

An experimental investigation on bricks by partial replacement of red soil with copper slag and sculpture waste

Vindhya Shree M P, Sai V Kalal, Prashanth Mugali, Sharath S, Prashanth Kumar

Abstract— Since the large demand has been placed on the building material industry especially in the last decade owing to the increasing population, increase in infrastructure and also increase in new infrastructural projects. Which causes a chronic shortage of building material; the civil engineering has been challenged to convert waste to use full building and construction material like brick. Recycling of such wastes as raw material alternative may contribute in the exhaustion of the natural resources which will help to create awareness towards clean environment. In the review of utilization of those waste, this paper reviewed recycling various waste like copper slag and sculpture waste with red soil in brick. All mixtures are subjected to oven curing until the testing age. However, the brick specimen size is 220mm*100mm*100mm. Bricks are one of the oldest types of building blocks. They are an ideal building material because they are relatively cheap to make, very durable, and require little maintenance. A brick is a block of ceramic material used in masonry construction, usually laid using various kinds of mortar. Bricks dated 10,000 years old were found in the middle east. Examples of the civilizations that used mud brick are the ancient Egyptians and the Indus Valley Civilization, where it was used exclusively. The first sun-dried bricks were made in Iraq, in the ancient city of Ur in about 4000 BC. Bricks are a widely used construction and building material around the world. Conventional bricks are produced from clay with high temperature kiln firing or from ordinary Portland cement (OPC) concrete, and thus contain high embodied energy and have large carbon footprint. In many areas of the world, there is already a shortage of natural source material for production of the conventional bricks.

Index Terms— Red soil, sculpture waste, copper slag.

1 Introduction

FOR environmental protection and sustainable development, extensive research has been conducted on production of bricks from waste materials. This paper presents a state-of-the-art review of research on utilization of waste materials to produce bricks. A wide variety of waste materials have been studied to produce bricks with different methods. The research can be divided into three general categories based on the methods for producing bricks from waste materials: firing, cementing and geo polymerization. Although much research has been conducted, the commercial production of bricks from waste materials is still very limited. The possible reasons are related to the methods for producing bricks from waste materials, the potential contamination from the waste materials used, the absence of relevant standards, and the slow acceptance of waste materials-based bricks by industry and public.

For wide production and application of bricks from waste materials, further research and development is needed, not only on the technical, economic and environmental aspects but also on standardization, government policy and public education related to waste recycling and sustainable development. The increase in the popularity of using environment friendly, low cost and light weight construction materials in building industry has brought about the need to investigate how this can be achieved by benefiting the environment as well as maintaining the material requirements affirmed in the standard. Recycling of waste generated from industrial and agricultural activities as building materials appears to be viable solution not only to such pollution problem but also to the problem of economic design of buildings (Perez JA et al, 1996). Brick belongs to the wide family of construction materials since it is mainly used for the construction of outer and inner walls in buildings. The brick industry is the most indicated technological activity sector to absorb solid waste due to the large quantity of raw material used by the sector as well as by the large volume of final products in construction.

Various attempts were made to incorporate various waste material in bricks production such as natural fibers, textile laundry waste water sludge, foundry sand, granite sawing waste, perlite, processed waste tea, sewage sludge, structural glass waste, PC and TV waste, fly ash, sugar cane bagasse ash, organic residue, steel dust, bottom ash, rice husk ash, silica fume, marble and granite waste, municipal solid incineration fly ash slag. This review highlights the effects of various waste material on the bricks property like physical and mechanical properties as well as thermal insulation.

Examined the properties of clay brick made by adding two materials like copper slag and sculpture waste to clay water mixture with baked and non-baked conditions. Compressive strength, water absorption was performed according to British standard BS3921:1985, and Malaysian Standards MS 76:1972. Results indicated that the compressive strength of the bricks were fulfilled the minimum requirement of BS3921:1985 for compressive strength of the conventional bricks. Efflorescence was only feasible for baked samples as the nonbaked ones formed severe deterioration while testing. The prevailing benefit of the fiber inclusion was more benefit for baked specimen where the strength gets surpassed that of nonbaked added only specimen.

