

INVESTIGATING THE STRENGTH OF BRICKS USING WASTE MATERIALS

Submitted in partial fulfillment of the requirements for the award of Bachelor of
engineering degree in civil engineering

By

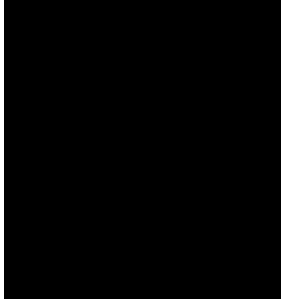
PRABHAKARAN M (Reg.No.37200053)

PRAVEEN KUMAR A (Reg.No.37200055)



**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENTAL
SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited with Grade “A” by NAAC
JEPPIAAR NAGAR, RAJIVGANDHI SALAI,
CHENNAI - 600 119**

APRIL 2021



SATHYABAMA

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Accredited with “A” grade by NAAC

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119

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DEPARTMENT OF CIVIL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **PRABHAKARAN.M (REG 37200053)** and **PRAVEEN KUMAR.A (Reg.No.37200055)**. Who carried out the project entitled “**INVESTIGATING THE STRENGTH OF BRICKS USING WASTE MATERIALS**” under our supervision from October 2020 to April 2021.

Internal Guide
Mrs. S. VANITHA M.E.,

Head of the Department

Submitted for Viva voce Examination held on_____

Internal Examiner

External Examiner

DECLARATION

We **PRABHAKARAN.M (37200053)** and **PRAVEEN KUMAR.A (37200055)** hereby declare that the project report entitled “**INVESTIGATING THE STRENGTH OF BRICKS WITH WASTE MATERIALS**” done by us under the guidance of **Mrs. VANITHA. M.E.** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Civil Engineering

DATE:

1.

PLACE:

2.

SIGNATURE OF CANDIDATE

ACKNOWLEDGEMENT

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We convey our thanks to **Dr. Devyani Gangopadhyay, B.Arch., M.T.P., Ph.D.**, Dean, School of Building and Environment and **Dr. S. Packialakshmi, M.E., Ph.D.**, and **Dr. R. Padmapriya, M.E., Ph.D.**, head of the department, dept of Civil Engineering for providing necessary support and details at the right time during the progressive reviews

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We wish to express our thanks to all Teaching and Non-Teaching staff members of the Department of Civil Engineering who were helpful in many ways for the completion of the project

ABSTRACT

This study aims to characterize the clay bricks produced by the addition of the two agricultural waste materials i.e. wooden waste ash and rice husk ash. Disposing off these waste materials is a very challenging task and is a hazard to environment. The Wooden waste ash and rice husk ash were collected locally from the cities of Viralimalai and Rajagiri, respectively. These were mixed with the clay for brick manufacturing in three different proportions i.e. 5, 10 and 15% by weight of clay. Mechanical i.e. compressive strength and modulus of rupture and durability properties i.e. water absorption; freeze-thaw and sulphate resistance of these bricks were evaluated. Test results indicated that the sulphate attack resistance and efflorescence of clay bricks incorporating Wooden waste ash and rice husk ash have been increased significantly. However, no significant effect on mechanical properties was observed. Furthermore, the additions of wastes have reduced the unit weight of bricks which decrease the overall weight of the structure leading to economical construction. Therefore, it can be concluded that the addition of waste materials in brick manufacturing can minimize the environmental burden leading towards more economical and sustainable construction.

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LIST OF SYMBOLS AND ABBREVIATIONS

Acronyms	Expansions
Kg	kilograms
%	percentage
KN	Kilo Newton
Mm	millimeter
M ²	meter square
M ³	meter cube
°C	Celsius
RHA	rise husk ash
WA	wooden waste ash

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Building material industry has witnessed an increased demand from the last decade due to an increased demand of housing for the growing urban population which has caused shortage of building materials. The crisis of raw material shortfalls is faced by the relevant industry to fulfill the increased demand of building materials. This situation has levied the need for searching other substitutes of raw materials. Consequently, as a result of this search for raw materials; the conversion of the industrial wastes to useful building and construction material has evolved as a substitute over conventional raw materials. By doing this not only the industrial waste will be recycled and used as building materials but there will be economic design of buildings.

The ultimate disposal of incinerated Bio mass ash can be accomplished by using it as an engineering construction material. One possible solution for the management of this sludge is to re-use it as a building material, namely, to incorporate this Bio mass ash into bricks. The fired clay brick is one of the most common and abundant masonry building materials and remain popular for its many characteristic properties. As such, the recycling of waste materials by incorporating them into bricks has been a popular topic of investigation over the last century, with varying degrees of success across a wide range of waste material.

In this study clay bricks have been prepared after incorporating RHA and WA in different proportion (5%, 10%, 15% by weight of clay). Burnt clay bricks were prepared in brick kiln on a massive scale. The utilization of these waste will be helpful in saving the natural resources along with economical and sustainable construction

CHAPTER 2

LITERATURE STUDY AND METHODOLOGY

2.1 LITERATURE REVIEW

First of all, various books and journals were collected for reference and were studied before starting the project work for having an idea about how the project should be. In this project an alternative building bricks are introduced. So, first the basic and essential characteristics of bricks were studied.

