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# EFFECT OF INDUSTRIAL SLUDGE AND COCONUT COIR IN STRENGTHENING OF RED BRICKS

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**Abstract -** *Industrial wastes are hazardous in nature, their disposal is of major concern. Recycling such wastes by utilizing them into building materials is a moderate solution for the pollution issues. The main aim of this work is to examine the utilization potential of industrial sludge and coconut coir as an alternative raw materials in the production of red bricks. To safeguard the environment, efforts are being taken for recycling different wastes and utilize them in valuable applications. The mixture was prepared was prepared with amount of 5%, 10%, and 20% sludge with addition of 0.1% of coconut coir as constant. The bricks were tested for their properties including compressive strength, water absorption, efflorescence, strength test, soundness test, hardness test, shape and size test according to IS standards. In this project, the test results are analyzed and effect of variables discussed. Recommendations and conclusions as to whether or not the industrial sludge bricks can perform adequately alongside the red soil are included.*

***Keywords-*** *hazardous, utilization, safeguard, environment, recommendations.*

## 1. INTRODUCTION

Brick is one of the oldest building materials. It is cheap, durable and easy to handle and work with. Clay bricks are most common. These are rectangular in shape. A brick is a block used in masonry construction. Typically bricks are stacked together or laid as brick work using various kinds of mortar to hold the bricks together and make a permanent structure. These are about 5000 years old. On the basis of field practice, the red bricks refer to those bricks which use red soil, adding industrial sludge and coconut coir, after mixture preparation, pressed while moulding, and natural curing methods into beings.

In India the building industry consumes about 20000 million bricks and 27% of the total natural energy consumption for their production. In addition to this, the use of industrial sludge and coconut coir for making bricks is ecologically advantageous since apart from saving precious top agricultural soil, it meets the social objective of disposing textile wastes otherwise are pollutants and nuisance. In this content search for an alternative material to sludge are in need. So various government agencies and research institutions have repeatedly recommended the use of waste materials such as industrial sludge and coconut coir as an alternative building material in making bricks. So in this project we had use the industrial sludge and coconut coir in the manufacturing of clay bricks by addition and partial replacement in bricks by weight respectively.

### NEEDS FOR STUDY

- To check the feasibility of dried industrial sludge as ingredient in brick making.
- Conservation of natural resources like clay
- To solve the problem of disposal of industrial sludge in urban region.
- To make eco-friendly low cost and durable construction material.

### OBJECTIVE OF STUDIES

- To give better environment to the urban region.
- Economical design and light weight product.
- To reduce the construction cost.
- To achieve strength in brick and investigation for check feasibility.
- To examine the effect of dry sludge in brick properties.
- Reduction in pollution.

### SCOPE OF THE PROJECT

- Rapid Industrialization and Urbanization is causing serious environmental problems. One of the major concerns amongst these is safe and sound disposal of solid wastes.
- There is a strong demand for environmentally safe reuse and effective disposal methods for sludge generated by the waste water treatment plants.

Textile industries are one of the largest sectors in India. Every year they generate large amount of revenues for Indian economy. This project is for the manufacture of efficient bricks using the sludge from textile industry and thus suggests a means for the waste disposal also.

### LITERATURE REVIEW

**Utilization of textile mill sludge in burnt clay bricks - Shrikant S Jahagirdar (2013)**, Investigation of the effect of

Textile mill sludge addition in burnt clay bricks is done under this study. 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 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. 800ºC 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/mm2 and water absorption of 20% as per the requirement.

**Reuse of natural waste material (coconut waste) for making light weight bricks - Namrata S. Tikhe (2018)**, The main objective of the present study is to reduce the quantity of soil with natural waste material. The coconut fibres are used to make light weight bricks. The coconut fibre which otherwise is land filled has been utilized to make construction bricks that serves a purpose of solid waste management. The bricks are prepared by coconut fibres with varying composition of soil reduced the quantity of soil (10%-25%) respectively. The prepared bricks are tested in compression strength machine for getting compressive strength of bricks. In that, if the percentage of soil decreases then the compressive strength of bricks decrease. At 25% of waste the water absorption of brick is 26.96% and compressive strength of brick is 2.7 $N/mm^2$ so it is not suitable for construction purpose. Maximum strength is achieved after replacing 10% and 15% of soil by coconut waste.