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The obtained compressive strength, flexural strength and water absorption values satisfy with the relevant international standards. The experimental observations reveal that high level replacement of red soil with copper slag and sculpture waste does not exhibit a sudden brittle fracture even beyond the failure loads, indicates high energy absorption capacity, reduces the unit weight dramatically and introduces smoother surface compared to the current concrete bricks in the market. The proposed mixing of waste water sludge with clay to produce bricks for civil construction. All bricks were fabricated by extrusion method, dried at 100 degrees Celsius and then fired at 900 degrees Celsius. Mechanical properties of ceramics as flexural strength and water absorption were satisfactory within the Brazilian legislation. The obtained results showed that sludge can be incorporate bricks until a concentration of 20% (mass basis) producing suitable bricks in terms of its mechanical properties. Besides, the produced bricks are safe and inert according to the applied leaching a solubilization tests. With high compressive strength of fiber reinforced mud bricks made out of clay, cement, basaltic pumice, lime and gypsum using plastic fiber, straw, polystyrene fabric as fibrous ingredients, each at a time. It was demonstrated that the fiber reinforced mud brick fulfill the compressive strength requirement of Turkish codes, whereby reducing the weight and material handling cost for housing.

A comparative study to produce ceramic bricks from clay with two types of foundry sand (green and core sand). Clay/green sand bricks with 35% green core and 25% green sand fired at 1050 degree Celsius have the better physical properties values, while the mineralogy is not significantly affected. It was shown that foundry sand is recommended as raw material in the manufacture of ceramic product, whereby saving in costs of brick production. India produces about 250 billion bricks per annum in the world to do so. The use of waste has become evident as a practical technology in brick production. Recent reviews on fired bricks have highlighted that assortment of organic and in-organic solid waste materials can be used by incorporating these into brick. Bricks are one of the oldest types of building blocks. They are an ideal building material because they are relatively cheap to make, very durable, and require little maintenance. A brick is a block of ceramic material used in masonry construction, usually laid using various kinds of mortar.

The copper slag production in industrial is large and increases with time. In each country the copper slag composition is different, since it is affected by socio economic characteristics, consumption patterns and waste management programs, but generally the level of copper slag in waste composition is high. The largest component of the copper slag smelting.as we know that Copper slag is by-product obtained during the copper smelting and refining process. It is a product which contains 30-35 percentage of copper, 12 per. Of silica and 5 percentage of calcium. Gypsum is a soft mineral composed of calcium with the calcium formula of $CaSO_4 \, 2H_2O$. Gypsum is widely mined and is used as fertilizer, and as the main constituent in many forms of plaster, blackboard chalk and wallboard. A massive fine-grained white or lightly tinted variety of gypsum, called alabaster, has been used for sculpture by many cultures including Ancient Egypt, Mesopotamia, Ancient Rome, the Byzantine Empire and the Nottingham alabasters of Medieval England.

Our life rivers pond obscure and clean water to drink. Some particular community to fulfill their religious customs and worship god. They deposit lots of waste thing to make this water resources unfit. Worship system causes water pollution and they are likely short-lived.

2 Objectives

- Objective of the research work is to study the effect of the copper slag and sculpture waste bricks.
- The properties of bricks with the view to study the comparison between clay brick, copper slag and sculpture waste.
- Copper slag and sculpture waste are enriched by silica, are the main constituents for conventional building material.
- The building structures are getting heavier with time, the use of this combination of bricks would be more efficient as well as environment friendly.
- The research will be helpful for the aquatic animal.
- To minimize the water pollution.
- Construction industries will build a new thrust by this research work.

3 Literature review

In this, an elaborative discussion is made regarding works done so far in this area as literature review. Several authors have reported the use of partial replacement of red soil with copper slag and sculpture wastes and in various civil engineering applications.

Hubli Kiran, Beedimani Priyanka, Aishwarya, Karale Suneel: A Study on Manufacturing of Bricks using Black Cotton Soil and Red Soil -The Physical Properties of Black Cotton Soil Red Soil and water are within the permissible limits as per relevant IS codes. The Physical Properties of manufactured bricks is better and are suitable for construction of common buildings.

Dr. T Shekar: Utilization of Industrial Wastes for production of Red Soil Bricks- It is possible to manufacture good quality bricks from locally available red soil and using industrial waste material either fly ash or granite waste or both. It possible to manufacture of bricks with higher compressive strength, lower percentage of water absorption and higher weight density for the soil-ash, soil-waste. The red soil is highly expansive and sticky in nature when it comes in contact with water, and hence it is very difficult to mix and pug the soil.

Chayan Gupta, Ravi Kumar Sharma: Black Cotton Soil Modification by the application of Waste Materials- In this research approach is made towards the way of improvement in the various geotechnical properties of black cotton soil such as index properties, swelling characteristics, consolidation characteristics, hydraulic conductivity characteristics and strength charac-

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teristics and strength bleeding it with waste materials such as river sand, fly ash and marble dust. It can be well stabilized with river sand, fly ash and marble dust as black cotton soil converts to a well graded material on their addition.