Preparation of eco-friendly construction bricks from hematite tailings

Youngling Chen, Yimin Zhang, Tiejun Chen, Yunliang Zhao, Shenxu Bao (2011)

Making construction bricks by using the hematite tailings , additives of clay and fly ash were added to the raw materials to improve the brick quality, Effect of raw materials formulation on the properties of fired specimens, effect of firing temperature, forming pressure and forming water content on the properties of fired specimens

Comparative study of the use of different biomass bottom ash in the manufacture of ceramic bricks

Yongliang Chen, Yimin Zhang, Tiejun Chen, Yunliang Zhao, Shenxu Bao

29,Dec-2017

The present study evaluates the suitability of several types of biomass bottom ashes[wood bottom ash(WBA), pine-olive pruning bottom ash(POPBA), olive stone bottom ash (OSBA), and olive pomace bottom ash (OPBA)] as an alternative source to replace ceramic raw material in the production of clay bricks.

Preparation of high strength autoclaved bricks from hematite tailings

Yunliang Zhao, Yimin Zhang, Tiejun Chen, Yongliang Chen, (2011)

Hematite tailings as main raw material to prepare high strength autoclaved bricks, optimum formulation was the mixtures of 70% hematite tailings, 15% lime and 15% sand, The compressive strength, flexural strength, compressive strength of hematite tailings autoclaved bricks after 15 freezing–thawing cycles and the mass loss of it with optimum process condition were 21.2 MPa, 4.21 MPa, 18.36 MPa and 0.72%,

respectively. They were well conformed to Autoclaved Lime–sand Brick Standard (GB119451999) for MU20 autoclaved bricks.

Autoclaved brick from low-silicon tailings

Zhao Jing, Liu Hong-jie (2007)

The load-bearing brick is made from low-silicon tailings by pressing and autoclaving process, in the presence of alkali-activated slag/ fly ash cementing material (AAFSC). Tailings accounts for 83% of the total mass of the brick. The compressive strength of the brick is up to 16.1 MPa, bending strength 3.8 MPa, and with low drying shrinkage and good freeze–thaw resistance. Some factors influencing the mechanical strength of the brick including forming pressure, forming water content and curing regime, are investigated. The hydration products, freeze–thaw durability and anti-carbonation characteristics of the products are discussed.

Development of bricks from waste material: a review paper:

Alaa.A.Shakir.(2013)

The large demand has been placed on building material industry especially in the last decade owing to the increasing population which causes a chronic shortage of building materials, the civil engineers have been challenged to convert waste to useful building and construction material. Recycling of such waste as raw material alternatives may contribute in the exhaustion of the natural resources; the conservation of not renewable resources; improvement of the population health and security preoccupation with environmental matters and reduction in waste disposal costs.

In the review of utilization of those waste, this paper reviewed recycling various waste material in bricks production. The effects of those wastes on the bricks properties as physical, mechanical properties will be reviewed and recommendations for future research as out comings of this review will be given. This reviewed approach on bricks making from waste is useful to provide potential and sustainable solution.

Reuse of natural waste material for making light weight bricks

Mohammad shahid Arshad *et al.* (2014) described, Bricks are a widely-used construction and building material around the world. Bricks are prepared from natural waste material which comprises of orange peels and coconut waste. Clay is used as a binding material for natural waste material and paper mill waste. The main objective of the present study is to reduce the quantity of clay with natural waste material. The orange peels and coconut waste which otherwise is land filled has been utilized to make construction bricks that serves a purpose of solid waste management. These wastes are used to reduce the quantity of clay as there is a greater shortage of clay in many parts of world. Initially, characterization of paper mill waste has been carried out by XRF, XRD and SEM. The SEM monographs shows that the waste has porous and fibrous structure. The bricks of prepared by orange peels and coconut waste with varying compositions of clay reduced the quantity of clay by (10% - 40% wt) and (10% - 60%) respectively and tested as per Bureau of Indian (BIS) 1077:1992 (fifth revision) and ASTM C 67-03a standards. From experimentation, it is observed that waste create bricks (WCB) prepared is light weight, shock absorbing and meets compressive strength requirements of ASTM C 67-03a and BIS. The brick making procedure being simple can be undertaken as rural entrepreneurship by unskilled labours of developing countries.

