength of brick is 3.50N/mm2, if it is less than 3.50 N/mm2 then it is not useful for construction purpose.

Compressive strength in N/mm2 = $Maximumloadatfailure inN$
Compression testing machine
$Averageareaofbedfacesinmm2$

Maximum compressive strength was obtained for 10% sludge ash bricks



Compressive strength graph of eco brick

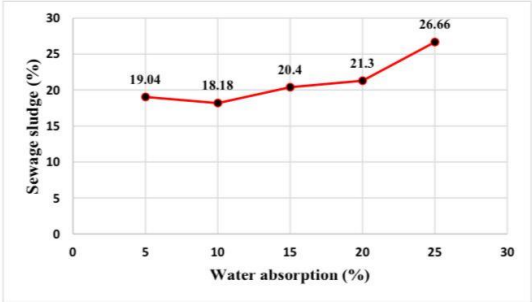


Bar diagram showing compressive strength for eco brick

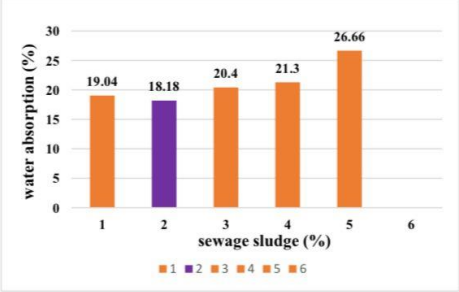
Compressive strength = 7.5 N/mm²

WATER ABSORPTION TEST

Water absorption is a key factor affecting the durability of brick. The less water infiltrates into brick, the more durability of the brick and resistance to the natural environment are expected. The water absorption for the bricks increases with increased sludge addition and decreased firing temperature, thereby decreasing its weathering resistance. When the mixture contains a rather higher amount of sludge, the adhesiveness of the mixture decreases, but the internal pore size of the brick increases. As a result, the quantity of absorbed water increases.



Water absorption graph for Eco-brick



Bar diagram showing water absorption for eco brick

Water absorption = 18.18%

Water absorption test on Eco bricks

No of bricks	Percentage of sludge	Weight before test (g)	Weight after test (g)	% of water absorption
1	5%	2100	2500	19.04
2	10%	2200	2600	18.18
3	15%	2200	2650	20.40
4	20%	2225	2700	21.30
5	25%	2250	2850	26.66
Conventional brick	0%	2400	2800	16.67

V. CONCLUSION

The conclusion is based on different experimental sets used, and its tests.

- Dry sludge is available free of cost so, we will reduce cost of brick.

- The researched brick type will be a big competitor to the cement brick and clay brick
- type in the market.
- This project shows that replacement of soil with this Sludge ash material reduce the
- weight of brick. And it's become light weight product.
- Environmental effects from wastes and disposal problems of waste can be reduced or
- controlled through this research.
- The maximum value of compressive strength was obtained in the 10% of sludge ash
- replacement in bricks.
- The bricks with sludge ash did not have any effect of efflorescence.
- Reduce the cost of construction.
- A better measure by an innovative Construction Material is formed through this
- project And its will help to less cost.

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