Dhamotharan Ms. G. Minnalkodi Dr. G. Dhanalakshmi: Comparative Study on Red Soil Bricks using Fly Ash and Crusher Waste- The maximum compressive strength of brick using red soil and fly ash is obtained 3.82 N/mm2. Maximum water absorption should not exceed 20% in the red soil and fly ash brick the water absorption is 12.3%. Hence the brick is suitable for building work.

S. Srikanth Reddy, A. C. S. V. Prasad, and N. Vamsi Krishna: Lime-Stabilized Black Cotton Soil and Brick Powder Mixture as Subbase Material- Black cotton soil procured from the local area, tested and resulted in very less CBR value, the mixture of 20% brick powder and 80% lime-stabilized black cotton soil under study resulted in increase in the CBR value. Use of brick powder reduces the cost of project as brick powder is freely available.

GouravDhane, Dhiraj Kumar, Akash Priyadarshee: Effect of fly ash on the properties of Red Soil- The aim of this review paper is to discuss the effect of fly ash on the basic engineering properties of red soil such liquid limit, plastic limit, compaction, CBR value etc. The addition of fly ash reduces the plasticity characteristics of red soil. The liquid limit, plastic limit, plasticity index, linear shrinkage decreased and shrinkage limit increased with the addition of fly ash. The maximum dry density increases up to 20% fly ash mix, and then gradually decreases whereas the optimum moisture content decreased with increase in fly ash content.

Basim Thabit Al-Khafaji: Study on the properties of Clay Brick Made with the Addition of certain Additives- The addition of admixture on clay brick mixes at high contents of decreases a compressive strength and to improve the properties of water absorption.

Padamanaban A. Karthik N. Sathish: Experimental study on manufacturing of bricks using waste magnesite soil- Manufacturing of bricks mixed with red soil and magnesite soil and another method is manufacturing bricks magnesite and admixtures. The project involves testing of two types of bricks and compressive strength and water absorption of conventional bricks. The results of type 1 bricks are found to be good compared to type 2 bricks. Hence type 1 bricks are suitable for construction.

Rajput et al. (2012): Utilization of Various Industrial Waste in Bricks- Produced the WasteCrete bricks by reuse of cotton (1-5%) and recycled paper mill waste (89-85%) with cement (10%). Lightweight, and high water absorption, tiny air pockets attributed to paper waste. Proposed double stage press operation to preserve surface smoothness on drying.

Vidhya et al. (2013): Utilization of various industrial waste in bricks- Utilization of pond ash and fly ash in bricks using lime as an activator, sand to reduce laminar cracks in bricks, and gypsum to accelerate the hardening process. Compressive strength increases with increase in lime content. 20% cost reduction.

Shakir el al. (2013): Utilization of various industrial waste in bricks- Use of billet scale a by-product of the steel industry in brick production with fly ash, quarry dust and OPC as a binder. Proposed a non-conventional method of brick production using a novel flowable method without pressing and firing. Fly ash and quarry dust acted as pozzolanic material with SiO_2 and Al_2O_3 reacting with $Ca(OH)_2$ from hydration of cement to form CSH and CASH.

Chaulia and Das (2008): Optimization of Process Parameters- Optimized the process parameters for fly ash brick manufacturing like water to binder ratio, fly ash, coarse sand and stone dust by Tog uchi method with an objective function to minimize the compressive strength. Compressive strength is a vital parameter to judge the stability and durability. Optimum level of process parameter found to be water to binder ratio of 0.4, fly ash of 39%, coarse sand of 24% and stone dust of 30% giving an optimized compressive strength of 166.22kg.cm2 with a tolerance of +_10.97 kg.cm2.

Rai et al. (2013): Fly ash bricks (Fired and Unfired)- Prepared and characterized the lime activated unfired bricks named as Fal-G using fly ash. SEM-EDXA results showed the initial formation of CASH phase with free silica. Reported formation of CSH and CAH with increased curing time, responsible for strength development (Pozzolanic Reaction). Availability of water for reaction affects strength development (25% optimal). Crushing strength could be further being improved by increasing molding pressure.

K. Mahendran April (2017): Experimental study on low cost bricks using copper slag and rise husk ash- From this literature we get the information that we can partial replace red soil with copper slag and other materials. And also increase in the ratio reduces the compression strength of brick.