Bricks: an excellent building material for recycling wastes – a review

Aeslina Abdul Kadir (2011)

Brick is one of the most common masonry units as a building material due to its properties. Many attempts have been made to incorporate wastes into the production of bricks, for examples, rubber, limestone dust, wood sawdust, processed waste tea, fly ash, polystyrene and sludge. Recycling such wastes by incorporating them into building materials is a practical solution for pollution problem. This paper reviews the recycling of different wastes into fired clay bricks. A wide range of successfully recycled materials and their effects on the physical and mechanical properties of bricks have been discussed. Most manufactured bricks with different types of waste have shown positive effects on the properties of fired clay bricks

Experimental Investigation on Replacement of Bagasse Ash in Bricks (L. Vignesh Kumar, B. Jai Vignesh)

This paper carried out partial replacement of fly ash by bagasse ash in order to reduce industrial waste. The effective use of these waste products is challenging task for researcher through environmental impact. Bagasse is often used as a primary fuel source for sugar mills. When burned in quantity, it produces sufficient heat energy to supply all the needs of a typical sugar mill, with energy to spare. This sugar manufacturing industries produces a lot of sugarcane bagasse ash which is disposed of in an open land. Huge quantity of ash which is a waste product, available at very negligible rate. This sugarcane bagasse ash is a fibrous waste product and has pozzolanic properties which can be made use in construction industry. Pozzolanic materials can be used as a partial replacement in the production of low cost fly ash bricks. The aim of this research was to make economical and green bricks to maintain environmental balance, and avoid problem of ash disposal. It is very essential to dispose these wastes safely without affecting health of human being and environment. So, there is a great need for its reuse, also it is found that bagasse ash is high in silica and found to have pozzolanic property. So it can be used as substitute to construction material.

Development of Lighter and Eco-Friendly Burnt Clay Bricks Incorporating Sugarcane Bagasse Ash (Anwar Khitap, Syed Minhaj Saleem Kazmi)

Utilization of waste materials in the production of burnt clay bricks can be helpful in reducing the landfill burden. This study aims to develop lighter and eco-friendly burnt clay bricks incorporating sugarcane bagasse ash (SBA). Clay bricks were manufactured in a local brick manufacturing industrial kiln, incorporating SBA by weight of clay in different proportions. To study the properties of bricks, different mechanical and durability tests were performed as per ASTM C67. Results showed that SBA can be helpful in manufacturing of lighter bricks. Bricks incorporating SBA exhibit compressive strength lesser than traditional clay bricks; however, burnt clay bricks incorporating 5% SBA by clay weight fulfilled the minimum requirement for compressive strength according to the Building code of Pakistan. Moreover, efflorescence was improved after adding the SBA in burnt clay bricks. Therefore, lighter and

Sustainable bricks can be produced after utilization of small amount of SBA (i.e., 5%) in burnt clay bricks.

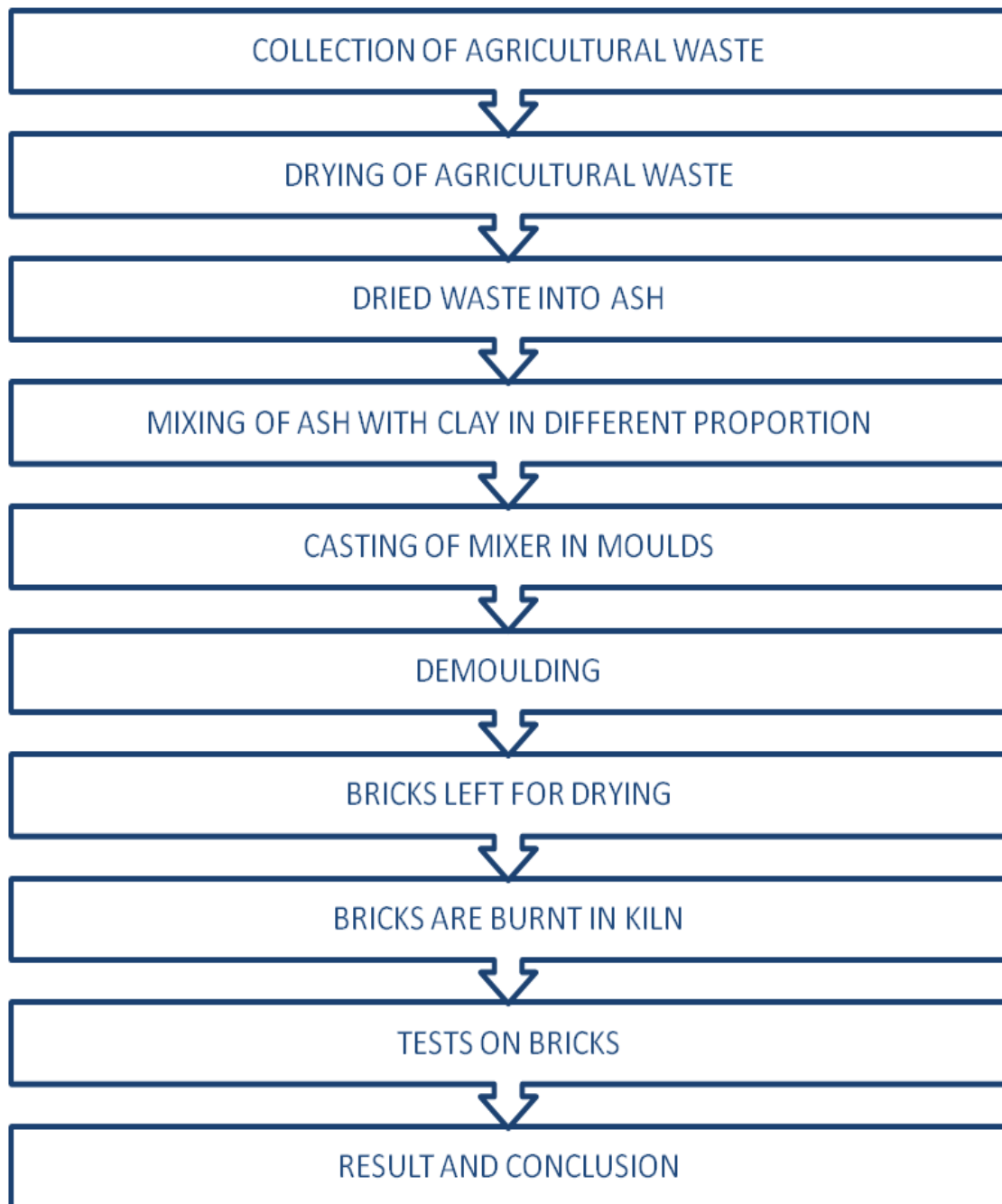
The use of different forms of waste in the manufacture of ceramic bricks

