# EXPERIMENTAL INVESTIGATION ON BRICK MANUFACTURING BY USING SLUDGE & PULP PRODUCTION RESIDUE

**D. Sakthivel[1], R. Dharunkumarasamy[2], L. Karthikeyan[3], S. Praveen Kumar[4], B. Surya[5]**

[1]*Assistant Professor (Sl.Gr), Department of Civil Engineering, Velalar College of Engineering Technology, Thindal, Erode, Tamil Nadu.*
[2,3,4,5] *Final Year Student, Department of Civil Engineering, Velalar College of Engineering Technology, Thindal, Erode, Tamil Nadu.*

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**Abstract -** *Bricks are the major concern building material used for constructional purpose. In earlier day's mud blocks & in now a days clay bricks are being used. In the manufacturing of clay bricks the $CO_2$ emission is more, since they are burned and the clay is exhausting. More than 300 million tons of industrial waste per annum in India mainly by chemical & industrial waste. Waste water treatment sludge is a type of waste obtained by industries. Paper pulp residue dominated during manufacturing of paper. Disposal of these waste into the environment causes land pollution. Many attempts have been made to overcome these problems. So the industrial waste materials & by products are used in the manufacturing of bricks. Here we have incorporated hypo sludge & the paper pulp residue along with fly ash, lime, quarry dust & gypsum to manufacture the bricks. The bricks are made without burning, $CO_2$ emission is controlled. Hype sludge & paper pulp residue are randomly added at different percentages such as 5%, 10%, 15% the tests are conducted & the optimum percentage is obtained from the results. This attempt will be a better solution for the pollution problem.*

***Key Words***: **Brick, Sludge, Pulp Production Residue.**

## 1. INTRODUCTION

### GENERAL

A brick is building material used to make walls, pavements in masonry construction. Traditionally, the term brick referred to a unit composed of clay, but it is now used to denote any rectangular units laid in mortar. A brick can be composed of clay-bearing soil, sand, and lime, or concrete materials. Bricks are produced in numerous classes, types, materials, and sizes. There are two main categories of bricks.

- Fired
- Non-fired bricks.

### Fired bricks

Fired bricks are burned in a kiln which makes them durable. Modern, fired, clay bricks are formed in one of three processes – soft mud, dry press or extruded. Depending on the country, either the extruded or soft mud method is the most common, since they are most economical.

### Non-fired bricks

Sewer Sludge, Burned Ash, Coal Ash, Molten Slag, Glass Waste & many other unused resources are utilized & are regenerated to form a revolutionary brick style block without baking. Although they are non-fired, they are very safe, high quality & low price.

## 1.2. TYPES OF BRICKS

- Common Burnt Clay Bricks
- Sand Lime Bricks (Calcium Silicate Bricks)
- Engineering Bricks
- Concrete Bricks
- Fly ash Bricks.

### 1.2.1. Common Burnt Clay Bricks

Common burnt clay bricks are formed by pressing in molds. Then these bricks are dried and fired in a kiln. Common burnt clay bricks are used in general work with no special attractive appearances. When these bricks are used in walls, they require plastering or rendering.

### 1.2.2. Sand Lime Bricks

Sand lime bricks are made by mixing sand, fly ash and lime followed by a chemical process during wet mixing. The mix is then molded under pressure forming the brick. These bricks can offer advantages over clay bricks such as:

- Their colour appearance is gray instead of the regular reddish color
- Their shape is uniform and presents a smoother finish that doesn't require plastering
- These bricks offer excellent strength as a load-bearing member.

### 1.2.3. Engineering Bricks

Engineering bricks are bricks manufactured at extremely high temperatures, forming a dense and strong brick, allowing the brick to limit strength and water absorption.

Engineering bricks offer excellent load bearing capacity damp-proof characteristics and chemical resisting properties. These bricks are used in specific projects and they can cost more than regular or traditional bricks.

### 1.2.4. Concrete Bricks

Concrete bricks are made from solid concrete and are very common among homebuilders. Concrete bricks are usually placed in facades, fences, and provide an excellent aesthetic presence. These bricks can be manufactured to provide different colours as pigmented during its production.

