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CREATION OF EQUIPMENT FOR MANUFACTURING LOW COST BLOCKS USING BLACK COTTON SOIL

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Abstract :*With growing population and increased in production of blocks, an alternate black cotton soil blocks has been adopted. Equipment with hydraulic jacks has been designed for manufacturing of blocks in low cost which serves for rural area construction. Black cotton soil is expansive clay with high potential for shrinking or swelling as a result of changing moisture content and volume. The soil has been stabilized by using cement. The block produced from the equipment will have more strength than conventional burnt clay brick. The brick specimens are prepared by combining black cotton soil and cement in different proportions. The brick specimen were then air dries , baked in kiln and tested for compressive strength, water absorption , efflorescence, acid test and weight density as per IS 3495 code procedure. Test results obtained in the present investigation indicate that it is possible to manufacture good quality bricks using locally available black cotton soil by suitably adding cement. These bricks can be used for small scale construction activities across the country.*

Keywords: Block equipment, black cotton soil, Stabilization, Shrinkage, Plastic & liquid limit

1. INTRODUCTION

1.1 Purpose:

The primary motivation is to make blocks in minimal effort using hydraulic jack and to stabilize the soil using cement in proper proportion. A relative investigation of Black cotton soil block and regular block is likewise made.

Black cotton soil is one of significant soil deposits of India. Additionally called as Regus soil commonly framed by lava basaltic rocks of Maharashtra, Saurashtra, Northern Karnataka, Tamil Nadu, Etc. Consequently they are dull in shading since it is rich in Iron and Magnesium or High content of organic matter. The rate of Montmorillonite is more in Black cotton soil which display high rate of swelling and shrinkage when exhibited to change in moisture content.

1.2 Principles of soil stabilization

1.2.1 Definition

The stabilization of soil implies change of properties of soil-air-water system to gain lasting properties and strength while the soil receives moist. Silt and clay, which can be binders of earth, are not stable when they get saturated. Therefore the aim of soil stabilization is to stabilize silts and clay.

1.2.2 Selection of stabilizer:

Selection of stabilizer mainly depends on properties of the soil as follows,

Table-1: Stabilizer selection

S.No	Content	Explanation
1	Durability	It deals with the ability of the structure of withstand in its whole life against destructive action like rain and frost. So to accelerate durability and the strength cement must be together with soil in different composition.
2	Shrinkage and Swelling	These are two main hitches takes place in BC soil. Black cotton soil has a linear shrinkage of 13%. Maximum permissible linear shrinkage of any soil is 3%. Hence to overcome this objection a suitable stabilizer, cement is added to soil to improve strength and erosion resistance property of the block.

1.3 Block equipment

The equipment is designed using hydraulic jack is a simple, low-cost portable machine for making building blocks from black cotton soil. The equipment was developed as a tool for small individual or mutual self-help pro-grams.

1.3.1 Advantages

The blocks have many advantages over other building materials.

1. Transportation cost is avoided since the machine is portable and the blocks are made near the construction site.
2. The cost of the building material is greatly reduced, since most of the raw materials come from the nearby sites.
3. The blocks are easily handled.
4. They are easier to make than concrete blocks that is they can be removed immediately from the press and stacked for curing without the use of a pallet.
5. The black cotton soil chosen is easily available.

1.4 Need for the study

A brick is a most important material in the field of construction. Since Red brick is widely used in many construction sites its demand is getting higher. An alternate for the red brick is adopted. On various studies stabilization of black cotton soil with cement produces high strength blocks.

Table-2: Need and objective of the study

S.No	Content	Explanation
1	Necessity of soil stabilization	• To reduce the volume of interstitial voids so as to reduce porosity and increase the density. • To increase the bond between the grains especially when the soil is wet. • To increase the cohesion and the mechanical characteristics.
2	Objective of the study	• To make an economical brick. • To make an ecofriendly brick. • To provide better employment in local areas. • To provide low cost construction in rural areas.

2. BLOCK EQUIPMENT

2.1 Parts

2.1.1 Outer frame

The outer frame is made of steel which act as a skeleton frame, constructed in a rectangular grid to support the floor, hydraulic jack and the piston. The frame at the floor level is movable provided with rollers at the edges of the steel frame.