**Eliche-QuesadaC.Martínez-GarcíaM.L.Martínez-CartasM.T.Cotes-
PalominoL.Pérez-VillarejoN.Cruz-PérezF.A.Corpas-Iglesias**

In this study, various industrial wastes such as urban sewage sludge, bagasse, and sludge from the brewing industry, olive mill wastewater, and coffee ground residue were blended with clay to produce bricks. The clay and waste were characterized by X-ray diffraction, X-ray fluorescence, and thermogravimetric, differential thermal, and chemical elemental analysis. The bricks were manufactured from clay and the optimal proportion of waste. The influence of the waste addition on the linear shrinkage, bulk density, water absorption, and mechanical and thermal properties was investigated. Water absorption increased to above 35% when urban sewage sludge, brewing industry sludge and bagasse were incorporated into the body, but the compressive strength decreased by a maximum of 19% and the thermal insulation increased by at least 8%. The incorporation of coffee grounds and olive mill wastewater of clay was more beneficial, with compressive strength values similar to bricks without waste and a 19% improvement in thermal conductivity. Water absorption and the SEM micrographs indicated that the changes in the results were due to the type of porosity formed by the quantity and the type of waste.

2.2 METHODOLOGY AND ANALYSIS

Flowchart Showing the Manufacture of Bricks



CHAPTER – 3

AIM AND SCOPE

3.1 OBJECTIVES

- To use biomass combustion ash waste (rice husk and wood ash) as secondary raw materials in the manufacture of clay bricks.
- To determine the physical and chemical properties of the wooden waste ash and rice husk ash.
- To determine the strength of the bricks by using the waste materials.
- To minimize the environmental pollution.

3.2 SCOPE:

- To promote the solid waste from the wooden cutting mills and rice mills as a useful product.
- To manage the disposal of waste product into construction raw material.
- To dispose the waste safely.
- To encourage the waste products as eco-friendly material.
- To make the bricks which are energy efficient which is the only viable solution to the environmental concerns and natural resources
- Conservation for future generations.

CHAPTER 4

EXPERIMENTAL TESTING

4.1 Material used

4.1.1 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 Viralimalai. The collected soil samples are dried and then used for the preparation for bricks in Kalkuthampatti, Viralimalai.

4.1.2 WOODEN WASTE ASH:

Wooden waste ash is the powdery residue remaining after the combustion of wood, such as burning wood in a fireplace, bonfire, or an industrial power plant.

4.1.3 RICE HUSK ASH:

Rice husks are the hard protective coverings of rice grains which are separated from the grains during milling process. In the course of a typical milling process, the husks are removed from the raw grain to reveal whole brown rice which upon further milling to remove the bran layer will yield white rice.





4.2 Experimental Procedure

4.2.1 Prepare the mold:

The standard size of a brick is 9x9x19 cm can make molds for single brick as well as multiple bricks.

4.2.2 Prepare the clay

Dig the required amount of soil and ship it to the brickmaking site. Test if the soils need to be mixed with some additional amount of sand. Mix a sufficient amount of water to the soil to make it clay. The clay should be solid enough to hold its shape, but at the same time it should be liquid enough to fill in the mold.

4.2.3 Make the raw brick

Pour the prepared clay into the mold and let it set for half an hour. After that it should easily come out from the mold as raw brick.