**Experimental investigation on bricks with the replacement of coconut fibre - G.VinothKanna (2018)**, Space allotments for various kind of waste have been a major problem in all countries of the world. We are using the waste, Coconut fibre in this project for building material and to protect environment and natural resource like clay and sand. The basic waste used in this project is coconut fibre in addition with polymer as used to attain the strength of the brick. At first we have to shredded coconut fibre into the small pieces, mix them at the right proportion to make this brick, bricks are allowed to laid on the ground with the help of the mould. According to the specifications water absorption is less than 20%. There is a positive effect of river sand & coconut fibre partially on clay brick samples that reach its optimum at 50% clay, 35% river sand and 15% coconut fibre by weight can be incorporated in raw materials.

## OBJECTIVE

The main objective of the project is to utilize the industrial waste sludge as a partial replacement of the raw material in the brick as to make eco-friendly and to provide better environment to urban and rural regions.

## MATERIAL INVESTIGATION

## INTRODUCTION

The details on materials and methods used in the project are discussed below.

## MATERIALS USED

- Red soil
- Industrial sludge
- Coconut coir
- Water

## RED SOIL

Laterite soils are red in colour due to little clay and more gravel of red sand stones.They have a high clay content which mean they have higher cation exchange capacity and water holding capacity than sandy soils.They are formed under condition of high temperature and heavy rainfall with alternate wet and dry periods.

Fig-1 : Red soil

## PROPERTIES OF RED SOIL

## GRAIN SIZE DISTRIBUTION

**Fig-2: Grain size distribution**

**TABLE 1: GRAIN SIZE DISTRIBUTION**

| SI.No. | I.S.Sieves Aperture size | Weight retained (gms) | % weight retained | Cumulative % retained | % Finer |
|---|---|---|---|---|---|
| 1 | 4.75mm | 68 | 6.8 | 6.8 | 93.2 |
| 2 | 2.36mm | 116 | 11.6 | 18.4 | 81.6 |
| 3 | 1.18mm | 157 | 15.7 | 34.1 | 65.9 |
| 4 | 600µ | 83 | 8.3 | 42.4 | 57.6 |
| 5 | 425µ | 118 | 11.8 | 54.2 | 45.8 |
| 6 | 300µ | 36 | 3.6 | 57.8 | 42.2 |
| 7 | 150µ | 220 | 22.0 | 79.8 | 20.2 |
| 8 | 75µ | 142 | 14.2 | 94 | 6 |
| 9 | Pan | 60 | 6.0 | 100 | 0 |

**CALCULATIONS**

1. Effective size of the soil $= D_{10} = 0.14$
2. Uniformity coefficient ($C_u$) $= \frac{D60}{D10} = \frac{0.84}{0.14} = 6$
3. Coefficient of curvature ($C_e$) $= \frac{(D30)^2}{D10XD60} = \frac{(0.3)^2}{0.84X0.14} = 0.77$
4. Fineness modulus $= \frac{Total\ sum\ of\ the\ cumulative\ \%\ retained}{100}$

   i. $= 487.5/100 = 4.88$
5. Coefficient of permeability, $K = 100D^2_{10} = 1.96$

Where,

$D_{10}$ is Diameter of particle corresponding to 10% finer

$D_{30}$ is Diameter of particle corresponding to 30% finer

$D_{60}$ is Diameter of particle corresponding to 60% finer

**SPECIFIC GRAVITY**

The Pycnometer is used for the determination of the specific gravity of soil Particles of both fine grained and coarse grained soils. The specific gravity of soil is determined using the relation,

$$G_s(\text{at } 27^\circ C) = \frac{Gs(at\ T1^\circ C) Specific\ gravity\ of\ water\ at\ T1^\circ C}{Specific\ gravity\ of\ water\ at\ 27^\circ C}$$

**Fig-3 : Specific gravity**

**OBSERVATION**

**TABLE 2: SPECIFIC GRAVITY**

| | | |
|---|---|---|
| 1 | Weight of pycnometer (W1)gms | 644 |
| 2 | Weight of pycnometer + dry soil(W2) gms | 1200 |
| 3 | Weight of pycnometer + soil + water (W3)gms | 1724 |
| 4 | Weight of pycnometer + water (w4)gms | 1478 |

**CALCULATIONS**

The specific gravity of the soil grains at T°C is calculated as follows,

$$G_s(\text{at } 27^\circ C) = \frac{(w2-w1)}{(w2-w1)-(w3-w4)}$$

$$= \frac{(1200-610)}{(1200-6!0)-(1724-1478)}$$

$G_s$(at 27°C) = 1.72

**PLASTIC LIMIT**

Plastic limit is the lowest moisture content and expressed as a percentage of the weight of the oven dried soil at which the soil can be rolled into threads without the soil breaking into pieces, also the moisture content of a soil at which a soil changes from a plastic state to a semisolid state.

