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Experimental Investigation on Compressed Earthen Blocks manufactured with Agro Waste Stabilized using Additives

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Abstract – A compressed earthen block (CEB), is a building material made primarily from an appropriate mix of fairly dry inorganic subsoil, non-expansive clay, sand, and aggregate, it is also known as a pressed earth block or a compressed soil block. Stabilized compressed earth block is an earthen block manufactured with additives such as cement, lime powder and etc. to enhance its characteristic strength. Agricultural Waste is unwanted or unsalable materials produced wholly from agricultural operations directly related to the growing of crops or raising of animals for the primary purpose of making a profit or for a livelihood. Bagasse ash is one among the Agrowaste produced vastly in Southern parts of India. Bagasse is a sustainable product because it is sourced with very little impact on the environment. It can be easily replenished because the residue can be obtained after every harvest. The main drawback of Bagasse ash is that it never degrades. In the present study an experimental

investigation is done on Compressed earthen blocks manufactured by replacing the soil with Bagasse ash up to certain limit then the blocks are stabilized using cement, lime powder, jute fibre and tested for its compressive strength.

Index Terms - Soil, Bagasse ash, Cement, Lime Powder, Jute Fiber

I. Introduction

The series of scientific discoveries and innovations in the field of construction has made changes in public economic systems for several advanced countries. The request for sustainable construction materials at low cost is growing as social, economic, and environmental issues grow in today's society. As architectural heritage, earth block masonry fascinates the interest of engineers for maintenance and modern construction since it is a material of high environmental and economical profile. Over the former few decades, earthen buildings were the most sustainable and widely used construction materials in developing countries. The recent interest in using natural materials is due to the increasing demand for housing as populations increase and to facilitate reduction of energy consumption in the building industry. The utilization of earth in housing construction offers a very high resistance to fire and provides a comfortably built living environment due to its high thermal and heat insulation value. It also offers other important factors that attribute to the achievement of a good house planning/design and construction solution. Earthen building techniques have been in use for thousands of years; the process of forming blocks by compacting earth into molds is an ancient technique, and structures built with these blocks have sustained and endured for a long time.

CEB technology has been developed for low-cost construction, as an alternative to adobe, and with some advantages. A commercial industry has been advanced by eco-friendly contractors, manufacturers of the mechanical presses, and by cultural acceptance of the method. Various types of CEB production machines exist, from manual to semi-automated and fully

automated, with increasing capital-investment and production rates, and decreased labor. Automated machines are more common in the developed world, and manual machines in the developing world.

Arun Kumar, Siva Kumar and Ambika (2021) studied on "Experimental study on compressed earth blocks using agricultural and industrial waste" and the Stabilizers used for the study includes Cement, GGBS, Rice husk ash which were added in different proportions for the preparation of compressed blocks 240x240x90 mm size. Compressive strength, water absorption and pulse velocity test were conducted. After conducting tests on compressed blocks with different proportion it was found that there was enhancement in terms of strength, durability, water absorption of the block.

Edighoman I. Ewa, Barisua E. Ngekpe and Kemejika I. Amadi- Oparaile (2020) studied on "Critical Review of Structural Characteristics of Stabilized Earth Blocks" and concluded that among several benefits, from this study it has been seen that the stabilization of earth blocks provides the earth with improved strength, volume stability, permeability, durability, and microstructure. These improved characteristics are key demands for concrete in the construction of domestic and industrial structures.

II. Materials

A. Soil

Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that together support life. Soil samples are collected from Bannur (Mysore district) and are tested for their geotechnical properties and strength.

B. Bagasse ash

Bagasse ash is a byproduct of sugar factories found after burning sugarcane. Bagasse which itself is found after the extraction of all economical sugar from sugarcane. The disposal of this material is already causing environmental problems around the sugar factories. In many tropical countries there are substantial quantities of Bagasse is rich in amorphous silica indicated that it has pozzolanic properties.

C. Cement

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Cement of OPC 33 grade is used for the experiment.

D. Lime Powder

Lime is calcium containing inorganic mineral composed primarily of oxides, and hydroxide, usually calcium oxide and/or calcium hydroxide. It is also the name for calcium oxide which occurs as a product of coal-seam fires and in altered limestone xenoliths in volcanic ejecta. The word lime originates with its earliest use as building mortar and has the sense of sticking or adhering.

E. Jute Fiber

Jute fibre is a type of plant fibre which is widely known for its ability to be spun into strong and coarse threads. Individual jute fibres are known to be soft, long, and shiny in nature. The plants belonging to the genus Corchorus are believed to be the primary producers of this fibre.

III. Methodology

- **Step 1**: Suitable soil sample will be collected for molding of earthen blocks.
  - (The soil contents should be having the particles as 50% Sand+20% Clay+15% Gravel and +15% silt).
- **Step 2**: Basics tests are conducted on the materials to know its index and engineering properties.
- **Step 3**: The mix proportion for the manufacturing of earthern blocks is as follows:

Table 3.1: Mix Proportion for blocks

BT – Block Type

BT 1	Soil – 80%	Cement – 10%	Bagasse Ash - 10%
BT 2	Soil – 70%	Cement – 10%	Bagasse Ash - 20%
BT 3	Soil – 60%	Cement – 10%	Bagasse Ash - 20% + Lime Powder – 10%
BT 4	Soil – 80%	Lime Powder – 10%	Bagasse Ash - 10%
BT 5	Soil – 70%	Lime Powder – 15%	Bagasse Ash - 15%
BT 6	Soil – 70%	Lime Powder – 10%	Bagasse Ash - 20%
BT 7	Soil – 60%	Lime Powder – 20%	Bagasse Ash - 20%
BT 8	Soil – 60%	Bagasse Ash – 20%	Jute Fiber – 20%

- **Step 4**: The Blocks were manufactured using the Hydraulic compressor.

