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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 found, 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

International Journal of Scientific & Engineering Research, Volume 11, Issue 5, May-2020
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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.

International Journal of Scientific & Engineering Research, Volume 11, Issue 5, May-2020
ISSN 2229-5518

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

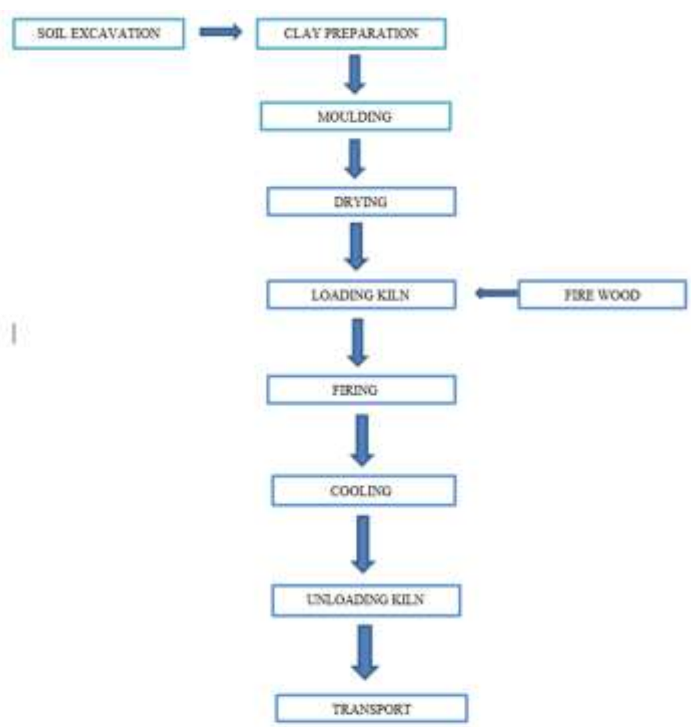
The water used for mixing of bricks and should be potable drinking water having PH range from 6 to 8. Water is a transparent, tasteless, odorless, and nearly chemical substance, which is the main constituent of Earth's streams, lakes, and oceans, and the fluids of most living organisms.

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:



International Journal of Scientific & Engineering Research, Volume 11, Issue 5, May-2020
ISSN 2229-5518

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 co-efficient of curvature (Cc).

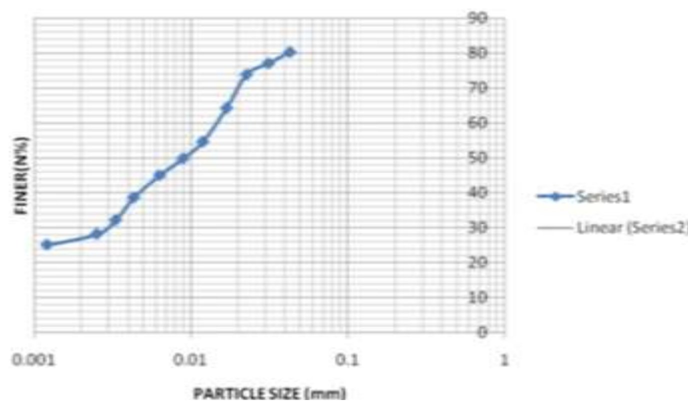
Uniformity coefficient (Cu):

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

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

Coefficient of curvature (Cc):

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



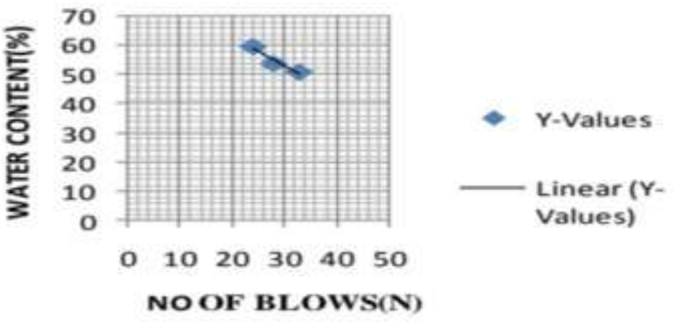
5.2 Liquid Limit

With 0% lime content

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

Graph:

International Journal of Scientific & Engineering Research, Volume 11, Issue 5, May-2020
ISSN 2229-5518



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

International Journal of Scientific & Engineering Research, Volume 11, Issue 5, May-2020
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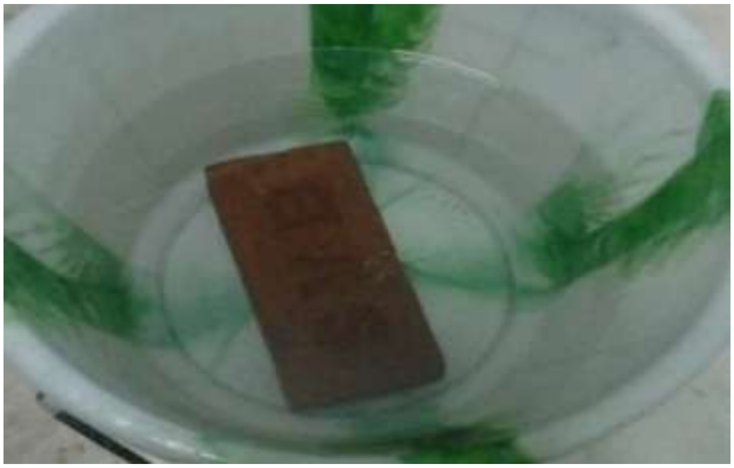
amount of moisture cement absorbed by brick under extreme conditions. In this test, sample dry bricks are taken and weighted. After weighing these bricks are placed in water with full immersing for a period of 24 hours. Then weigh the wet brick and note down its value. The difference between dry and 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.

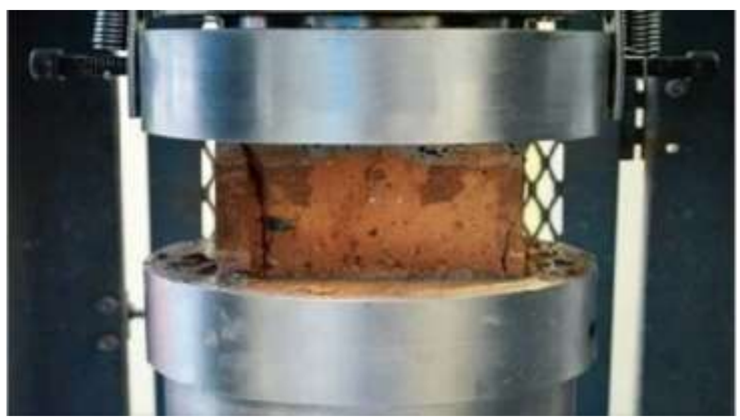


Fig: Crushing Strength of Brick

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

International Journal of Scientific & Engineering Research, Volume 11, Issue 5, May-2020
ISSN 2229-5518

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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