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STUDY OF SOIL-CEMENT BRICKS AND ITS CHARACTERISTICS TO REDUCE ENVIRONMENTAL ISSUES CAUSED BY NORMAL CLAYEY BRICKS

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Abstract: Bricks are the major construction material, as it is made from clay which is abundantly available in nature. Bricks helps to regulate the interior temperatures by its unique feature of absorbing heat and slow release rate. But on the other side, the amount of air pollutants produced from the brick kilns in India are approximately 0.94 million tonnes of particulate matter (PM); 3.9 million tonnes of CO and 127 million tonnes of CO_2 per year. In this research work, ecofriendly soil cement bricks are made with varying cement content and various tests were conducted regarding compressive strength, hardness, water absorption, efflorescence and soundness of bricks. These are cost effective, energy efficient materials compared to the normally clay burnt bricks and fly ash bricks.

Index Terms **- Soil, Cement, Bricks, energy, clayey bricks.**

I. INTRODUCTION

House is the third need of human in the world. In India, the population has been increasing rapidly. Due to this rapid growth of population, the demand of house is more. It is needed to supply economical & ecofriendly construction material. Now-a-days, various alternative materials are available for construction of various structural members. Soil cement bricks are one of the alternatives which are not in the existence at present days. Soil is principle raw material, OPC and water are the two constituent raw materials for Soil Cement Bricks (SCB). The amount of Portland cement to be used will depend upon the soil content. Soil Cement Bricks are also known as Stabilized compressed earth blocks. Soil cement bricks reduces the time required for completion of particular work or project. Soil cement bricks mainly depends on the raw material which is amply available at the site of construction. This helps to reduce the time required for the completion of project. Currently, many brick making machines are available which produces large numbers of bricks. Soil cement bricks provides more strength and resistance to water when contrasted with normal clayey bricks. It is brittle in nature and has low tensile strength. Strength of these bricks will depend on the water content to be added and the amount of compaction has done to bricks. Cement + Soil stabilized bricks requires proper curing of 3 – 4 weeks. Sandy soil is most preferred than clayey soil for casting purpose.

II. BACKGROUND

From the literature survey, the quantity of cement used in soil cement bricks is not varied. Graphical representation of results obtained from compressive strength, hardness, soundness, efflorescence and water absorption tests of soil cement bricks was not done. Comparison of results for different tests for bricks with varying cement content is not done.

III. METHODOLOGY

Various tests were conducted to soil and cement to obtain the different properties such as compressive strength and shear strength for different proportions of cement with the individual behavior.

3.1 Properties of soil

Particle Size Analysis was conducted to the soil sample. The distribution of different sizes of particle gives us the type of soil that will be used in the estimation of cement content that is to be added. The type of soil can be identified by Unified Soil Classification System.

Table 1: Particle size distribution of soil by using sieve analysis test

Sieve	Mass Retained (g)	% Retained	Cumulative % Retained	% of Fines
4.75 mm	202	20.34	20.34	79.66
2.36 mm	206	20.74	41.08	58.92
1.18 mm	240	24.16	65.24	34.76
600 µ	60	6.04	71.28	28.72
425 µ	148	14.90	86.18	13.82
300 µ	43	4.33	90.51	9.49
150 µ	59	5.94	96.45	3.55
75 µ	19	1.91	98.36	1.64
Pan	16	1.61	99.97	0.03
Total =	993 grams			

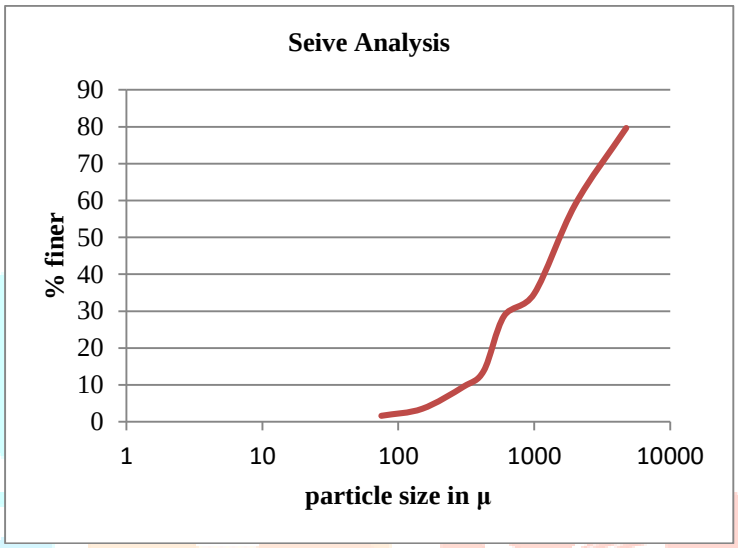

Figure 1: Graph between % of Fineness and size of sieves

Specific Gravity

By using conical flask Method, Specific Gravity of the soil is calculated

Table 2: Calculation of Specific gravity of soil

Description	1	2
Empty weight of conical flask (w1)	183	183
Conical flask + soil (w2)	564	550
Conical flask +soil + water (w3)	1031	1040
Conical flask + water	830	830
Specific Gravity	2.11	2.33

Specific Gravity of Soil obtained is **2.22**

Free Swell Index

Volume of soil in kerosene filled in graduated jar =10ml

Volume of soil in distilled water filled in graduated jar = 11ml

$$\text{Free swell index} = \frac{11-10}{10} \times 100$$

$$= 11\%$$

Hence soil is low degree of expansiveness

Compaction Test

The compaction test will give the maximum density at certain moisture content.