**OBSERVATIONS**

**TABLE 3: PLASTIC LIMIT**

| S.NO. | W1(gm) | W2(gm) | W3(gm) |
|---|---|---|---|
| 1 | 15 | 24 | 22 |
| 2 | 12 | 22 | 20 |

**CALCULATIONS**

Moisture content(W) $= \frac{w2-w3}{w3-w1} \times 100$

The average moisture content is taken as the plastic limit of the soil

$w_p = 33.3\%$

**UNCONFINED COMPRESSION TEST**

The unconfined compression test is the special form of Triaxial Compression test where the Lateral Confining pressure is zero. This test is classified as undrained or quick test even though small amount of drainage takes place during the test. The test can be conducted on undisturbed or remoulded cohesive soil samples. Normally this test is conducted an soil samples at natural water content.

**Length = 70 mm Diameter = 35 cm Area = 962.11mm²**

**TABLE 4: UNCONFINED COMPRESSION TEST**

| Compression dial gauge reading | | Proving ring dial gauge reading | | Strain ε | 1 - ε | A' = A/ (1 – ε) | Stress = P/A (x10⁻³) N/mm² |
|---|---|---|---|---|---|---|---|
| Div | mm | Div | P(Load | | | | |
| 100 | 1 | 5 | 3.1 | 0.014 | 0.986 | 975.77 | 3.177 |
| 200 | 2 | 7 | 4.34 | 0.029 | 0.971 | 990.85 | 4.380 |
| 300 | 3 | 10 | 6.2 | 0.043 | 0.957 | 1005.34 | 6.167 |
| 400 | 4 | 11 | 6.82 | 0.057 | 0.943 | 1020.27 | 6.685 |
| 500 | 5 | 13 | 8.06 | 0.071 | 0.929 | 1035.64 | 7.783 |
| 600 | 6 | 14 | 8.68 | 0.086 | 0.914 | 1052.64 | 8.246 |
| 700 | 7 | 16 | 9.92 | 0.1 | 0.9 | 1069.01 | 9.280 |
| 800 | 8 | 18 | 11.16 | 0.114 | 0.886 | 1085.91 | 10.278 |
| 900 | 9 | 18 | 11.16 | 0.129 | 0.879 | 1094.55 | 10.195 |
| 1000 | 10 | 18 | 11.16 | 0.143 | 0.857 | 1122.65 | 9.940 |

**STANDARD PROCTOR' COMPACTION TEST**

The proctor compaction test is used for determining the optimal moisture content at which a soil type will become most dense and achieve its maximum dry density.

Diameter of mould = 10.2 cm

Height of mould = 11.4 cm

Volume of mould = 931.52 cm³

Weight of mould

without collar(w1) = 3784 gm

**TABLE 5: STANDARD PROCTOR' COMPACTION**

| S.No. | Water content% | Weight of the mould + compacted soil(w2) gm | Weight of the compacted soil(w2-w1)gm | Bulk density $\rho = \frac{w2-w1}{V}$ g/cc | Dry density $\rho_d = \frac{\rho}{1+w}$ g/cc | Theoretical dry density $\rho_{d(theo)} = \frac{G.}{1+w.G}\rho w$ |
|---|---|---|---|---|---|---|
| 1 | 6% | 5547 | 1763 | 1.89 | 1.78 | 1.56 |
| 2 | 8% | 5684 | 1900 | 2.04 | 1.89 | 1.51 |
| 3 | 10% | 5731 | 1947 | 2.09 | 1.9 | 1.47 |
| 4 | 12% | 5718 | 1934 | 2.07 | 1.85 | 1.43 |
| 5 | 14% | 5680 | 1896 | 2.03 | 1.78 | 1.39 |

**DIRECT SHEAR TEST**

The direct shear test is used to measure the shear strength properties of soil or rock material. The shear strength of a soil is its maximum resistance to shearing stress at failure . It depends on angle of shearing resistance and cohesion.