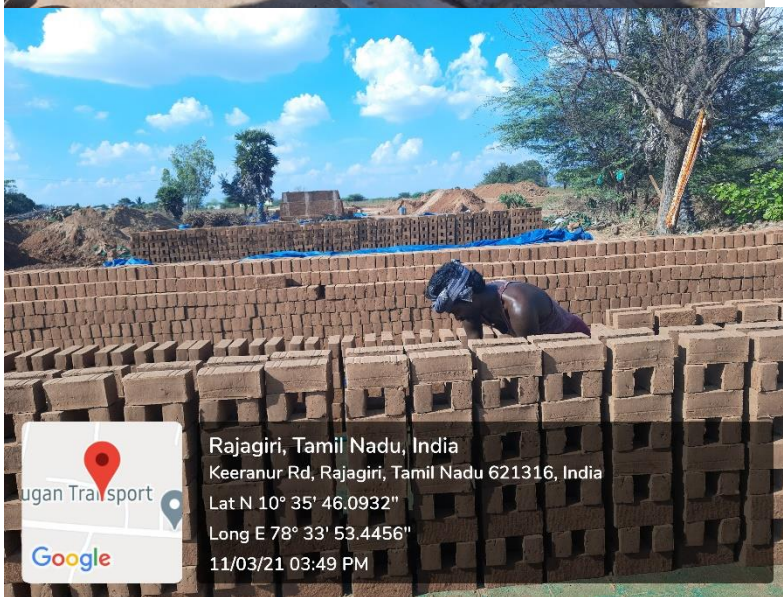
4.2.4 Sun drying

The raw brick should be kept on dry sand in the sun for drying by solar energy. This is an important step for making adobe brick. Leave the brick until all the exposed edges become white. After that turn them on their edges. This whole process may take at least three weeks. The final moisture content of the adobe clay brick will be around 10-15%. At this point, the adobe bricks will be ready to use.

4.2.5 Fire Drying:

In the process of burning, the dried bricks are burned either in clamps (small scale) or kilns (large scale) up to certain degree temperature. In this stage, the bricks will gain hardness and strength so it is important stage in manufacturing of bricks. The temperature required for burning is about 900°C. If they burnt beyond this limit they will be brittle and easy to break. If they burnt under this limit, they will not gain full strength and there is a chance to absorb moisture from the atmosphere.

Hence burning should be done properly to meet the requirements of good brick.





Rajagiri, Tamil Nadu, India
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4.3 BRICKS

The bricks are obtained by molding clay in a rectangular block of uniform size and then by drying and burning the blocks. As the bricks are of uniform size, they can be properly arranged and further, as they are in lightweight, no lifting appliance is required for them. The common brick is one of the oldest building materials and it is extensively used at present as a leading material in construction. In India, process of brick making has not changed since many centuries except some minor refinements. There has been hardly any effort in our country to improve the brick-making process for enhancing the quality of bricks.

A brick is generally subjected to the following tests to find out its suitability for the construction work.

4.3.1 Absorption

A brick is taken and it is weighed dry. It is then immersed in water for a period of 24 hours. It is weighed again and the difference in weight indicates the amount of water absorbed by the brick. It should not, in any case, exceed 20% of weight of dry brick.

4.3.2 Crushing Strength

The crushing strength of a brick is found out by placing it in a compression-testing machine. It is compressed till it breaks, as per BIS: 1077-1957, the minimum crushing strength of brick is 3.50 N/mm^2 . The brick with crushing strength of 7 -14 N/mm^2 are graded as 'A' and those having above 14 N/mm^2 is graded as 'AA'.

4.3.3 Hardness

In this test, a scratch is made on the brick surface with the help of finger nail. If no impression is left on the surface, the brick is treated to be sufficiently hard.

4.3.4 Presence of soluble salts

The soluble salts, if presents in brick will cause efflorescence on the surface of bricks. For finding out the presence of soluble salts in brick, it is immersed in water for 24 hours. It is then taken out and allowed to dry sunshade. The absence of grey or white deposits on its surface indicates absence of soluble salts.

If the white deposit covers about 10% surface, the efflorescence is said to be slight and it is considered as moderate, when the white deposit cover about 50% surface. If grey or white deposits are found on more than 50% of surface, the

efflorescence becomes heavy and it is treated as serious, when such deposits are converted into powdery mass.

4.3.5 Shape and size

In this test, a brick is closely inspected. It should be of standard size and its shape should be truly rectangular with sharp edges. For this purpose, 20 bricks of standard size (190mm X 90mm X 90mm) are selected at random and they are stacked length wise, along the width and along the height.

4.3.6 Soundness

In this test, two bricks are taken and they are struck each other. The bricks should not break and a clear ringing sound should be produced.

4.3.7 Structure

A brick is broken and its structure is examined. It should be homogeneous, compact and free from defects such as holes, lumps etc.

CHAPTER 5

RESULTS AND DISCUSSION

There are four different tests are undergone in Bricks;

They are,

1. Visual Test,
2. Compressive Strength Test,
3. Water Absorption Test,
4. Efflorescence Test.

5.1 VISUAL TEST

Sl.No	TESTS	Y/N
1)	The bricks should be well finished, smooth and are free from cracks.	Yes
2)	They should possess 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 15 % when immersed in water for 24 hours.	Yes
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5.2 COMPRESSIVE STRENGTH TEST

5.2.1 Apparatus

A compression testing machine, the compression plate of which shall have a ball seating in the form of portion of a sphere the Centre of which coincides with the Centre of the plate, shall be used.