R. Sumathi Dec (2016): Study and analysis in making of bricks using debris- From this literature we get the information that how much degree of heat is required to burn the bricks.

A. Sumanthi (2014): Comparison strength of brick with addition of lime and gypsum- From this literature A. Sumanthi reviews that by adding of gypsum to the brick it will increase the fire resistance property. And with addition of lime it will boost the strength to the brick.

Amit Vishvakarma Dec (2016): Experiment study of brick by using e-waste and sculpture waste- From this literature we get the information that sculpture waste gives better finishing look as compared to other materials.

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4 Materials and Methodology

The physical and chemical properties of various materials use to carry out this experimental study. The minerals are Red Soil, Clay, Sculpture waste, Copper slag, Lime, Water. In this study, test on waste materials performed after gradation into fine coarse for both cases, all the tests are performed according to Indian Standards.

4.1 Red Soil

Red soil is a type of soil that develops in a warm, temperature, moist climate under deciduous or mixed forest, having thin organic and organic-mineral layers overlying a yellowish-brown leached layer resting on an alluvial red layer. Red soils are generally derived from crystalline rock. They are usually poor growing soils, low in nutrients and humus and difficult to cultivate because of its low water holding capacity. Red soils denote the third largest soil group of India covering an area of about 3.5 lakhs sq. km (10.6% of India's area) over the Peninsula from Tamil Nadu in the south to Bundelkhand in the north and Raj mahal hills in the east to Katchch in the west. They surround the red soils on their south, east and north.

The soil in India, also known as the omnibus group, have been developed over Archaean granite, gneiss and other crystalline rocks, the sedimentary of the Cuddapah and Vindhyan basins and mixed Dharwarian group of rocks. Their coloris mainly due to ferric oxides occurring as thin coatings on the soil particles while the iron oxide occurs as heamatite or as hydrous ferric oxide, the color is red and when it occurs in the hydrate form as limonite the soil gets a yellow color. Ordinarily the surface soils are red while the horizon below gets yellowish color.

The texture of red soil varies from sand to clay, the majority being loam. Their other characteristics include porous and friable structure, absence of lime, kankar and free carbonates, and small quantity of soluble salts. Their chemical composition includes non-soluble material 90.47%, iron 3.61%, aluminium 2.92%, organic matter 1.01%, magnesium 0.70%, lime 0.56%, carbon dioxide 0.30%, potash 0.24%, soda 0.12%, phosphorus 0.09% and nitrogen 0.08%. However significant regional differences are observed in the chemical composition.

In general, these soils are deficient in lime, magnesia, phosphates, nitrogen, humus and potash. Intense leaching is a menace to these soils. On the uplands, they are thin, poor and gravelly, sandy, or stony and porous, light-colored soils on which food crops like bajra can be grown. But on the lower plains and valleys they are rich, deep, dark colored fertile loam on which, under irrigation, they can produce excellent crops like cotton, wheat, pulses, tobacco, jowar, linseed, millet, potatoes and fruits. These are also characterized by stunted forest growth and are suited to dry farming.

Red soils are formed by weathering of the ancient crystalline and metamorphic rocks. Their color is red due to their very high iron content. They are found in areas of low rainfall and is obviously less leached than laterite soils. They are sandier and less clayey soils.

Red soil in India are poor in phosphorus, nitrogen and lime contents. The red soils cover a large portion of land in India. It is found in Indian states such as Tamil Nadu, southern Karnataka, north-eastern Andhra Pradesh and some parts of Madhya Pradesh, Chhattisgarh and Odisha.

4.2 Clay

Clay is one of the most abundant natural mineral materials on the earth. For brick manufacturing, clay must possess some specific properties and characteristics. Clay is a finely-grained natural rock or soil material that combines one or more clay minerals with possible traces of quartz, metal oxides and organic matter. Geologic clay deposits are mostly composed of phyllosilicate minerals containing variable amounts of water trapped in the mineral structure. Clays are plastic due to particle size and geometry as well as water content and become hard, brittle and non-plastic upon drying or firing. Depending on the soil's content in which it is formed, clay can appear in various colors from white to dull grey or brown to deep orange-red.