**TABLE 6: DIRECT SHEAR**

| S.No. | Normal stress (σ) Kg/cm² | Shear force at failure | | Shear stress(τ) Kg/cm² |
|---|---|---|---|---|
| | | Div | kg | |
| 1 | 0.5 | 65 | 15.912 | 0.044 |
| 2 | 1 | 120 | 29.376 | 0.061 |
| 3 | 1.5 | 135 | 33.048 | 0.078 |

**PROPERTIES OF RED SOIL**

**TABLE 7: PROPERTIES OF SOIL**

| S.No. | Properties | Resulting vaue |
|---|---|---|
| 1 | Specific gravity | 1.72 |
| 2 | Plastic limit | 33.3% |

| | | |
|---|---|---|
| 3 | Shear strength | 0.05 N/mm² |
| 4 | Dry density of the soil | 1.9 gm/cc |
| 5 | Optimum moisture content | 10% |

**INDUSTRIAL SLUDGE**

- Now a day, disposal of sewage has become a necessity for society.
- It has been found that each person produce 35 to 85 grams of solid sludge per day.
- In recent years, waste production has increased drastically in developing nations such as India
- There are two methods to solve the problem such as disposal of solid waste (dry sludge) including land filling and using dry sludge as fertilizers. But by both these methods some harmful material remains in sludge which causes harm to environment including land, air and water as a whole.

**Fig-4 : Industrial sludge**

**PROPERTIES OF SLUDGE**

**$p^H$**

$p^H$ is a measure of acidity and base of an aqueous solution, $p^H$ measurement is useful in effluent treatment to find design, types and efficiency. Discharges from water treatment plant have both acidic and alkaline effluents. The WHO guidelines the tolerance limit of the $p^H$ value of the industrial effluent as 6 to 9. The discharge of waste water into water bodies may cause a drop or increase in their $p^H$ due to the size and activities of microbial population. $p^H$ value of dried sludge is 9.

**Temperature**

Higher water temperature decreases the solution viscosity and causes increase in the diffusion rate, thereby increasing adsorption. Higher temperature can also disrupt the adsorptive bond and slightly decreases adsorption. It depends on the organic compound being removed, but generally, a lower temperature seems to favour adsorption.

**Chlorides ($Cl^-$)**

Chloride is introduced into industrial effluents as sodium chloride. Being highly soluble and stable, they are unaffected by effluent treatment and nature, thus remaning as a burden on the environment. The level of salt as chloride under acid conditions can be determined by titrating a known volume of effluent with a silver nitrate solution, using potassium chromate as an indicator, Chloride content in sludge produced from dyeing industry is Nil.

**Total hardness**

The presence of calcium and magnesium contributes to water hardness. Total hardness is more (640 ppm as $CaCO_3$) in the final outlet compared to that of raw water. Calcium content of final outlet was observed to be greater than 200 mg/l. The magnesium ($Mg^{2+}$) content of final outlet (184 mg/l) was beyond 50 mg/l rendering the water unpalatable. Generally calcium and magnesium maintain a state of equilibrium in most waters. Presence of more magnesium in water will adversely affect the soil quality converting it to alkaline and decreases crop yields.

**Total dissolved solids**

The value of total dissolved solids (TDS) for the final outlet was found to be lesser than that of raw water. TDS is found to be lesser than the WHO standard of 2000 ppm for the discharge of waste water into surface water. TDS may increase salinity of the water and thus may render it unfit for irrigation and drinking purposes.

**Oxygen demand**

Oxygen is required for both the survival of these bacteria (aerobic bacteria) and the breakdown of the components. Depending on their composition, this breakdown can be quite rapid or may take a very long time. If effluent with a high oxygen demand is discharged directly into surface water, the sensitive balance maintained in the water becomes overloaded. This is often achieved by using bacteria in a properly operated effluent treatment plant, a process demanding high levels of oxygen. This can be achieved in two different ways:

**Biochemical oxygen demand (BOD)**

The technique for measuring biochemical oxygen demand (BOD) is complex. The BOD analysis which is widely used to assess the environmental demands of waste water. BOD is a measure of the oxygen requirements of bacteria under controlled conditions, many effluent components take longer period than the period of analysis to break down. Some chemicals will only be partially broken down, while others may not be significantly affected.