2.1.2 Hydraulic press

A hydraulic press is a device using a hydraulic cylinder to generate a compressive force. It uses a hydraulic equivalent of a mechanical lever, and was also known as a Bramah press. It works on the principle of inverse of reciprocating pump. The parts of the system is

- One part acts as a pump with the modest with mechanical force acting on a small cross sectional area.
- The other part act as a piston over a largest area which generates correspondingly large mechanical forces
- A small- diameter cubing press cyclinder.is needed if the pump is separated from the press cylinder.

2.2 MOLD BOX:

2.2.1 Purpose – It is a bottom portion of the Block equipment, in that we need to fill the sand. Service life of the block is 50 years. Tolerance limit is 5%

2.2.2 Dimension:

Brick size – 240mm x 115mm x 73mm and the tolerance interval of the length of the brick should be 235mm – 245mm. Mold size – 200 x 100 x 100mm

2.3 HANDLE:

- It is a kind of steel frame and is used to lift the mold
- Beams – One end is cantilever and the other end is free. The distance is 150mm and one end is connected to the cylindrical rod & the other end of the rod is attached to the mold with the handle after soil gets compacted.

3. MATERIALS AND METHODOLOGY

3.1 Cement:

It is a substance used in construction that sets, hardens and can adhere with other materials. Type of the cement – 53 grade cement and it is most effective in swelling properties of soil.

Depending upon its composition, thoroughness of burning and fineness of grinding cement properties may vary they are

1. Provide strength to masonry.
2. Stiffens or hardens early.
3. Possesses good plasticity.
4. An excellent building material.
5. Good moisture resistant.

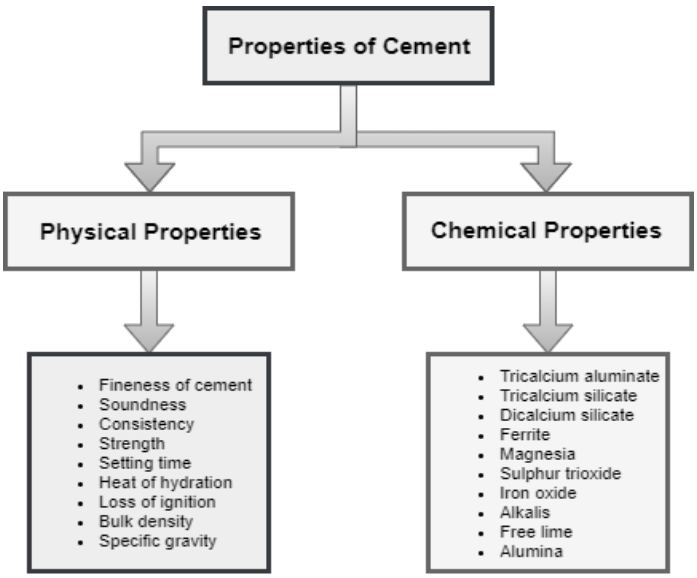

Fig-1: Properties of cement

Table-3: Physical properties

S.No	Content	Value
1	Density of cement	1440kg/m^3
2	Specific gravity	3.15
3	Fineness	370 kg/m^2
4	Initial setting and Final setting time	30 min and 600 min
5	Comprehensive strength	53MPa
6	Codal Provision	IS12269-1987

Table-4: Chemical composition

Compound	Chemical composition (in %)
CaO	57.84
SiO2	20.33
Fe2O3	4.68
Al2O3	3.40
MgO	1.51
MnO	0.10

TiO2	0.09
K2O	0.72
Na2O	0.51
SO3	7.26
Loss on ignition	3.42
Insoluble residue	1.23

3.2 BLACK COTTON SOIL

Manufacture of bricks from black cotton soils presents many difficulties because of its highly shrinkable nature and presence of lime nodules. Cement is, therefore, used as an opening material.

3.2.1 Characteristics of Black cotton soil

- Plasticity index is one of the important characteristics of soil to determine the behavior of soil in the presence of water.
- Compressive strength of cement stabilized BC soil found more reliable.
- The change of electrolytic environment in black cotton soil leads to very significant changes in consolidation characteristics.
- Black cotton soil (BC soil) has very low bearing capacity and high swelling and shrinkage characteristics.
- Due to its peculiar characteristics, it forms a very poor foundation material for road construction.
- Soaked laboratory CBR values of Black Cotton soils are generally found in the range of 2 to 4%.
- The equilibrium swelling reached over a period of 6 to 70 days in general for all expansive soils.
- Plasticity index and linear shrinkage decreased with the increase of lime content, a mixture of both lime and cement is necessary for adequate stabilization of road bases for heavy wheel loads on the black cotton soils.