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Clays are plastic due to particle size and geometry as well as water content, and become hard, brittle and non-plastic upon drying or firing. Depending on the soil's content in which it is formed, clay can appear in various colors from white to dull grey or brown to deep orange-red. Although many naturally occurring deposits include both silts and clay, clays are distinguished in size and mineralogy. Silts, which are fine-grained soils that not include clay minerals, tend to have larger particle sizes than clays. There is, however, some overlap in particle size and other physical properties. The distinction between silt and clay varies

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by discipline. Geologists and soil scientists usually consider the separation to occur at a particle size of 2m (clays being finer than silts), sedimentologists often use 4-5m, and colloid chemists use 1m. Geotechnical engineers distinguish between silts and clays based on the plasticity properties of the soil, as measured by the soil Atterberg limits. ISO 14688 grades clay particles as being smaller than 2m and silt particles as being larger.

Mixtures of sand, silt and less than 40% clay are called loam. Loam makes good soil and is used as a building material. Clay exhibit plasticity when mixed with water in certain proportions. However, when dry, clay becomes firm and when fired in a kiln, permanent physical and chemical changes occur. These changes convert the clay into a ceramic material. Because of these properties, clay is used for making pottery, both utilitarian and decorative, and construction products, such as bricks, wall and floor tiles. Different types of clay, when used with different minerals and firing conditions, are used to produce earthenware, stoneware and porcelain. Prehistoric human discovered the useful properties of clay. Some of the earliest pottery shards recovered are from central Honshu, Japan. They are associated with the Jomon culture and deposits they were recovered from have been dated at around 14,000 BC.

Clay sinstered in fire were the first form of ceramic. Bricks, cooking pots, art objects, dishware, smoking pipes, and even musical instruments such as the ocarina can all be shaped from clay before being fired. Clay is also used in many industrial processes, such as paper making, cement production, and chemical filtering. Until the late 20th century, bentonite clay was widely used as a mold binder in the manufacture of sand castings.

Clay, being relatively impermeable to water, is also used where natural seals are needed, such as in the cores of dams, or as a barrier in landfills against toxic seepage (lining the landfill, preferably in combination with geotextiles).

4.3 Sculpture waste

Gypsum is a soft material composed of calcium with the calcium formula of $CaSO_4\ 2H_2O$. Gypsum is widely mined and is used as a fertilizer, and as the main constituent in many forms of plaster, blackboard chalk and wallboard.

Physical Properties of Gypsum

Chemical Classification	Sulphate
Color	Clear, Colorless, White, Grey, Yellow, Red
Streak	White
Luster	Vitreous, Silky, Sugary
Diaphaneity	Transparent to translucent
Cleavage	Perfect
Specific Gravity	2.3
Chemical Composition	Hydrous Calcium Sulphate, $CaSO_4\ 2H_2O$
Crystal System	Monoclinic
Uses	Used to manufacture dry wall, plaster, and joint compound. An agricultural soil treatment.

Any material that can be shaped in three dimensions can be used sculpturally. Certain materials, by virtue of their structural and aesthetic properties and their availability, have proved especially suitable. The most important of these are stone, wood, metal, clay, ivory, and plaster. There are also a number of materials of secondary importance and many that have recently come into use.

4.4 Copper slag

Copper slag used for this work is taken from Suyog suppliers (zone-11), a dealer in Pune which is used for sand blasting and the supplier brought the slag from Baruch, thoothukudi. Copper slag is a by-product of copper extraction by smelting. During smelting, impurities become slag which floats on the molten metal. Slag that is quenched in water produces angulargranules which are disposed of as waste or utilized as discussed below. Slag from ores that are mechanically concentrated before smelting contain mostly iron oxides and silicon oxides.

Copper slag is mainly used for surface blast-cleaning. Abrasive blasting is used to clean and shape the surface of metal, stone, concrete and other materials. In this process, a stream of abrasive grains called grit are propelled toward the workpiece. Copper slag is just one of many different materials that may be used as abrasive grit. Rate of grit consumption, amount of dust generated, and surface finish quality are some of the variables affected by the choice of girt material. Copper slag can be used in concrete production as a partial replacement for sand. Copper slag is used as a building material, formed into blocks. The usage of this slag reduces the usage of primary materials as well as reduces energy demand in building.

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Due to the same reasons the granulated slag is usable as a filler and insulating material in house foundations in a cold climate. Numerous houses in the same region are built with a slag insulated foundation.

4.5 Lime

Lime is a calcium-containing inorganic mineral in which carbonates, oxides, and hydroxides predominate. In the strict sense of the term, lime is calcium oxide or calcium hydroxide. It is also the name of the natural mineral (native lime) Cao which occurs as a product of coal seam fires and in altered lime stone xenoliths in volcanic ejecta. 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. Lime industries and the use of many of the resulting products date from prehistoric times in both the Old World and the New World. Lime is used extensively for waste water treatment with ferrous sulphate.