**Chemical oxygen demand (COD)**

The method measures the oxygen required to oxidize the effluent sample wholly. It sets a value for the materials that would normally be digested in the BOD analysis, the longer term biodegradable products, as well as the chemicals that remain unaffected by bacterial activity. A suitable volume of effluent is boiled with a powerful oxidizing agent (potassium dichromate) and sulphuric acid. As the effluent components oxidize, they use oxygen from the potassium dichromate, the amount used being determined by titration, it is easier to manage larger numbers of samples. The semi-colloidal material that forms part of the suspended solids is also included in the BOD and COD determinatios.

**Specific gravity of sludge**

Weight of s.g. bottle $w_1$ = 0.027 gm

Weight of s.g. bottle + Sludge $w_2$ = 0.044 gm

Weight of sp.gr. bottle + Sludge + Kerosene $w_3$ = 0.078 gm

Weight of sp.gr. bottle + Kerosene $w_4$ = 0.070 gm

Weight of sp.gr. bottle + Water $w_5$ = 0.079 gm

Specific gravity of Kerosene $G_{s(k)}$ = $(w_4 - w_1) / (w5 - w1)$

= (0.070 – 0.027) / (0.079 – 0.027)

= 0.82

Specific gravity of sludge $G_s$ = $(w2 - w1) / [(w3 - w1) - (w3 - w4)]*G_{s(k)}$

= 1.48

**TABLE 8: TRESTING ON SLUDGE**

| S.No | Testing on sludge | Resulting value |
|---|---|---|
| 1 | $P^H$ value | 9 |
| 2 | Turbidity value | 15 |
| 3 | Chloride tests of industrial sludge | Nil – Absence of chloride content |
| 4 | Total suspended solids | 6.5 mg/l |
| 5 | Specific gravity | 1.48 |

**COCONUT COIR**

Coconut coir is a natural fibre extracted from the husk of coconut. It is found between the hard, internal shell and the outer coat of a coconut.It has the advantage of not sinking, so can be used in long lengths on deep water without the added weight dragging down boats and buoys.

**Fig-5: Coconut coir**

**APPLICATIONS OF COCONUT COIR**

- Coir is very hot resistant, making it perfect for outdoor products. It is also becoming increasingly popular as a potting mix and organic soil amendment.
- Coirs has been used to enhance concrete and mortar, and has proven to improve the toughness of concrete and mortar.
- Coirs got tremendous property of good temperature management so this is widely used for insulation purposes.
- They have got excellent water holding quality so used to create some irrigation systems for irrigation agriculture purposes.

**PROPERTIES OF COCONUT COIR**

- Length in cm = 10 to 30
- Density = 1.40 gm/cc
- Breaking elongation = 30%
- Diameter in mm = 0.1 to 1.5
- Swelling in water = 5%
- Aspect ratio(average) = 150(dia 0.3 to 0.9 mm,length 6 to 24 mm)

**MIX PROPORTION**

The mix proportion of bricks are tabulated below.

**Table 9 EFFECTIVE REPLACEMENT OF RED SOIL WITH SLUDGE AND COCONUT COIR**

| Sample ID | Composition | | |
|---|---|---|---|
| | Clay soil | Coconut coir | Sludge |
| STD 1 | 100% | - | - |
| STD 2 | 100% | - | - |
| STD 3 | 100% | - | - |
| A1 | 100% | 0.01% | - |
| A2 | 100% | 0.01% | - |
| A3 | 100% | 0.01% | - |
| B1 | 95% | 0.01% | 5% |
| B2 | 95% | 0.01% | 5% |
| B3 | 95% | 0.01% | 5% |
| C1 | 90% | 0.01% | 10% |
| C2 | 90% | 0.01% | 10% |
| C3 | 90% | 0.01% | 10% |
| D1 | 85% | 0.01% | 15% |
| D2 | 85% | 0.01% | 15% |
| D3 | 85% | 0.01% | 15% |

**PROCESS OF BRICK MANUFACTURING**

There are four different operations involved in the process of brick manufacturing:

1. Preparation of base material
2. Moulding
3. Drying
4. Burning

**Preparation of base material**

The two raw materials namely red soil and sludge act as major ingredients. In addition to this, the percentage of coconut coir is kept constant. The raw materials with required proportion i.e. red soil and sludge with 0.1% of coir are mix together and sprinkled with water. After mixing the material properly it is kept in same manner for 12 to 16 hours. After 12 to 16 hours the mixture is again mixed properly by adding some water. All the mixing is done manually with hand and feet.