### 1.2.5. Fly Ash Bricks

Fly ash brick is a building material, specifically masonry units containing class C or class F fly ash & water, the bricks last for more than 100 freeze – thaw cycles. Owing to the high concentration of calcium oxide in class C fly ash, the brick is described as "Self-Cementing". The manufacturing method saves energy, reduces Pollution & costs 20% less than traditional clay brick manufacturing

### 1.3. WASTE

Waste may be defined as an unwanted material generated after the manufacturing process of industrial or from agricultural, or from house hold activity. It is the discarded material which essential requirement of disposal.

Waste causes many nuisances in the environment. It produces many types of viral or bacterial infection for the human and animal which create bed effect on health.

### 1.3.1. Waste Water Treatment Sludge

Sludge is a semi solid slurry that can be produced from a range of industrial processes from water treatment, waste water treatment or on-site sanitation systems. It can be produced as a settled suspension obtained from conventional drinking water treatment as sewage sludge from waste water treatment process.

Sewage sludge is a solid, semi solid or slurry residual material that is produced as a by-product of waste water treatment process. This residue is classified as Primary & Secondary Sludge. Primary sludge is generated from chemical precipitation, Sedimentation and other primary processes, whereas Secondary sludge is the activated waste biomass resulting from biological treatments.

### 1.3.2 Paper Pulp Residue

Pulp is a lignocellulosic fibrous material prepared by chemically or mechanically separating cellulose fibers from wood, Fiber crops, waste paper (or) rags. It includes newspapers, magazines & even toilet paper. Pulp is one of the most abundant raw materials. Chemical pulps are used for making Nano cellulose. Processing paper pulp to residue derived fuel can enhance physical stability & improve gasification efficiency.

### 1.4. NECESSITY AND SCOPE OF THE STUDY

- To check the feasibility of sludge as ingredient in brick making.
- To find a solution for the natural resources like clay.
- To solve the problem of waste disposal.
- To make eco-friendly low cost and durable construction material.

- Achieving the properties of bricks with replaced materials.
- Reduce the use of natural resources.
- Reduce the emission of $CO_2$ due to burning of bricks.

## 2. LITERATURE REVIEW

**R.V.Ralegaonkar, Sachin, A. Mandavgane, "Reuse of recycle paper mill waste in energy absorbing light weight bricks" (2011).** They have developed a way to create paper bricks from recycling waste made from 90% recycled paper mill waste and 10% cement, the mixture is mechanically mixed and pressed into molds and then cured in the sun. The physical and mechanical properties of brick samples with paper pulp and binder are investigated. The test results shows that RPMW-cement combination provides results which can be potentially used in the production of lighter and economical new brick materials. The observations during the tests show high energy absorption capacity even beyond the failure load. This composition produces brick which weigh half of that of the conventional clay Bricks. Their bricks are made from 90% recycled paper mill waste that has already been used in false ceilings and partition walls.

**G.V.S. Siva Prasad, Padmanabha Reddy "Study and Behaviour of some properties of Paper Crete Brick with Modular Bricks". International Journal of Engineering Research (2015).** This carried an experimental work on Paper Crete concrete cubes with normal mix and aggregate based mix made with cement, sand, paper pulp and aggregate indifferent mix proportions for determine the some properties. They had reported as Paper Crete can easily be molded into any desired shape, light in weight compared to conventional clay bricks and very good surface finish can be achieved. The weight of this brick is 2/3$^{rd}$ to 3/5$^{th}$ lesser than conventional clay bricks. Papercrete brick does not expand or contract, so sheets of glass or glass block can be embedded in and trimmed with Papercrete. Using the Paper Crete brick in a building, total cost will be reduced from 20 to 25%.

**Shrikant S Jahagirdar "Utilization of Textile Mill Sludge in Burnt Clay Bricks" (2015).** In this paper they are introducing the Textile mill sludge in the manufacturing of the bricks my mixing the clay soil and textile mill sludge together. He took the sludge for bricks by mixing with the clay soil as 0% to 35% by weight. Different samples of each percentage undergone through the various tests like compressive strength test, water absorption test, efflorescence as per the procedures of Bureau of Indian Standards. After the testing, the author conclude that the dry sludge can be used in the bricks as the partial replacement for the clay in the well burnt bricks. Hence it may reduce some cost of brick also. Textile mill sludge can be used up to 15% without compromising the chemical and physical properties of the bricks as per the IS code. As the organic matter is present in the sludge, when the brick is burnt at the 5500 oC temperature, it created the voids in the bricks. Which reduces the compressive strength of the brick and it increases the water absorption capacity as well.

