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ECO – BRICKS, INNOVATIVE MODERN BUILDING MATERIAL

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Abstract- Construction industry is the second largest industry in the world. Precious natural resource materials were used in the construction industry, which are in depleting condition. In the current scenario, there is a need for the sustainable building material as the existing materials like bricks, hollow blocks and other light weight concrete blocks cause environmental pollution in many ways. Compressed Cement Stabilized Soil Block (CSSB) will be the suitable alternative and proves to be a sustainable building material. The main advantage of this CSSB is reduced emission of carbon, reduced cost, non-usage of external energy like burning of bricks, usage of electricity and elimination of transportation cost as because of the utilization of locally available materials. The CSSB has been made by using cement as the stabilizer. In this work cement is used as the stabilizer, coconut coir as fibrous and waste plastics as a material with portable mould with a ratio of clay 60%, sand 25%, cement 11% and coconut coir 4%. The standard proctor compaction test and the direct shear test have been conducted to study the soil characteristics. Experimental studies shows that the CSSB blocks can be used for non-load bearing walls and also for low load bearing construction for sustainable environment.

Key words: Eco –bricks, coconut coir, CSSB, waste plastics, Modern material.

I. Introduction

Rapid urbanization and the continuous growth of industrialization throughout the world together with the increasing living standards have turned the creation of the built environment into a rising threat to the natural environment. Buildings account for one-sixth of the world's freshwater withdrawals, one-quarter of its wood harvest and two-thirds of its material and energy flows. Moreover, the excessive and inappropriate sealing (urbanization) of land/soil surfaces by ultra and infra structures, which is the outcome of the population increase i.e. mainly as migration, has been a driving force of degradation of the hydraulic cycle. The increased consumption of materials and resources together with the associated creation of solid and toxic wastes underscore the need for the construction industry to develop, use and dispose building products in a sustainable manner. Sustainable construction is using our natural resources in such a way that they meet our economic, social and cultural needs, but not depleting or degrading these resources to the point that they cannot meet these needs for future generations. Compressed Soil blocks can be stabilized with cement or lime, mentioned as Compressed Stabilized Soil Blocks – CSSB, which has better compressive strength and less water absorption. With cement stabilization, the blocks must be cured for four weeks after manufacturing. Then it can be dried and be used like common bricks.

II. Literature Review

Earlier studies on compressed blocks have been studied for achieving good results in manufacturing.

P. J. Walker, "Strength, Durability and Shrinkage Characteristics of Cement Stabilised Soil Blocks", investigated Cement and Concrete Composites, vol. 17, pp, 301-310, 1995, Stabilization methods of earthen blocks mainly depend on the type of the soil. Walker suggested basic guide lines for cement stabilizations and recommended 5-10% cement stabilization for manual pressing to achieve a saturated compressive strength in the range of 1-3 N/mm2. Compressive strength of 19% improvement was observed for the compressive strength of blocks stabilized with fibrous coir wastes @0.5%.

K. Joseph, W. Pornnapa, and H. Jongjit, suggested "Development of fiber-based soil–cement block with low thermal conductivity," Cement and concrete composites, vol. 27, pp, 111-116, 2008,During the last decades, the use of fibers as admixtures either to complement or replace wood has grown exponentially due to economic, environmental and political reasons. The use of coconut fibers as admixtures in soil- cement blocks showed a reduction in the thermal conductivity and weight of soil-cement blocks with a lowered compressive strength.

G. Khosrow, R. D. T. Filho, and N. P. Barbosa, "Behaviour of composite soil reinforced with natural fibers," Cement and concrete composites, vol. 21, pp, 39-48, 1999, has studied on the inclusion of coconut and sisal fibers in soil blocks with a fiber content of 4% by weight showed a reduction in the occurrence of visible cracks and gave highly ductile blocks.

M. Bouhicha, F. Aouissi, and S. Kenai "Performance of composite soil reinforced with barley straw," Cement and concrete composites, vol. 27, pp, 617-621, 2005, has investigated the performance of composite soil reinforced with barley straw showed a positive effect of decreasing shrinkage with straw inclusion, enhancing compressive strength and a reduction in the curing time.

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B. Hanifi, A. Orhan, and S. Tahir, "Investigation of fiber reinforced mud brick as a building material," Construction and building materials, vol. 19, pp, 313-318, 2008, has found that the Fiber reinforcement of mud blocks with plastic, polystyrene and barley straw in certain geometric fashion exhibited 17 to 21% compressive strength improvement.

Experimental investigation and feasibility study on stabilized compacted earth block using local resources Kabiraj.K1, Mandal.U.K2, has Investigated mainly to find out a suitable mix proportion to blend locally available materials such as soil, sand, clay, grits, jute, etc. with cement for making compacted earth block for construction of affordable residential buildings. The blocks were cured and tested for compressive strength, water absorption and density. Based on the results, it has been concluded that the compacted cement stabilized earth blocks both with or without jute fiber may be a cost effective and environment friendly alternative to the burnt clay bricks in lightly loaded building rural.