The rocks and minerals from which these materials are derived, typically limestone or chalk, are composed primarily of calcium carbonate. They may be cut, crushed, or pulverized and chemically altered. Burning of these minerals in a lime kiln converts them into the highly caustic material burnt lime, unslaked lime or quicklime and through subsequent addition of water, into the less caustic (but still strongly alkaline) slaked lime or hydrated lime (calcium hydroxide, Ca(OH)2), the process of which is called slaking of lime.

In the lime industry, limestone is a general term for rocks that contain 80% or more of calcium or magnesium carbonates, including marble, chalk, oolite and marl. Further classification is by composition as high calcium, argillaceous (clayey), silicious, conglomerate, magnesian, dolomite, and other limestones. Uncommon sources of lime include coral, sea shells, calcite and ankerite.

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 1,000 degrees Celsius (1,830-degree F) in different types of lime kilns to produce quick lime according to the reaction. Lime has an adhesive property with bricks and stones, it is often used as binding material in masonry works. It is also used in white washing as wall coat to adhere the white wash onto the wall.

The process by which limestone (calcium carbonate) is converted to quicklime by heating, then to slaked lime by hydration, and naturally reverts to calcium carbonate by carbonation is called the lime cycle. The conditions and compounds present during each step of the lime cycle have a strong influence of the end product, thus the complex and varied physical nature of lime products.

4.6 Water

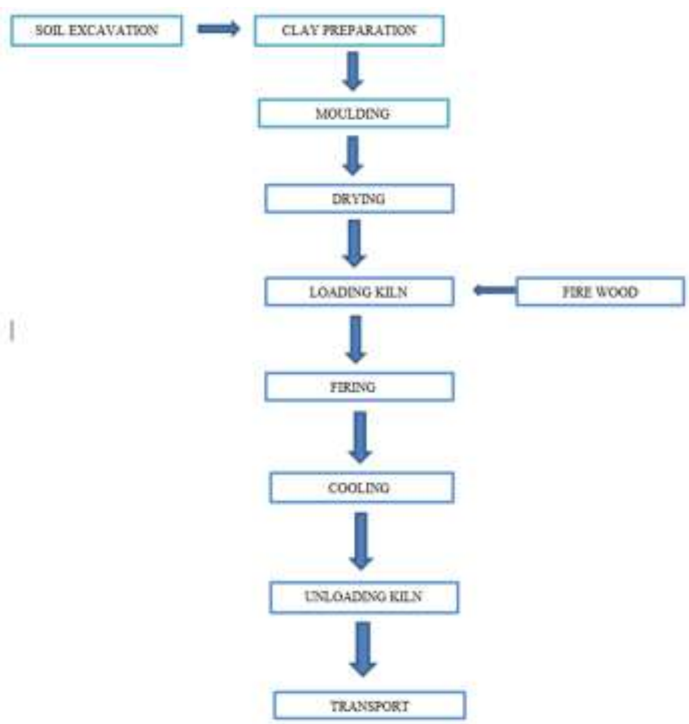
The water used for mixing of bricks and should be potable drinking water having PH range from 6 to 8. Water is a transparent, tasteless, odorless, and nearly chemical substance, which is the main constituent of Earth's streams, lakes, and oceans, and the fluids of most living organisms.

Total Quantity of Brick Raw Material:

RAW MATERIAL	QUANTITY
Red soil	150kg
Copper Slag	4kg
Sculpture Waste	4kg
Clay	18kg
Lime	9kg

4.7 Methodology

Below diagram depicts the methodology used for this study:



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5 Tests On Red Soil

5.1 Particle Size Analysis

Results of Test – 1

S. No	IS Sieve	Mass Retained (g)	% Retained	Cummulative % Retained	Cummulative % Finer (N)
1	4.75 mm	41.70	10.43	10.43	89.58
2	2.36 mm	55.61	13.90	24.33	75.67
3	1.78 mm	53.30	13.33	37.65	62.35
4	1.18 mm	51.60	12.90	50.55	49.45
5	600 microns	68.60	17.15	67.70	32.30
6	300 microns	61.60	15.40	83.10	16.90
7	150 microns	41.80	10.45	93.55	6.45
8	75 microns	3.45	1.10	95.40	5.70
9	Pan	18.39	4.60	100.0	0.00