5.2.2 Preconditioning

Remove unevenness observed in the bed faces to provide two smooth and parallel faces by grinding. Immerse in water at room temperature for 21 hours. Remove the specimen and drain out any surplus moisture at room temperature. Fill the frog (where provided) and all voids in the bed face flush with cement mortar (1 cement, clean coarse sand of grade 3 mm and down). Store under the damp jute bags for 24 hours followed by immersion in clean water for 3 days. Remove, and wipe out any traces of moisture.

Mix	Sample 1 (kN)	Sample 2 (kN)	Sample 3 (kN)	Average Compressive Strength(N/mm ²)
M1	81	78	77	4.59
M2	82	91	85	5.02
M3	98	102	99	5.82
Conventional Mix	150	115	163	8.34

5.2.3 REFERENCE

The Indian Standard IS 5454: 1976 'Method for sampling of clay building bricks (first Revision)' *is* a necessary adjunct to this standard.

$$\text{Compressive strength in N/mm}^2 \text{ (kgf, cm}^2\text{)} = \frac{\text{Maximum load at failure in N(kgf)}}{\text{Average area of the bed faces in mm}^2 \text{ (cm}^2\text{)}}$$

$$\text{M1 Compressive Strength (N/mm}^2\text{)} = \frac{81 \times 1000}{190 \times 90} = 4.73 \text{ N/mm}^2$$

$$\text{M1 Compressive Strength (N/mm}^2\text{)} = \frac{78 \times 1000}{190 \times 90} = 4.56 \text{ N/mm}^2$$

$$\text{M1 Compressive Strength (N/mm}^2\text{)} = \frac{77 \times 1000}{190 \times 90} = 4.5 \text{ N/mm}^2$$

$$\text{M2 Compressive Strength (N/mm}^2\text{)} = \frac{82 \times 1000}{190 \times 90} = 4.79 \text{ N/mm}^2$$

$$\text{M2 Compressive Strength (N/mm}^2\text{)} = \frac{91 \times 1000}{190 \times 90} = 5.32 \text{ N/mm}^2$$