3.2.2 PROPERTIES OF BC SOIL

3.2.2.1 Physical properties

Soil contains mineral particles, organic matter, water and air. The combinations of these determine the soil's properties its texture, structure, porosity, chemistry and colour. Soil is made up of different-sized particles. Comparative study of black cotton soil with red soil is adopted.

3.2.2.2 Specific gravity

Sand particles composed of quartz have a specific gravity ranging from **2.65 to 2.67**. Inorganic clays generally range from **2.70 to 2.80**. Soils with large amounts of organic matter or porous particles (such as diatomaceous earth) have specific gravities below **2.60**. Some range as low as **2.00.**

3.2.2.3 Optimum moisture content:

The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. These laboratory tests generally consist of compacting soil at known moisture content into a cylindrical mold of

standard dimensions using a compactive effort of controlled magnitude. The soil is usually compacted into the mold to a certain amount of equal layers, each receiving a number of blows from a standard weighted hammer at a specified height. This process is then repeated for various moisture contents and the dry densities are determined for each. The graphical relationship of the dry density to moisture content is then plotted to establish the compaction curve. The maximum dry density is finally obtained from the peak point of the compaction curve and its corresponding moisture content, also known as the optimal moisture content.

3.2.2.4 Consistency test:

Consistency is the term used to describe the ability of the soil to resist rupture and deformation. It is commonly describe as soft, stiff or firm, and hard.

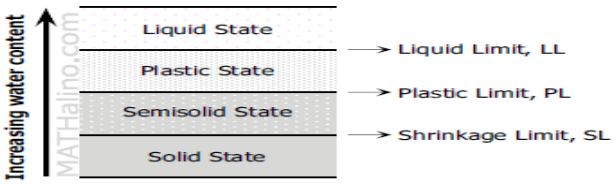

Figure 2 Atterberg Limits

Liquid Limit, LL

Liquid limit is the water content of soil in which soil grains are separated by water just enough for the soil mass to loss shear strength. A little higher than this water content will tend the soil to flow like viscous fluid while a little lower will cause the soil to behave as plastic.

Fig-3: Casagrande apparatus

Plastic Limit, PL

Plastic limit is the water content in which the soil will pass from plastic state to semi-solid state. Soil can no longer behave as plastic; any change in shape will cause the soil to show visible cracks.

Fig-4: Plastic limit

3.2.2.5 UNCONFINED COMPRESSIVE STRENGTH TEST

- Purpose – To determine the unconfined compressive strength.
- Uses - To calculate the unconsolidated undrained shear strength of the clay under unconfined conditions. The unconfined stress is taken as the maximum load attained per unit area.

3.2.2.6 CBR test

Purpose – It is a kind of penetration test for evaluation of the mechanical strength of natural ground. CBR is developed for measuring load bearing capacity and those soils are used for building roads. The harder the surface is the higher the CBR rating.

Moist – CBR of 10 and Crushed rock – CBR over 80 and California Limestone – Value of 100.

Table-5: Comparison of BC soil and Red soil

S.No	Description		Black cotton soil	Red soil
1	Specific gravity		2.4	2.5
2	Liquid limit (%)		60	44.5
3	Plastic limit (%)		45	35.3
4	Plasticity index		15	9.2
5	Grain size distribution (%)	Gravel	1	-
		Sand	30.5	40
		Silt	44.3	25.5
		Clay	24.5	34.8
6	Maximum dry density (KN/m3)		1.5	1.8
7	Optimum moisture content (%)		18.5	17.8
8	CBR value		4.5	8.3
9	Unconfined compressive strength(KN/m2)		98	150
10	IS soil classification		MH	CL