Results of Test – 2

S. No	IS Sieve	Mass Retained (g)	% Retained	Cummulative % Retained	Cummulative % Finer (N)
1	4.75mm	43.00	10.75	10.75	89.25
2	2.36mm	49.70	12.43	23.18	76.83
3	1.76mm	59.60	14.90	38.08	61.93
4	1.18mm	53.70	13.43	51.50	48.50
5	600 micron	67.0	16.75	68.25	31.75
6	300 micron	60.80	15.20	83.45	16.55
7	150 micron	41.0	10.25	93.70	6.30
8	75 micron	5.30	1.33	95.88	4.13
9	Pan	16.50	4.13	100.0	0.0

Average of Tests

Cummulative % Finer (N)		
Test 1	**Test 2**	**Average**
89.58	89.25	89.59
75.67	76.83	75.78
63.35	61.93	61.82
49.45	48.50	48.84
32.30	31.75	32.11
16.90	16.55	17.0
6.45	6.30	6.87
5.70	5.45	6.08
0.00	0.00	0.00

Result:

From the curve calculate uniformity coefficient (Cu) and coefficient of curvature (Cc).

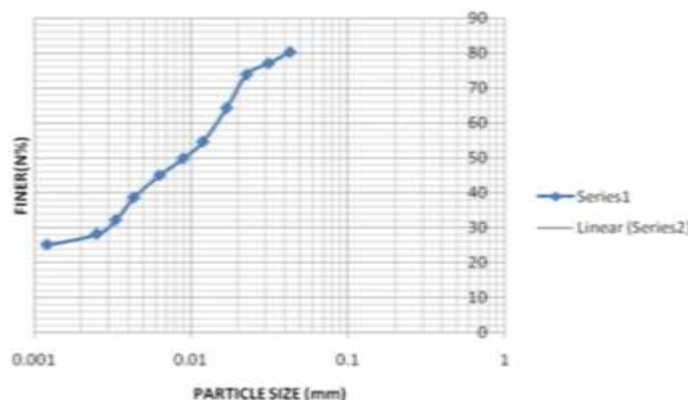
Uniformity coefficient (Cu):

$$Cu = D60/D10 = 1.8/0.2 = 9$$

From the graph and IS code soil is Medium graded soil.

Coefficient of curvature (Cc):

$$Cc = (D30)2/ (D10*D60) = (0.55)2/ (0.2*1.8) = 0.84$$



5.2 Liquid Limit

With 0% lime content

No of Blows	Water Content %
28	53.80
23	51
24	59.88

Graph:

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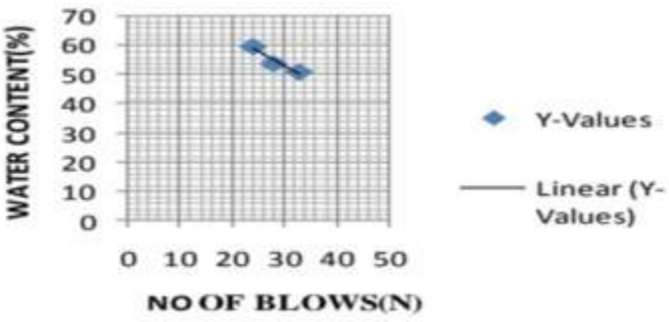

Result from the graph we obtained the liquid limit corresponding to 25 blows.

Liquid Limit is 58%

5.3 Plastic Limit

Plastic Limit Mean Value = 28%
Plasticity index (Ip):
Ip = Wl-Wp
= 58-28 = 30
Soil is a high plasticity clay. Hence soil is a highly clay.
Liquid Limit=58%
Plastic Limit=28%
Plasticity index=30
Liquidity index (Li):
Li=(W-PL)/ (LL-PL) = (35-28)/ (58-28)
= 24%
Activity of soil (A):
A= Ip / F = 28 / 6
= 4.66 > 4

Container No	Trail 1	Trail 2	Trail 3
Weight of container W1 (gm)	8.8	8.5	8.2
Weight of container + Wet soil sample, W2 (gm)	15.3	14.4	15.5
Weight of container + dry soil sample, W3 (gm)	13.5	12.7	13.1
Water content % = [(W2-W3)/(W3-W1)]*100	28.2	23.61	32

So, it means soil is highly active clay soil.

6 Mix Design

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining the relative proportion with the object of producing brick of certain minimum strength and durability as economically as possible. One of the ultimate aims of studying the various properties materials of brick, technoligist to design for a particular strength and durability the design of brick mix is not a simple task on account the widely varying properties of the constituent materials the conditions that prevail at the site of work in particular the exposure conditions that are demanded for a particular word which the mix design.