$$\frac{85 \times 1000}{190 \times 90}$$

M2 Compressive Strength (N/mm²) = 4.97 N/mm²

$$\frac{98 \times 1000}{190 \times 90}$$

M3 Compressive Strength (N/mm²) = 5.73 N/mm²

$$\frac{102 \times 1000}{190 \times 90}$$

M3 Compressive Strength (N/mm²) = 5.96 N/mm²

$$\frac{99 \times 1000}{190 \times 90}$$

M3 Compressive Strength (N/mm²) = 5.78 N/mm²

$$\frac{150 \times 1000}{190 \times 90}$$

Conventional Mix, Compressive Strength (N/mm²) = 8.77 N/mm²

$$\frac{115 \times 1000}{190 \times 90}$$

Conventional Mix, Compressive Strength (N/mm²) = 6.72 N/mm²

$$\frac{163 \times 1000}{190 \times 90}$$

Conventional Mix, Compressive Strength (N/mm²) = 9.53 N/mm²

$$\frac{4.73 + 4.56 + 4.5}{3}$$

Average Compressive Strength of M1 = 4.59 N/mm²

$$\frac{4.79 + 5.32 + 4.97}{3}$$

Average Compressive Strength of M2 = 5.02 N/mm²

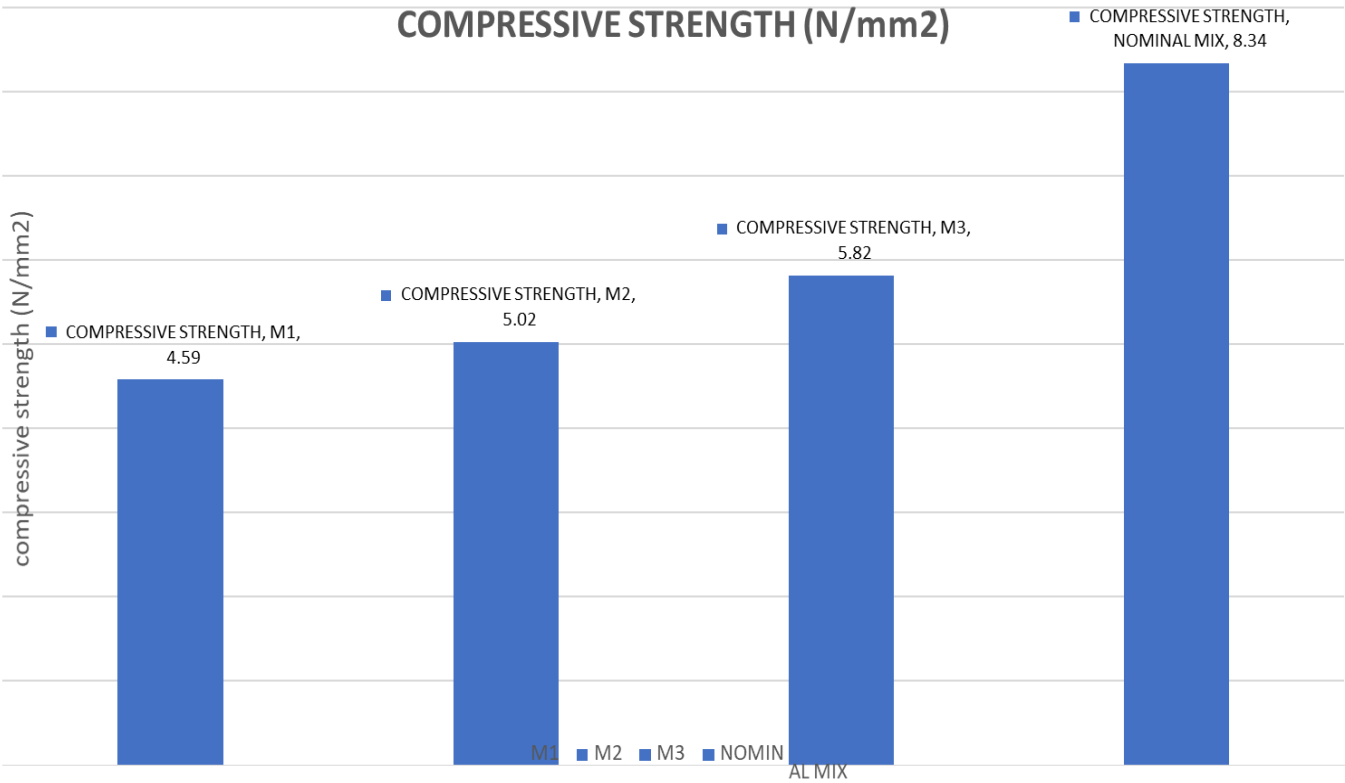
$$\frac{5.73 + 5.96 + 5.78}{3}$$

Average Compressive Strength of M3 = 5.79 N/mm²

$$\frac{8.77 + 6.72 + 9.53}{3}$$

Average Compressive Strength of Conventional Mix =

= 8.34N/mm2



5.3 WATER ABSORPTION TEST

5.3.1 Apparatus

A sensitive balance capable of weighing within 0.1 percent of the mass of the specimen; and a ventilated oven.

5.3.2 Preconditioning

Dry the specimen in a ventilated oven at a temperature of 105 to 115°C till it attains substantially constant mass. Cool the specimen to room temperature and obtain its weight (M₁). Specimen warm to touch shall not be used for the purpose.

WATER ABSORPTION TEST RESULTS

Mix	Dry Weight (Kg) M ₁	Wet Weight (Kg) M ₂	Water Absorption (%)
W1	2.913	3.182	9.23
W2	2.805	3.167	12.90
W3	2.790	3.192	14.40
Conventional Mix	2.885	3.389	17.46

5.3.3 REFERENCE

The Indian Standard IS 5454: 1976 'Method for sampling of clay building bricks (first Revision)' is a necessary adjunct to this standard.