Diameter of the mould, d = 15 cm

Height of the mould, h = 12.7 cm

Weight of the mould, W_1 = 5.546 kg

Weight of the mould + soil = W_2

Volume, V = 2244.27 cm^3

Table 3: Compaction Test of the soil

S.No	W_2 (grams)	W_2-W_1 (grams)	Wet density $= \frac{W_2 - W_1}{V}$	Water content (w) in %	Dry density ρ_d
1	11290	6670	2.2	15.71	1.76
2	11240	6620	2.21	16.6	1.86
3	11130	8510	2.17	16.94	1.88
4	11160	6540	2.18	17.64	1.85

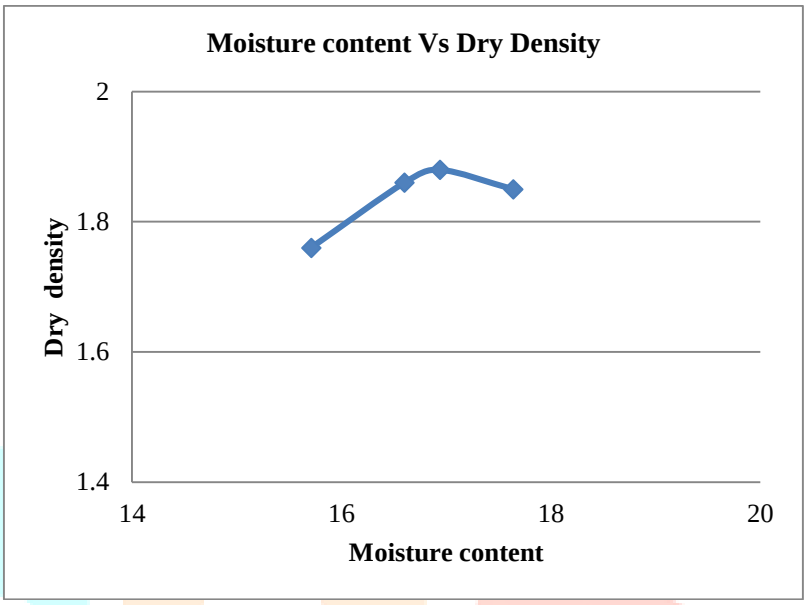

Figure 2: Graph between moisture content and Dry density

From the graph, for the soil sample optimum moisture content observed 16.97% and Maximum dry density found 1.88 gm/cc

3.2 Properties of the cement

Properties of the cement carried out are given below.

Specific Gravity of Cement

Table 4: Calculation of specific gravity of cement

S.No.	Description	Weight in grams
1	Weight of empty bottle (W_1)	66
2	Weight of bottle + Cement (W_2)	187
3	Weight of bottle + Cement + Kerosene (W_3)	257
4	Weight of bottle + Kerosene (W_4)	176

$$\text{Specific Gravity of Cement} = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)} = \frac{121}{121-81} = 3.02$$

Fineness of Cement

Table 5: Calculation of fineness of cement

S.No	Weight of cement (grams)	Cement Retained (%)
1	100	7.5
2	100	8.7
3	100	6.7

Fineness of cement = 7.6%

Normal Consistency of Cement

Table 6: Calculation of Normal consistency of cement

S. No.	Water content (%)	Penetration (mm)
1	25	26
2	27	29
3	28	31
4	29	34

Normal Consistency of Cement is 29%.

3.3 Production of soil cement blocks

The process of production of soil-cement block undergoes three steps. They are (a) soil preparation (b) block pressing, and (c) stacking and curing.

a. Soil Preparation

Soil used in the preparation of soil cement blocks is sieved through 4.75 mm sieve in order to remove bigger lumps, gravel etc. Sieved soil is spread into a thin layer on level ground and then a certain percentage of cement is spread on top and mixed thoroughly using a spade. Now water is sprinkled on the dry soil-cement mixture and mixed manually, such that the water gets dispersed uniformly. The wetted soil-cement mixture is pressed into a block using the machine. Soil preparation has to be carried out in batches such that the wetted soil-cement mixture should be converted into blocks within 40 minutes. This is mainly to avoid setting of the cement before pressing into a block.

b. Block Pressing

The processed soil underwent compaction to form blocks using a moulding machine. This operation consists of the following activities: (a) Feeding the processed soil into the mould, (b) block compaction and (c) block ejection.

c. Stacking and Curing

The blocks are stacked on the flat surface. Dose stacking without any gaps is done to prevent the drying of blocks while curing. The stack covered with straw on top is kept moist by sprinkling water for 3 to 4 times daily for 3 weeks.