Design of bricks mix requires complete knowledge of the various properties of these constant material, this make the task of mix design more complex and difficult design brick mix needs not only the material properties and properties of brickin plastic condition it also needs wider knowledge and experience of brick manufacturing.

Even the proportion of the material of concrete found at the laboratory requires modification and readjustments to suit the field condition. With the better understanding of the properties, the concrete is becoming more and more an exact material than in past. The structural designer specifies certain minimum strength and the technologist designs the brick mix with the knowledge of the materials, site exposure conditions and standard of supervision available at the site of work to achieve this minimum strength and durability.

Further the site engineer is required to make the concrete at site closely following the parameters suggested by the mix designer to achieve the minimum strength specified by the stuctural engineer in some cases the site engineer may be required slightly modify the mix proportions given by the mix designer. He also makes cubes or cylinders sufficient in number and tests them to confirm the acheivements with respect to the minimum specified strength, Mix designer, earlier, may have made trail cubes with representative materials to arrive to the value of standard derivation are coefficient of variation to be used in the mix design. Production of concrete requires meticulous care at every stage, the incidents of good and bad concrete are same but good rules are not observed it become bad.

6.1 Mix Proportions for Trail Number

Table depicting the brick mix design

MIX 1	MIX 2	MIX 3
Red Soil 80%	Red Soil 75%	Red Soil 75%
Clay 10%	Clay 10%	Copper Slag 3%
Lime 5%	Lime 5%	Sculpture Waste 2%
Copper Slag 5%	Sculpture Waste 5%	Clay 15%
		Lime 5%

7 Tests On Bricks

7.1 Water Abosorption Test

The test was done by immersing the brick in water for 24 hours. Absorption test is conducted on brick to find out the

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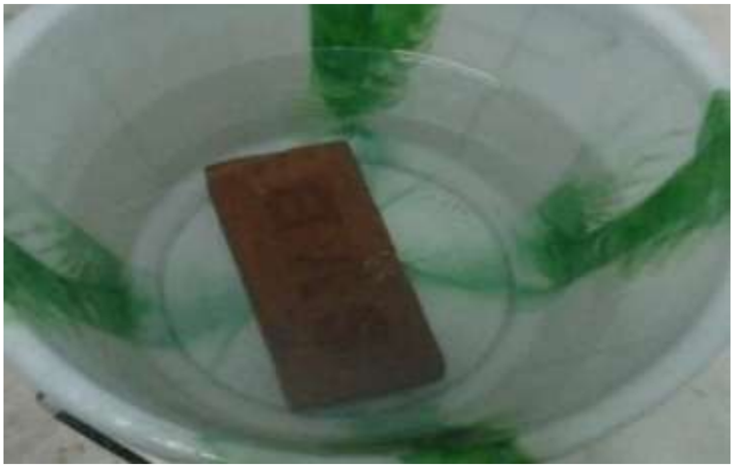
amount of moisture cement absorbed by brick under extreme conditions. In this test, sample dry bricks are taken and weighted. After weighing these bricks are placed in water with full immersing for a period of 24 hours. Then weigh the wet brick and note down its value. The difference between dry and wet brick weights will give the amount of water absorption. For a good quality of a brick the amount of water absorption should not exceed 20% of weight brick.



Tests Result:

Weight of Brick	Mix 1	Mix 2	Mix 3
Initial	2.99	2.89	2.98
Final	3.52	3.45	3.40
Result	7.6%	7.6%	8.1%

Mix 1

Mix 2 and Mix 3

7.2 Compression Strength Test

Crushing strength of bricks is determined by placing brick in compression testing machine. After placing the brick in compression testing machine, apply load on it until brick breaks. Note down the value of failure load and find out the crushing strength value of brick.

Fig: Crushing Strength of Brick

Test Results:

Trail No	Sample	Size in mm	Bearing Area	Compressive Strength in KN/mm
1	M-1	220*100	22000	150
2	M-2	220*100	22000	145
3	M-3	220*100	22000	140

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Pictures

Mix 1

Mix 2

Mix 3

8 Conclussions

- As per the result of Compression strength. If the number of proportion increases in brick ratio, then the strength of the brick is also reducing.
- The brick with less mix ratio had better compression result as compared to other bricks.
- And by the way the strength of bricks is not too minimum, so we can use this bricks for low strength structures and that will be environmental friendly.

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