III. Compressed Cement Stabilized Soil Blocks

Soil is a universal building material, its strength is improved by adding stabilizing materials such as cement or lime, for building construction. Low cost is a primary advantage of soil block construction. An overall cost reduction of about 50 percent over conventional construction can be realized. Other advantages are that building materials are usually readily available and little skill and training are required for their use.

A. Mix Ratio

Cement stabilized soil blocks are made from soil mixed with following stabilizing material formed into blocks under high pressure and cured in the shade and by wet curing. Clay-60%, Sand -25%, Coir -4%, Cement-11%.

The manufacturing method of CSSB blocks are described below in the Figure.1, and the details are mentioned in the stepwise procedure.

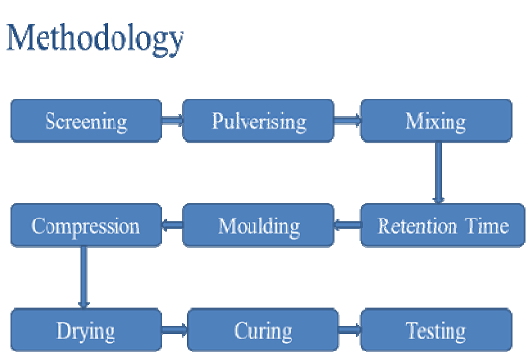

Fig.1. CSSB Block Manufacturing Method

B. Screening

This operation is intended to eliminate all undesirable materials like roots, dry leaves etc. together with any component with a diameter greater of less than that required. This operation also enables the earth to be loosened in a uniform manner.

C. Pulverizing

The operation is intended to break down lumps made up of coarse material and/or fines. It can also be used to split coarse material to reduce it to smaller diameter aggregates.

D. Mixing

A series of technical operations aimed at making the prepared earth, to which additives and / or filler may have been added, to make it homogeneous. Mixing most often takes place in two stages: dry mixing before adding water and wet mixing after adding water.

E. Retention Time

Retention time is the delay between the start of wet mixing and the compression of the earth.

F. Compression / Moulding

Compression is the operation which consists of compressing the material in a confined space known as a mould using a static or dynamic mode. Compression is followed by immediate demoulding, freeing the shaped block.

G. Curing

Curing is the period following compression during which two types of phenomena principally occur. These can be differentiated as follows:

- Physical and chemical reactions between the various components of the mix and above all between the earth and the additives resulting in the stabilization of the block.
- Drying which consists in the gradual removal of manufacturing humidity by evaporation.

IV. Properties of CSSB

The CSSB building material is culturally acceptable in nearly all countries, including the United States, as it holds good properties to be the innovative, economical and easily available building material. The comparison of properties of various bricks are tabulated as mentioned in Table. 1

TABLE I. Comparison of Properties of Bricks

Property	CSSB	Fired Clay Bricks	Calcium Silicate Bricks	Dense Concrete Blocks	Aerated Concrete Blocks	Light Weight Concrete Blocks
Wet compressive strength(MN/ m^2)	Jan-40	May-60	Oct-55	Jul-50	02-Jun	Feb-20
Moisture Movement(%)	0.02- 0.2	0.00 - 0.02	0.01 - 0.035	0.02 - 0.05	0.05- 0.010	0.04-0.08
Density (kg/m^3)	1700	1400	1600	1700	400-950	600
	2200	2400	2100	2200	-	1600
Thermal conductivity W/m C	0.81 - 1.04	0.7 - 1.3	1.1 - 1.6	1.1 - 1.7	0.1 - 0.2	0.15 - 0.7
Durability against rain	Good to Very Poor	Excellent to very poor	Good to moderate	Good to poor	Good to moderate	Good to Poor

V. Various Tests Carried Out on CSSB

Following tests were carried out to assess the strength and other properties of CSSB to find its suitability as a sustainable material, standard size of block 115 x 75 x 230 mm.

- Liquid limit test
- Plastic limit test
- Shrinkage limit test
- Standard proctor compaction test
- Direct shear test
- Compressive strength test
- Water absorption test
- Load impact test

A. Test on Soil by Atterberg Limits

This test method covers the determination of the liquid limit, plastic limit and plasticity index of soils. The liquid and plastic limits of soils are often referred as the Atterberg limits.

1) **Atterberg Limits**:

In the test for liquid limit, the liquid limit of the sample is found to be 28.48 and the flow index of the sample is found to be 23.73. In the test for plastic limit, the plastic limit of the given fine soil was found out as 13.6%, Plasticity index was found out as 14.88 and the Toughness index was found out as 0.58. In the test for Shrinkage limit, the Shrinkage limit of the given was found to be 21.08%.

2) Shrinkage Limit

The Shrinkage Limit (SL) is the water content where further loss of moisture will not result in any more volume reduction. The test to determine the shrinkage limit is ASTM International D4943. The shrinkage limit is much less commonly used than the liquid and plastic limits.