**B. Shobha, "Utilization of Water Treatment Plant Sludge in the Brick Manufacturing" (2015).** In this paper she is saying that due to urbanization of the areas, it is very serious problem to dump the Waste sludge. We can drastically reduce the dumping problem of sludge by using it in to the manufacturing of bricks by partially replacing it with the clay soil. Before the use of sludge in to the bricks, the characteristics of sludge like PH, Aluminum, Lead, and Chromium were checked. Bricks were manufactured with the sludge variation of zero to thirty percent. Use of sludge in the bricks can reduce the cost of the brick also. All the bricks manufactured with sludge were tested to check the compressive strength and water absorption. As per the author, bricks up to 30% waste water sludge can be used for the non-load bearing structures.

## 3. OBJECTIVES

### 3.1. FLY ASH

Coal combustion product that is composed of the particulates (fine particles of fuel) that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with, bottom ash removed from the bottom of the boiler, it is known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide ($SiO_2$) (both amorphous and crystalline), aluminium oxide ($Al_2O_3$) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.

| Component | Bituminous | Subbituminous | Lignite |
|---|---|---|---|
| $SiO_2$ (%) | 20-60 | 40-60 | 15-45 |
| $Al_2O_3$ (%) | 5-35 | 20-30 | 20-25 |
| $Fe_2O_3$ (%) | 10-40 | 4-10 | 4-15 |
| CaO (%) | 1-12 | 5-30 | 15-40 |
| LOI (%) | 0-15 | 0-3 | 0-5 |

**Two classes of fly ash**

**Class F fly ash**

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 7% lime (CaO).

**Class C fly ash**

Fly ash produced from the burning of younger lignite or sub-bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash hardens and gets stronger over time. Class C fly ash generally contains more than 20% lime (CaO).

Worldwide, more than 65% of fly ash produced from coal power stations is disposed of in landfills and ash ponds, although companies such as Duke Energy are starting initiatives to excavate coal ash basins due to the negative environmental impact involved.

In India, fly ash bricks are used for construction. Leading manufacturers use an industrial standard known as "Pulverized fuel ash for lime-Pozzolana mixture" using over 75% post-industrial recycled waste, and a compression process. This produces a strong product with good insulation properties and environmental benefits.

### 3.2. QUARRY DUST

Quarry fines are produced from crushed rocks to obtain coarse aggregates. The proportions of fines vary according to the rock material used on the crushing process. In this project quarry fine is a term referring to fines and filler materials which will be use as portion replacement of natural sand of same sizes.

There are many applications of quarry dust in construction, processing, and landscaping and recreational applications.

**Table 2. Components of quarry dust**

| Element | Unit | Percentage |
|---|---|---|
| Calcium | %w/w | 6.44 |
| Iron | %w/w | 10.5 |
| Magnesium | %w/w | 6.54 |
| Sulfur | %w/w | 0.21 |
| Potassium | %w/w | 1.25 |
| Phosphorus | mg/kg | 30.30 |
| Cobalt | mg/kg | 35 |
| Copper | mg/kg | 43 |
| Manganese | mg/kg | 7.9 |
| Molybdenum | mg/kg | <5 |
| Zinc | mg/kg | 9.2 |
| Silicon | %w/w | 21.6 |

In the construction industry, quarry dust is used as an aggregate substitute especially for sand in a concrete mixture. The application of quarry dust can reduce the cost of construction.
Quarry dust is used to produce concrete blocks. It is mixed with chalk and gypsum to produce blocks. Quarry dust is also used to produce tiles, landscaping and recreational.

### 3.3. LIME

Lime is calcium oxide or calcium hydroxide. It is also the name of the natural mineral (native lime) CaO. The word lime originates with its earliest use as building mortar and has the sense of sticking or adhering.

These materials are still used in large quantities as building and engineering materials (including limestone products, cement, concrete, and mortar),as chemical feedstocks, and for sugar refining, among other uses.

Limestone is extracted from quarries or mines. Part of the extracted stone, selected according to its chemical composition and optical granulometry, is calcinated at about 1000 °C (1830 °F) in different types of lime kilns to produce quicklime according to the reaction.

Dry slaking is when quicklime is slaked with just enough water to hydrate the quicklime, but remain as a powder and is referred to as hydrated lime. In wet slaking, a slight excess of water is added to hydrate the quicklime to a form referred to as lime putty.

Because lime has an adhesive property with bricks and stones, it is often used as binding material in masonry works. It is also used in whitewashing as wall coat to adhere the whitewash onto the wall.