**Moulding**

After mixing the lump of mix is taken, rolled in sand and slapped into mould. The mould used is metal mould and is of size 190 mm*90 mm*90 mm. The mould is empty at drying area where bricks are arranged for dry in weight.

**Drying**

After moulding process, the bricks contain some amount of moisture in it. So, drying is to be done otherwise they may cracked while burning. The drying of raw bricks is done by natural process. The bricks are laid in stacks. When bricks are kept in sunlight after every two day they are turned over to facilitate uniform drying and prevent from warping. The period of drying may be 8 to 10 days. It also depends upon the weather conditions.

**Burning of bricks**

After 8 to 10 days they are ready to be burnt in kiln. The green bricks arranged in kiln and insulation is provided with mud pack. Fire holes are left to ignite the kiln are later sealed to keep the heat inside. The temperature is maintained at about 750˚C to 800˚C. This is maintained for week. After a week kiln is disassembled and bricks are sorted according to colour. Colour is an indication of the level of burning.

**EXPERIMENTAL WORK**

**Properties of red brick**

**Colour**

The colour of good brick should be uniform. It may red coloured.

**Shape**

Bricks should be uniform in shape with sharp straight right angled edges.

**Size**

Size of the bricks should be standard size which is of moderate size. Size of the brick is 190mm*90mm*90mm.

**Soundness**

A good brick should give metallic ringing sound when struck with another.

**Hardness**

A good brick should be sufficiently hard which can be tested by a finger nail. No mark should be left on the surface of the brick when scratched with thumb-nail.

**Compressive strength**

The crushing strength of a brick should not be less than 10-12N/mm as mentioned in IS 3495:1992 Part I.

**Water absorption**

First class brick should not absorb water more than 12-16% of its dry weight when soaked in water for 24hrs as per IS 3495:1992 Part II specifications.

**Structure**

A good brick should show fine, compact and uniform structure in broken.

**Strength**

The bricks should not break when dripped on hard ground from a hen about 1m.

**Durability**

A good brick should be able to resist the effects of weathering agencies like temperature, rain, etc.

**TESTS ON RED BRICKS**

The following tests are conducted on the bricks to find their suitability.

1. Compression strength test

2. Water absorption test.

3. Efflorescence test.

4. Shape and size test.

5. Structure test.

6. Soundness test.

7. Hardness test.

8. Strength test.

**Compression strength test**

Compressive strength is one of the important properties of bricks. Red bricks with sludge and coconut coir of size 19x9x9cm were cast. After casting it is taken and allowed to dry and tested in compressive strength testing machine. The specimens were tested according to the IS 3495:1992 Part II the rate of loading was about 14 $N/mm^2$ per minute till the failure occurs and note the maximum load at failure. Three numbers of whole bricks from sample collected should be taken and place the perforated faces of the brick between two plywood sheets each of 3mm thickness and carefully centered between the plates of the testing machine.

The load at failure is maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine. The calculations are using below formula,

Compressive strength = (Maximum load at failure (N))/ Average area of bed face ($mm^2$)

**Fig-6: Compression testing machine**

**Water absorption test**

Dry the specimen in a ventilated oven at a temperature of 105 °C to 115°C till it attains substantially constant mass. Cool the specimen to room temperature and obtain its weight ($W_1$) specimen too warm to touch shall not be used for this purpose. Immerse completely dried specimen in clean water an temperature of 27°C for 24 hours. Remove the specimen and weigh the Specimen after it has been removed from water ($W_2$). The test is carried per IS 3495:1992 Part II specifications. Water absorption, % given by the formula,

$W = [(W_1-W_2)/W_1] \times 100$

**Fig-7 : Water absorption test**

**Efflorescence test**

The presence of alkalis in the brick is not desirable because they form patches of red powder by absorbing moisture.

Hence to determine the presence of alkalis this test is performed. Place the specimen in a glass dish containing 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 25mm. After second evaporation absorb the brick for white or red patches.

**Fig-8: Efflorescence test**

### Size and shape test

In this test a specimen brick should be closely inspected. It should be of standard size and shape should be truly rectangular with sharp edges twenty bricks are randomly selected and stacked length wise, along the width and the height. For good quality bricks, the result should be within the permissible limit.