3) Plastic Limit

The plastic limit is determined by rolling out a thread of the fine portion of a soil on a flat non-porous surface .If the soil is plastic; this thread will retain its shape down to a very narrow diameter. The sample can then be remoulded and the test is repeated. As the moisture content falls due to evaporation, the thread will begin to break apart at larger diameters. The plastic limit is defined as the moisture content where the thread breaks apart at a diameter of 3 mm (about 1/8 inch). A soil is considered as a non-plastic if a thread cannot be rolled out down to 3 mm at any moisture.

4) Liquid Limit

The liquid limit (LL) is the water content at which a soil changes from plastic to liquid behavior. The original liquid limit test of Atterberg's involved mixing a part of clay in a round-bottomed porcelain bowl of 10-12 cm diameter. A groove was cut through the pat of clay with a spatula and the bowl was then struck many times against the palm of one hand.

B. Standard proctor compaction test

In the test for Standard proctor compaction, shown in below Figure.2, the Optimum moisture content was found out as 12.5%, the maximum dry density of the sample was 2.10 kg/cm3, the Void ratio at the maximum dry density was found to be 1.73 and the Porosity at maximum dry density was found to be 0.634. Test details are tabulated in Table. 2 &3

Fig.2. Compaction test

TABLE II. Proctor Compaction Test

S. No	Wt. of mould+ Compacted soil(w_2)	Wt. of compacted soil(w_2-w_1)	Wet density $\gamma = w/v$	Dry density $\gamma_d = \gamma/1+w$
1	4200	2073	2.20	2
2	4360	2233	2.370	2.116
3	4158	2031	2.156	1.859

4	4030	1903	2.020	1.712

TABLE III. Line of Constant Degree of Saturation

S. No	W (percent)	γ_d S_r=100%	γ_d S_r=90%	γ_d S_r=80%
1	10%	4.539	4.438	4.317
2	12%	4.697	4.575	4.433
3	16%	3.959	3.834	3.688
4	18%	3.578	3.455	3.314

C. Compressive Strength Test

Compressive strength is the capacity of a material or structure to withstand axially directed pushing forces, it provides data (or a plot) of force vs deformation for the conditions of the test method. When the limit of compressive strength is reached, brittle materials are crushed. Concrete can be made to have high compressive strength, e.g. many concrete structures have compressive strengths in excess of 50 Mpa, whereas a material such as soft sandstone may have a compressive strength as low as 5 Mpa or 10 Mpa. The Average Compressive Strength of various class block are tabulated in the below Table.4 with compressive strength testing machine in Figure.3.

Fig.3. Compressive strength testing machine

TABLE 4. Compressive strength of various class designation

Class Designation	Average Compressive Strength	
	Not Less than (N/mm^2)	Les than (N/mm^2)
350	35	40
300	30	35
250	25	30
200	20	25
175	17.5	20
150	15	17.5
125	12.5	15
100	10	12.5
75	7.5	10
50	5	7.5
35	3.5	5

In the test for Compressive strength, the Compressive strength on Coir added CSSB was found out as 9.1 N/mm^2 and Waste plastic added CSSB was found to be 7 N/mm^2.

D. Water Absorption Test

Three numbers of whole blocks from the sample are tested, the average water absorption shall not be more than 20% by weight up to class 125 and 15% by weight for higher class.

Fig.4. Water absorption Test

Fig.5.Weighing Process of Plastic & Coir CSSB

In the test for water absorption, the absorption of water in coir added CSSB was found out as 13.66% and the absorption of water in Plastic scrap added CSSB was found out as 10.86%.

Table.5 below gives the comparison of results obtained from normal Cement stabilized soil blocks (CSSB) with the CSSB samples made using coconut coir and plastic scrap as stabilizing agent.

TABLE V. Comparison of Compressive Strength and Water Absorption Quality between the Normal CSSB and Proposed Sample CSSB.

Content	Compressive strength	Water absorption test
CSSB	5.14 N/mm^2	9.91%
CSSB using waste Plastic scrap	7.0 N/mm^2	10.86 %
CSSB using coconut Coir	9.1 N/mm^2	13.66 %

VI. Conclusion

Compressed cement stabilized soil block has a size of 115 x 75 x 230 mm has been produced and tested for various properties like compressive strength, impact load and water absorption. The mould used for making the block was designed by our team member. The block can be made in any shape accordance to the need and requirement. The composition of block requires clay 60%, and 25%, cement 11 % & fiber 4%.

Compressive strength of sample has been found to be 8.9 N/mm^2 of weighting 3.5 kg and water absorption was found to be 13.65% and no impact was found till 1 m height.

CSSB using coconut coir is found to have better compressive strength and better water absorption quality was found in plastic scrap added CSSB when compared to normal CSSB blocks tested. Therefore coir added CSSB blocks can be used for construction in a economical way, as a innovative building material.

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