Gypsum is often added to Portland cement to prevent early hardening or "flash setting", allowing a longer working time.

### 3.4. WASTE WATER TREATMENT SLUDGE

Sludge is a semi solid slurry that can be produced from a range of industrial processes from water treatment, waste water treatment or on-site sanitation systems. It can be produced as a settled suspension obtained from conventional drinking water treatment as sewage sludge from waste water treatment process.

Sewage sludge is a solid, semi solid or slurry residual material that is produced as a by-product of waste water treatment process. This residue is classified as Primary & Secondary Sludge. Primary sludge is generated from chemical precipitation, Sedimentation and other primary processes, whereas Secondary sludge is the activated waste biomass resulting from biological treatments.

### 3.5. PAPER PULP RESIDUE

Pulp is a lingo cellulosic fibrous material prepared by chemically or mechanically separating cellulose fibers from wood, Fiber crops, waste paper (or) rags. It includes newspapers, magazines & even toilet paper. Pulp is one of the most abundant raw materials. Chemical pulps are used for making Nano cellulose. Processing paper pulp to residue derived fuel can enhance physical stability & improve gasification efficiency.

## 4. COLLECTION MATERIALS

### 4.1. PAPER

Paper is the main constituent materials. Due to tremendous increase in paper, 1600$m^3$ paper are wasted in India per day. Paper is principally wood cellulose, which is considered as fibrous materials.

### 4.2. CEMENT

Cement is one of the important binding materials in today construction materials. In this project, 43 grade ordinary Portland cement (OPC) confirming to IS 8112-1989 cement used.

### 4.3. QUARRY DUST

Quarry dust is used as it passes the properties similar to sand. Quarry dust is a waste material obtained from local stone quarries white crushing stones, crusher helps to reduce the caste of construction.

### 4.4. FLY ASH

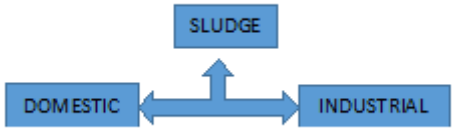
Fly ash is a waste by product from thermal power plants which use coal as fuel. Flu ash is used to reduce the use of cement.

### 4.5 LIME

Lime is calcium oxide or calcium hydroxide. It is also the name of the natural mineral (native lime) CaO. The word lime originates with its earliest use as building mortar and has the sense of sticking or adhering.

### 4.6 SLUDGE

Types of Sludge:



### 4.7. METHODOLOGY

1) Collection of sludge
2) Drying of Sludge
3) Brick making
4) Testing of Brick

### 4.7.1 METHODS OF MANUFACTURING OF BRICKS

- Mixing
- Moulding
- Drying

## 5. CHEMICAL CHARACTERISTICS

### 1) pH

The hydrogen ion concentration is an important quality parameter of waste water & measured to be 6.8 compared to 7.1 with treated effluent. Low value of pH is due to metabolism of fungus & metabolic production of acids by indigenous micro flora.

### 2) Colour

The colour of the waste water depends upon the different industrial process. The measurement and removal of colour is essential part as it is unfit for recycling without proper treatment.

### 3) Suspended Solids

The concentration of suspended solids measured from inlet of ETP ranges from 1160-1380 mg/l after treatment. The concentration of suspended solids measured from effluent ranges from 322-505 mg/l respectively.

### 4) Total Dissolved Solids

The concentration varied from inlet 1043-1293 mg/l whereas from treated effluent varied from 807-984 mg/l respectively. The value shows TDS are in permissible limit as compared with Indian standards.

### 5) BOD & COD

BOD & COD levels of influent waste water varied from 268-317 mg/l & 1110-1272 mg/l respectively. Whereas the BOD & COD levels of effluent varied from 176-282 mg/l and 799-1002 mg/l respectively. The slight reduction in BOD & COD value shows that removal percentage is 40-50% and 30-40%.