### Strength test

In this test the brick is dropped on hard a ground from a height of about 1m. The brick should not break this shows that the brick is strong. The figure shows that the brick dropped from 1m height and it does not its fail.

**Fig-9: Strength test**

### Structure test

In this test brick is broken or the broken brick is collected and closely observed. If there are any flows, cracks or holes present on the broken face then that is not good quality brick.

**Fig-10: Structure test**

### Soundness test

This test is conducted with two bricks are held by hands and struck with one another. If the bricks give clear metallic ringing sound and don't break then these are good quality bricks.

### Hardness test

In this test a scratch is made on the brick surface with a hard thing. If that does not let any impression then that is good quality brick. The brick does not show any impression of starch over its surface.

**Fig-11: Hardness test**

## TEST RESULTS AND DISCUSSIONS

The basic experiments mentioned in the previous chapter are conducted and the results are tabulated as follows.

The size of the brick specimen is 190 x 90 x 90mm.

Area of the specimen is 190 x 90 = 17100mm.

**TABLE 10 COMPRESSION STRENGTH OF CONVENTIONAL BRICKS**

| S.NO | DESCRIPTION | CONVENTIONAL BRICK LOADS(KN) |
|---|---|---|
| 1 | SAMPLE 1 | 3.73 |
| 2 | SAMPLE 2 | 3.85 |
| 3 | SAMPLE 3 | 3.75 |
| 4 | COMPRESSION STRENGTH ($N/mm^2$) | 3.775 |

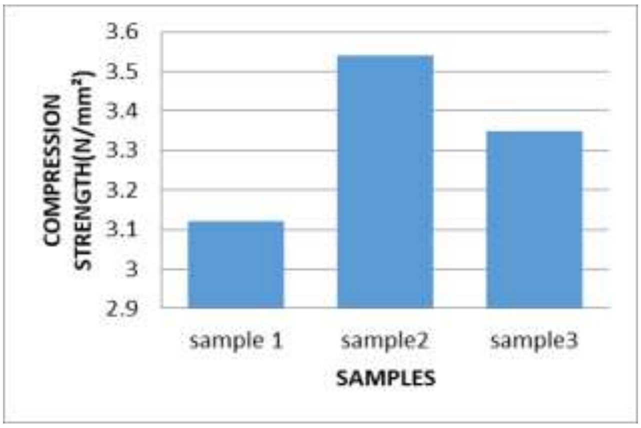


Fig-12 : Compression strength for conventional brick

**TABLE 11 COMPRESSION STRENGTH TEST WITH REPLACEMENT OF SLUDGE AND ADDITION OF COCONUT COIR**

| S.NO | DESCRIPTION | SLUDGE REPLACED | | |
|---|---|---|---|---|
| | | 5% | 10% | 15% |
| 1 | SAMPLE 1 | 3.12 | 3.78 | 3.43 |
| 2 | SAMPLE 2 | 3.54 | 3.73 | 3.18 |
| 3 | SAMPLE 3 | 3.35 | 3.7 | 3.53 |
| 4 | COMPRESSION STRENGTH ($N/mm^2$) | 3.34 | 3.735 | 3.38 |

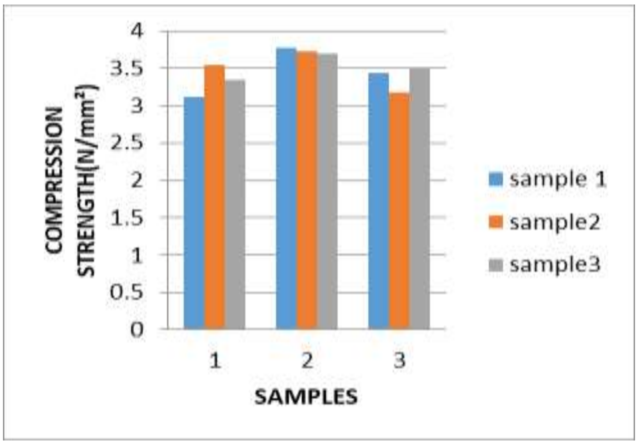


Fig-13 : Compression strength for sludge replaced brick

**TABLE 12 WATER ABSORPTION TEST FOR CONVENTIONAL BRICK**

| S.NO | CONVENTIONAL BRICK | WATER ABSORPTION (%) | AVERAGE WATER ABSORPTION (%) |
|---|---|---|---|
| 1 | SAMPLE 1 | 10.11% | |
| 2 | SAMPLE 2 | 12.08% | 11.7% |
| 3 | SAMPLE 3 | 12.21% | |