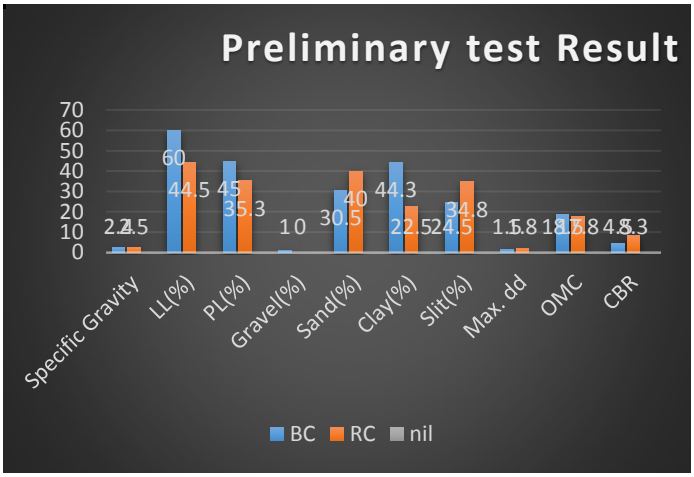

Fig-5: Comparison of BC soil and Red soil

3.2.2.7 Chemical properties

Table-6: Chemical properties

S.No	Compound	Composition (%)	
		BC SOIL	RED SOIL
1	CaO	-	-
2	SiO2	31.01	25.46
3	Fe2O3	4.74	35.53
4	Al2O3	16.19	31.13
5	MnO	0.13	-
6	TiO2	1.34	-
7	LOI	<52	-
8	Others	-	7.91

3.3 Water

Water is a transparent, tasteless, odorless, and nearly colorless chemical substance that is the main constituent of Earth. Mixing water for blocks should be clean and free from injurious amounts of oils, acids, alkalies, salts, organic matter, or other potentially

deleterious substances. When water is used to produce blocks, it has to be potable and for best performance, it should not exceed 25°C. pH value as per IS456- 2000 must be ≥**6.0.**

4. METHODOLOGY

Collection of BC soil
↓
Crushing and grinding the raw material
↓
Sieve passing through 2.36mm thick sieve
↓
Testing of sample
↓
Add 5% cement content with BC soil sample
↓
Sprinkle water and mix thoroughly until it attains its consistency
↓
Place the mixture in the mold
↓
Release the piston slowly until the flow frame lifts
↓
Raise the handle after the soil gets compacted
↓
Move the equipment for the next cycle
↓
Dry it in open air for 7 days
↓
Curing
↓
Test the blocks (BC Brick and Red Brick)
↓
Compare the result with block red
↓
Generate the Graph with BC Brick and Red brick
↓
Obtain the result from the comparative study

5. TESTS AND RESULTS

5.1 Compression test

Compressive strength test on bricks are carried out to determine the load carrying capacity of bricks under compression. After studying different literature it was found that ordinary bricks get crushed at 3.5N/mm2 but the brick prepared using cement as a stabilizer do not get crushed just get compressed and it is ready to take loads. The brick were prepared by adding 5% of cement in black cotton soil. This test is carried out with the help of compression testing machine.

5.2 Water absorption test

The water absorption of bricks is not directly related to the porosity owing to the nature of pores themselves. Some of pores may be through pores which permit air to escape in absorption tests and allow free passage of water in absorption tests, but other are completely seated and inaccessible to water under ordinary conditions. For this reason it is seldom possible to fill more than about three quarters of pores by simple immersion in cold water. For measuring total absorption the boiling method is adopted. More is the water absorption capacity weaker is the brick and vice versa.

5.3 Efflorescence test

Efflorescence is the usual terms for deposit of soluble salts, formed in or near the surface of the pores materials, as a result of evaporation of water in which they have been dissolved. These salts may be

traced to the brick itself, sand used in construction, the foundation soil, ground water, water used in the construction and lose earth leftover in contact with brick work. When water percolates through poorly compacted concrete or through cracks or along badly made joints, the lime compound with in the concrete leached out which leads to the formation of salt deposits on the surface of the block, known as Efflorescence.

6. Summary and Conclusion

6.1 Summary

Brick place a vital role in the field of construction. Nowadays due to the shortage of bricks, a research on Brick made of Black cotton soil has been adopted. Black cotton itself has swelling and shrinkage properties which are not suitable for manufacturing of bricks. On various stabilizers like fly ash, lime, rice husk, cement and sand, industrial waste, etc. 5%cement is added as a stabilizer with Black cotton soil for its stabilization because of its availability, good plasticity and moisture content. On various studies and experiments it has been resulted that BC brick provides good strength, durability and aesthetic in appearance.

6.2 Conclusion

BC brick was successfully manufactured using cement as a stabilizer. In this work we have compared the results of conventional brick and BC brick.

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