3.4 Energy consumption and environmental issues

Energy efficient, economical, and environmentally sound building technologies are essential for the sustainable construction practices. Studies conducted by Jagadish (1979) have shown that 5000 Kg of wood is burnt in the producing bricks sufficient for a 50 m² house. Massive housing programs based on energy intensive materials such as bricks will lead to intolerable pressures on the energy resources such as wood and coal. Considerable amount of energy can be saved by using pressed soil-cement block contrasted with burnt brick. Here, an energy of 5.85 MJ/kg of cement has been considered for calculation. The table clearly shows that soil-cement blocks consume only 25-30% of the energy used for brick production.

Table 7**:** Energy comparison in traditional burnt bricks and soil-cement blocks

S.No	Type of unit	Size in mm	Energy per unit (MJ)	Energy per m^3 of units
1	Burnt brick	230×10×70	3.8 - 4.5	2228
2	Soil cement block	230×190×80	2.34	536

IV. Results And Discussion

Test result on bricks

Tests were carried out for different percentages of cement and combination of cement and lime in the composition of bricks. Various results of the bricks are obtained and given below

Compressive Strength of Bricks

Table 8: Compressive Strength of Bricks with cement content

S.No.	% of Cement	Compressive Strength N/mm^2
1	5	4.17
2	7	5.39
3	9	8.69

From the results of compressive strength of bricks observed that, by increasing the content of the cement compressive strength of the brick is observed increased. With 2% of the cement content increased then compressive strength of the cement is getting increased 29%. The compressive strength of brick is observed the contionously increasing with the increment of cement content. The maximum compressive strength of the brick (8.69 N/mm^2) is found at the stage of adding 9% of cement.

Table 9: Compressive Strength of Bricks with cement and lime contents

S.No.	% of Cement	% of lime	Compressive Strength, N/mm^2
1	5	1.3	5.56
2	7	1.5	7.73
3	9	1.7	12.08

From the results of compressive strength of bricks observed that, by increasing the content of the cement and lime then the compressive strength of the brick is observed increased. With 2% of the cement content increased then compressive strength of the brick is found increased by 29%. The compressive strength of brick is observed that contionously increasing with the increment of cement content.

Water Absorption Test

Table 10: Water absorption for cement content bricks

S.No.	% of Cement	Water Absorption (%)
1	5	11.7
2	6	11.6
3	7	9.3

From the results of water absorption for cement bricks observed that, by increasing the cement content then the water absorption is found decreased. With the adding of cement water absorption is getting decreased.

Table 11: Water absorption for cement and lime content bricks

S.No.	% of Cement	% of lime	Water Absorption (%)
1	5	1.3	16.2
2	7	1.5	11.7
3	9	1.7	9.9

From the results of water absorption for cement bricks observed that, by increasing the cement and lime content then the water absorption is found decreased. With the adding of cement and lime water absorption is getting decreased.

Efflorescence Test

Table 12: Efflorescence Test Results for cement content bricks

S.No.	% of Cement	Efflorescence
1	5	Nil
2	7	Nil
3	9	Nil

Table 13: Efflorescence Test Results for cement and lime content bricks

S.No.	% of Cement	% of lime	Efflorescence
1	5	1.3	Nil
2	7	1.5	Nil
3	9	1.7	Nil

Due to the adding cement and lime in the composition of the soil bricks, free from the appearance of the efflorescence. Nowadays efflorescence is the major problem in the engineering aspect. With the small percentage of cement and lime content in the composition of soil bricks, the efflorescence can be minimized.

Hardness Test

When the brick surface is scratched with finger nail no scratch is appeared on the surface of the brick.

When the brick surface is scratched with a knife scratch is appeared on the surface of the brick.

Therefore, the hardness is greater the 2.5 and less than 5.5.

Soundness Test

When two bricks are struck each other, a ringing sound is appeared but the generated sound is low when compared to clay burnt bricks and fly ash bricks.

Advantages

1. The main component of the soil mixture is abundant in nature and generally available on the construction site or close to it.
2. The constructive process of the soil-cement mixture is very simple and can be conducted by unskilled labour.
3. The application of mortar is unnecessary due to the smooth finish of monolithic walls as a result of the perfection of pressed faces (walls).
4. Low aggression to the environment, since it eliminates the firing process.
5. Low transport costs because it is produced at the construction site itself.

CONCLUSION

The soil cement bricks are ecofriendly as these bricks are not burnt which helps in reduction of many air polluting gases. The energy required for the soil cement bricks is less when contrasted with normal clayey bricks as it eliminates burning of bricks. The soil required for these bricks can be taken from the site itself which reduces the cost of transportation of soil. The main advantage of the adding of cement and lime in the composition of soil brick is to enhance the strength and durability of the soil cement brick masonary construction and minimise the efflorescence appearance it helps free from white patches and loss of paint. The compressive strength as well as water absorption and other tests prove that these bricks perform well when compared with traditional clayey bricks.

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