## 6. PROPERTIES

**PROPERTIES OF QUARRY DUST**

| S.NO | Name of test | Experimental value |
|---|---|---|
| 1. | Fineness modulus | 2.82% |
| 2. | Specific gravity | 2.24 |
| 3. | Water absorption | 2.46% |

**PROPERTIES OF CEMENT**

| S.NO | Name of test | Experimental value |
|---|---|---|
| 1. | Fineness modulus | 5% |
| 2. | Specific gravity | 2.31 |
| 3. | Consistency test | 30% |
| 4. | Setting Time | 26 min |

**PROPERTIES OF FLY ASH**

| S.NO | Name of test | Experimental value |
|---|---|---|
| 1. | Fineness modulus | 6% |
| 2. | Specific gravity | 3.9 |
| 3. | Consistency test | 47% |
| 4. | Setting Time | 18 min |

**MIX PROPORTIONS**

*Percentage by weight*

| Mix | Mix Percentage | Crusher % | Cement % | Fly ash % | Lime % | Waste Sludge % | Paper pulp Residue % |
|---|---|---|---|---|---|---|---|
| M1 | 5 % | 70.7 % | 2.65 % | 17.7 % | 5.9 % | 5 % | 5 % |
| M2 | 10 % | 67.7 % | 2.05 % | 15.7 % | 4.5 % | 10 % | 10 % |
| M3 | 15 % | 64.7 % | 1.75 % | 13.7 % | 3.8 % | 15 % | 15 % |

## 7. RESULTS AND DISCUSSIONS

### A. Compression Test

It determiner the Strength of bricks. Bricks used for construction should have compression strength more than 2.5 N/mm$^2$.Modulus of elasticity decreases due to increase in quantity of paper pulp & fly ash.

| S.No | Conventional Bricks (kN) | Mix 1 (5% replacement)(kN) | Mix 2 (10% replacement)(kN) | Mix 3 (15% replacement)(kN) |
|---|---|---|---|---|
| 1 | 155 | 83 | 73 | 68 |
| 2 | 129 | 79 | 70 | 56 |
| 3 | 116.5 | 81 | 68 | 48 |
| **Average Compressive strength in N/mm$^2$** | **7.80** | **3.13** | **2.70** | **1.89** |

### B. Water Absorption Test

It used to find out water absorption ratio. Upto 20% water absorbs less, above 20% it is high & these bricks are not suitable for water logging & exterior walls.

| Conventional bricks | Sludge bricks |
|---|---|
| There is no presence of grey or white deposits on the bricks. This indicates the absence of soluble salts in bricks. | Observation of water is very less and no grey or white deposits on the bricks. This indicates the absence of soluble salts in bricks. |

### C. Efflorescence test

Bricks were immersed in water for 24 hrs. Bricks were taken out & allowed to dry in shade. Here was no grey (or) White deposit on the brick surface. It results that bricks are free from soluble salts.

### D. Hardness Test

Scratch made on brick surface .While the scratch was made with the help of figure nail on the bricks are very light impression was left this bricks surface. It is tested the result should be efficiently hard.

| Conventional bricks | Sludge bricks |
|---|---|
| No finger nail impression is observed. It is observed from that the bricks are more resistance to external forces. | No impression of finger nail. It is observed from that the bricks are sufficiently strong. |

### E. Soundness test

Two Bricks from same proportion were taken and they were struck with each other. The bricks where not broken and a clear ringing sound was produced. So the bricks are good.

| Conventional bricks | Sludge bricks |
|---|---|
| Clear metallic ringing sound is observed. | Bricks did not break and produced a clear metallic ringing sound. |

### F. Fire Resistance Test

Bricks was wiped with cloths& flammable sticks were fixed. After 5 min, bricks were observed against that resistant to fire.

## 8. CONCLUSIONS

- Paper pulp bricks gives an economical option to green buildings.
- Paper pulp bricks have the ability to provide sufficient strength to walls.
- This Study helps in converting the non-valuable paper into bricks & makes it valuable.
- Strength of bricks decreased with increase in sludge concentration.
- Water absorption results indicated that sludge have less water absorption power.
- Bricks with sludge did not have any effect of efflorescence.

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## 10. BIOGRAPHIES:

D.SAKTHIVEL M.E.,
Assistant Professor(Sl.Gr),
Department of Civil Engineering,
Velalar College of Engineering and Technology, Erode.

R.DHARUNKUMARASAMY,
Final Year Student,
Department of Civil engineering,
Velalar college of engineering and technology, Erode.

L.KARTHIKEYAN
Final Year Student,
Department of Civil engineering,
Velalar college of engineering and technology, Erode.

S.PRAVEEN KUMAR
Final Year Student,
Department of Civil engineering,
Velalar college of engineering and technology, Erode.

B.SURYA
Final Year Student,
Department of Civil engineering,
Velalar college of engineering and technology, Erode.