Table 3.2: Properties of Materials

Materials	Tests Conducted	Result
Soil	Specific Gravity on Soil	2.65
	Liquid Limit of Soil	41%
	Plastic Limit of Soil	15.5%
	Maximum Dry Density & OMC	1.848 g/cc 12%
Cement	Specific Gravity	3.05
Lime Powder	Specific Gravity	2.05
Jute Fibre	Specific Gravity	1.48

Table 3.3: Tests conducted on materials

Materials	Tests Conducted
Soil	Specific gravity Consistency Dry density & OMC
Bagasse ash Cement Lime Powder Jute Fiber	Specific gravity

Table 3.4: Tests conducted SCEB

SCEB – Stabilized compressed earthen block

Compressive strength Test
Water Absorption test

IV. Results & Discussion

Earthen blocks manufactured using bagasse ash and stabilized using cement, lime powder and Jute fiber was tested for compressive strength and water absorption. Cost analysis & number of units required for 10ft*10ft is tabulated below.

Table 4.1: Compressive Strength test results

Block Types	Weight of the Block in kg	Load in kN	Area mm^2	Compressive Strength in N/mm^2
Block type 1	23.1	36.4	82580.48	2.9
Block type 2	24.4	24.5	82580.48	2.85
Block type 3	23.8	28	82580.48	2.74
Block type 4	23.4	34	82580.48	2.5
Block type 5	23.5	26	82580.48	2.3
Block type 6	23.2	22.8	82580.48	2.1
Block type 7	23.8	26.3	82580.48	2.2
Block type 8	22	23	82580.48	2.4

The block type 1 having 80% of soil,10% of cement and 10% of bagasse ash has the highest value of compressive strength of 2.9 MPa

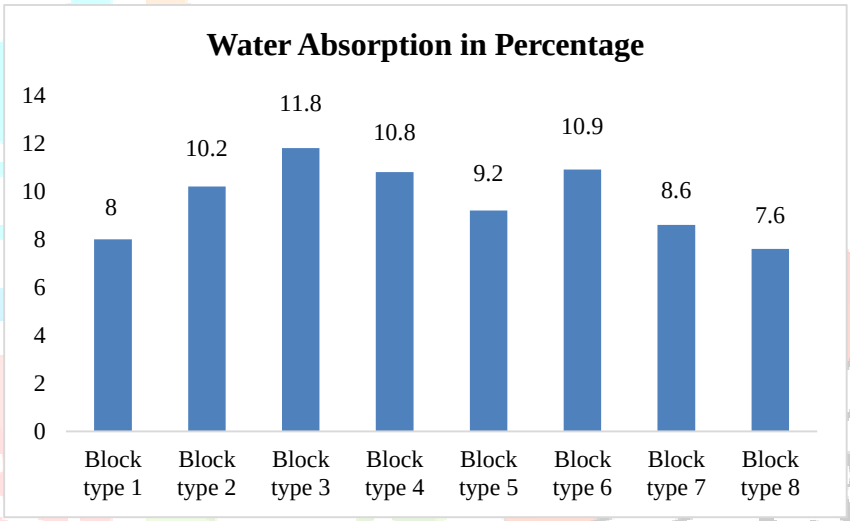

Fig 4.1: Variation of Water Absorption in SCEB

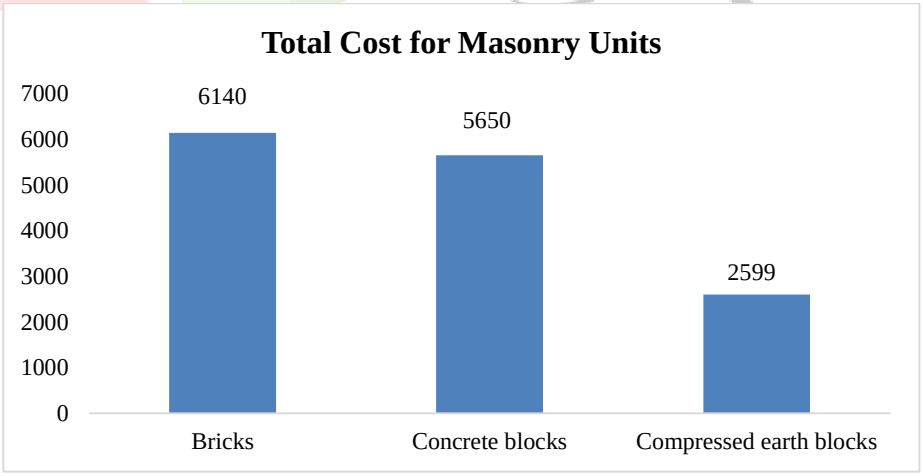

Fig 4.2: Comparison of Cost of masonry units for 10ft*10ft wall construction

V. Conclusion

1. From experimental observation bagasse ash can be used as a replacement for soil up to a limit of 20% with additives in manufacturing earthen blocks.
2. The experimental study shows Cement, Jute Fibre and Lime Powder (up to 10% limit) as additive enhances the compressive strength of a compressed earth block replaced with bagasse ash.
3. From the experimental observations jute fibre enhances the compressive strength of CEBs higher than lime powder because of its cohesive properties' nature with soil.
4. From Estimation analysis for a 10ft*10ft wall, number of compressed earth blocks required is 125, whereas the brick is 1350 which is way higher and the cost comparison also shows that 85% increment when compared with bricks.

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