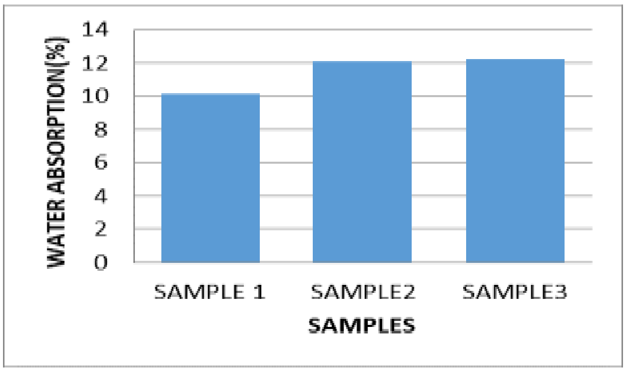


Fig-14 : Water absorption for conventional brick

**TABLE 13 WATER ABSORPTION TEST WITH REPLACEMENT OF SLUDGE AND ADDITION OF COCONUT COIR**

| S.NO | SLUDGE REPLACED | INITIAL WEIGHT ($W_1$)(kg) | WEIGHT AFTER TAKEN FROM WATER($W_2$)(kg) | WATER ABSORPTION (%) |
|---|---|---|---|---|
| 1 | 5% | 2.536 kg | 2.889 kg | 13.91% |
| 2 | 10% | 2.420 kg | 2.780 kg | 14.88% |
| 3 | 15% | 2.350 kg | 2.750 kg | 17.02% |

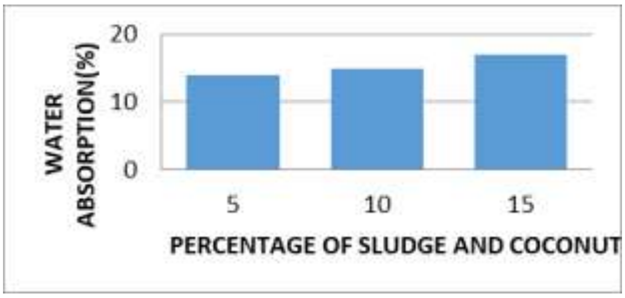


Fig-15 : Water absorption for sludge replaced brick

**TABLE 14 COMPARITIVE TEST RESULTS ON CONVENTIONAL RED BRICK WITH REPLACEMENT OF SLUDGE AND COCONUT COIR AS AN ADDITIVE**

| S.NO | DESCRIPTION | CONVENTIONAL BRICK | SLUDGE REPLACED | | |
|---|---|---|---|---|---|
| | | | 5% | 10% | 15% |
| 1 | COMPRESSIVE STRENGTH ($N/mm^2$) | 3.78 $N/mm^2$ | 3.34 | 3.73 | 3.38 |
| 2 | WATER ABSORPTION (%) | 11.7% | 13.91 % | 14.88 % | 17.02 % |
| 3 | EFFLORESCENCE | Nil | | | |

| | | |
|---|---|---|
| 4 | SHAPE AND SIZE TEST | Good |
| 5 | STRUCTURE TEST | No lumps and holes |
| 6 | SOUNDNESS TEST | Sounded well |
| 7 | HARDNESS TEST | No impression when scratched the brick |
| 8 | STRENGTH TEST | The bricks had not break |

## CONCLUSION

Based on limited experimental investigations, the following servations are made regarding the partial replacement of sludge with coconut coir in the manufacturing of red bricks. Maximum compressive strength is obtained at 15% replacement of sludge (3.77N/mm$^2$). It is reduces the cost of material per brick. It is found that water absorption property of prepared brick is (17%). Environmental effects of wastes and disposal problems of waste can be reduced through research. It is less weight when compared to conventional bricks. The brick shows no white patches over its top surface during efflorescence test. The brick has no cracks flows in structure test. The brick does not have any impressions over its surface when hardness test is performed. From this it is understand that the red brick with waste produces less weight and with standard strength. So it can be used for load bearing walls, interior partition walls. These bricks are cost effective bricks also.

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