$$\frac{M_2 - M_1}{M_1} \times 100$$

Water Absorption % =

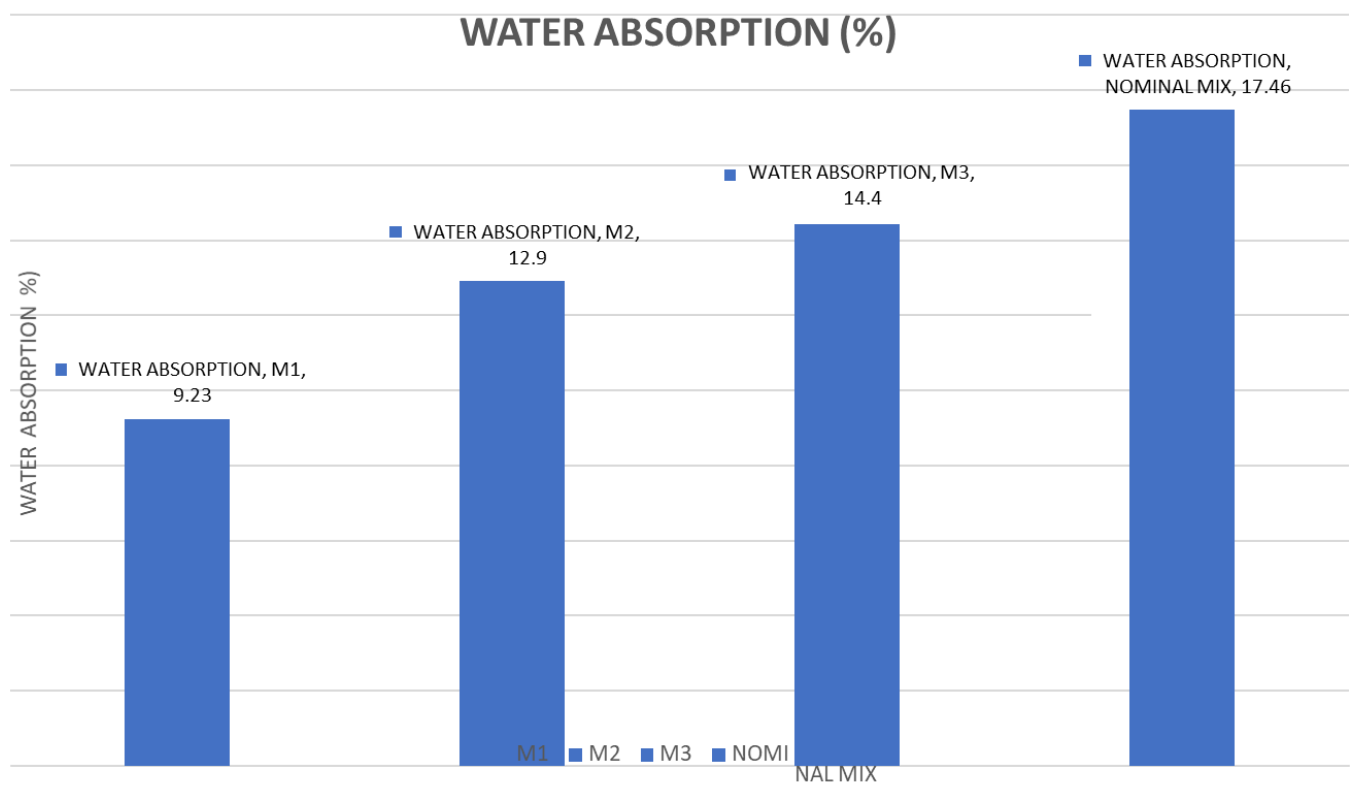
$$\text{Water Absorption \% (W1)} = \frac{3.182 - 2.913}{2.913} \times 100 = 0.0923 \times 100 = 9.23\%$$

$$\text{Water Absorption \% (W2)} = \frac{3.167 - 2.805}{2.805} \times 100 = 0.129 \times 100 = 12.9\%$$

$$\text{Water Absorption \% (W3)} = \frac{3.192 - 2.790}{2.790} \times 100 = 0.144 \times 100 = 14.4\%$$

$$\text{Water Absorption \% (Conventional Mix)} = \frac{3.389 - 2.885}{2.885} \times 100 = 0.1746 \times 100 = 17.4\%$$





5.4 EFFLORESCENCE TEST

5.4.1 Apparatus

A shallow flat bottom dish containing sufficient distilled water to completely saturate the specimens. The dish shall be made of glass, porcelain or glazed stoneware and of size 180 mm x 180 mm X 40 mm depth for square shaped and 200mm dia X 40 mm depth for cylindrical shaped.

Mix	Efflorescence		
	Sample 1	Sample 2	Sample 3
M1	Slight	Slight	Slight
M2	Nil	Nil	Nil
M3	Nil	Nil	Nil
Conventional Mix	Nil	Nil	Nil

5.4.2REFERENCE

The Indian Standard IS 5454: 1976 'Method for sampling of clay building bricks (first Revision)' is a necessary adjunct to this standard.

5.4.3Report

The liability to efflorescence shall be reported as 'nil', 'slight', 'moderate', 'heavy' or 'serious' in accordance with the following definitions:

1. **Nil** - When there is no perceptible deposit of efflorescence.
2. **Slight** - When not more than 10 percent of the exposed area of the brick is covered with a thin deposit of salts.
3. **Moderate** - When there is a heavier deposit than under 'slight' and covering up to 50 percent of the exposed area of the brick surface but unaccompanied by powdering or flaking of the surface.
4. **Heavy** - When there is a heavy deposit of salts covering 50 percent or more of the exposed area of the brick surface but unaccompanied by powdering or flaking of the surface.
5. **Serious** -When there is a heavy deposit of salts accompanied by powdering and/or flaking of the exposed surfaces.

CHAPTER 6

CONCLUSION

- Agriculture waste (RHA and WA) utilization in burnt clay bricks is an effective way of disposal of waste materials leading to sustainable construction. Lighter bricks can be produced after addition of RHA and WA in burnt clay bricks.
- Lighter bricks are helpful in achieving economy during construction. Brick specimens after incorporating RHA and WA showed less compressive and flexural strength.
- Furthermore, porosity, water absorption and initial rate of absorption was increased with the addition of waste in burnt clay bricks. High porosity is usually related with good insulation properties.
- Burnt clay bricks with 15% waste addition can be used in moderate weather according to water absorption results.
- Efflorescence results were also encouraging. Based on the study, it can be concluded that bricks incorporating RHA and WA up to 15% can be effectively used for construction purposes leading to sustainable construction.

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