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The Behaviour of Stabilized Mud Block and Burnt Clay Brick Masonry and Stabilized

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Abstract:
The prevailing shortage of many building materials based on natural resources has led to a considerable price escalation in recent times. This has created opportunities for developing many alternative masonry materials that can be used for wall construction. Compressed stabilised earth bricks, solid blocks and interlocking blocks are few such materials. To reduce the number of bricks used in a given area, Rat-trap bond is also gaining popularity. All these will create many challenges to the professionals involved in the building industry that have to be solved by providing data on strength and behaviour characteristics. This research compares the strength, load deformation characteristics and the applications of English and Rat-trap bond patterns in masonry construction. The findings are based on burnt clay bricks and compressed stabilized earth bricks and blocks in order to investigate comparable performance.

***Keywords:* Compressed stabilized earth blocks (CSEB), bond patterns**

INTRODUCTION

Providing affordable housing is a challenge around the world, especially in developing countries. The impediments to solving the housing problem are scarcity and high cost of building materials. Ideally, low-cost housing must rely on locally available raw materials. Furthermore, such materials must be abundantly available and be renewable in nature [1-2]. Local soil has always been the most widely used material for earthen construction in India.

Mud walls have been used for the buildings since ancient times. Mud wall buildings can be seen throughout the world and mud construction techniques are still in vogue in many parts of the world. Cob wall, adobe, rammed earth, and wattle and daub are some of the common techniques of building mud walls. Using mud for wall construction has distinct advantages [3-4]. Mud is readily available locally, low cost, recyclable and environment friendly and it provides better thermal comfort than other materials. Major drawbacks of mud walls are larger wall thickness, loss of strength on saturation and erosion due to rain impact. These drawbacks can be minimized or eliminated by using soil stabilization techniques [5].

Stabilized mud blocks are produced via soil stabilization processes. Stabilized mud blocks can be prepared by compacting a moist mixture of soil and cement in a machine. It is also called compressed earth blocks or soil-cement blocks when only cement is used as a binder [6-7]. Stabilized mud blocks have been used for masonry construction in Australia, France, India, Columbia, Chile, Algeria, Brazil, Thailand and many other countries. Understanding the strength of stabilized mud block masonry is essential for a satisfactory use of the new building material. At present, there is hardly any organized information on the properties of masonry using stabilized mud blocks. It is to be noted here that the information available on the strength of brick masonry may not be useful for understanding stabilized mud block masonry. There is hence a clear need for systematic study of various parameters affecting the

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strength of stabilized mud block masonry [8]. The present investigation attempts to study the effect of mortar properties on the strength of stabilized mud block masonry.

Stabilized mud blocks (SMBS) are manufactured by compacting a wetted mixture of soil, sand and stabilizer in a machine into a high-density block. Such blocks are used for the construction of load bearing masonry. This paper focuses on some issues pertaining to strength of stabilized mud block masonry, both dry and wet, the effect of the strength of five cement mortar mixes and two soil-cement mortars mixes using stack-bonded prisms. A systematic experimental investigation was undertaken to know the parameters affecting the strength of masonry in cement mortar of different proportions and soil-cement mortar [9-10].

II. MATERIALS AND METHODS

A. Stabilized Mud Block

Stabilized mud blocks can be prepared by compacting a moist mixture of soil and cement in a machine. A number of studies are available on the properties and use of soil cement blocks for building construction9.A manually operated machine called AURAM 240 was used to make blocks for the present study. Locally available soil was used. The grain size distribution of the soil is shown in fig- 1. The liquid limit and plastic limit of the soil are 30.6 and 16 respectively. The block making process consists of mixing the cement and screened soil

1) Mortar Properties

In general low strength mortars are used for masonry construction. Cement mortar proportions of 1:6 (cement: sand) and 1:8 are very common. Masons normally use rather high water –cement ratios for satisfactory workability, leading to low strengths. In this investigation five different cement mortar proportions and soil cement mortar proportions were used with rather high water cement ratios [11-12]. The strength of 50mm cubes tested at different periods is given in table II. The higher the sand content ratio the greater was the water requirement. A soil cement mortar with 5% cement by weightis also attempted. The 50mm cubes tested for strength were cast using the mortar from the same mix as used in the masonry prism casting. It is clear from table II that lean cement mortars with high watercement ratios and soil-cement mortar can lead to low strengths. The increase in mortar strength from 7 days to 28 days varies between 75% to 102% for different mortar proportions.

2) Strength of Stabilized Mud Block Masonry

Masonry Specimens the compressive strength of stabilized mud block masonry was determined by testing the masonry prisms. Five block high stack bonded masonry prisms (block size 240mm x 240mm x 90mm and prism size 240mm x 240mm x 510mm) were used. A mortar joint thickness of 10mm was maintained for all the prisms. The height to thickness ratio of the prism= 2.13. The prisms were cured for 28 days under wet burlap [13]. Dry strength was determined after drying in air in sunlight for 35 days after curing. In case of wet strength, the prisms were saturated by sprinkling with water before testing. A minimum of 6 prisms were tested in each case.

B. Stabilized Compressed Earth Blocks

The new technology focuses on stabilized earth masonry brick development incorporating an industrial by-product material, which is vital for the future of construction. The stabilized earth masonry brick technology relies on the use of an activated industrial by-product (Ground Granulated Blast-furnace Slag – GGBS) and natural earth. Due to the use of a by-product material in the formulation, it is anticipated that the final pricing of the stabilized earth masonry building brick will be reduced. The added environmental advantage of utilizing industrial by-products available in the country will further improve the sustainability profile of masonry brick production.

C. Stabilized Rammed Earth Walls

In the ideal situation sufficient quantities of soil suitable for rammed earth construction will be sourced from the

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spoil material arising from foundation excavations and other groundworks and/or a suitable borrow pit on site. The ideal soil will require no further treatment (screening or blending) and will be at its optimum moisture content for the chosen method of compaction.

Not surprisingly this situation is the exception rather than the rule for rammed earth construction. In-situ soils are likely to require some processing, such as drying or screening, following excavation. In the absence of a suitable in-situ material soil will require transport from a remote source and possible storage on site prior to ramming. Soil homogeneity is of course important in rammed earth construction both for structural integrity and architectural finish [14].

Therefore, it is important that once the soil has been excavated and prior to placing it into the formwork, variations in soil quality, including most importantly moisture content, are minimized. Pre-processing of soils for rammed earth construction depends on the type of soil, but broadly speaking consists of excavation, screening and mixing thoroughly to correct moisture content.

MATERIAL AND METHODS

Locally available soil inside our college premises has been used to for this experimental work. Preliminary investigation and rough assessment showed that the red loamy soil is satisfactory to be used in the production of stabilized mud blocks.[18] The top soil containing organic matter is dug out and the soil below 2ft of ground level is excavated and processed by sieving it through 4.75mm sieve, the gravel content retained on the sieve is rejected. Basic physical properties of soil are tested as per IS code[19] ,to confirm its suitability for making stabilized mud blocks and the results obtained are tabulated in **Table 1.** Particle size distribution curve is plotted for the results obtained from sieve analysis and the same is shown in **Fig. 1.** the soil can be classified as well graded soil as it contains a good representation of particles of all sizes

Table 1 : Physical properties of soil

S/N	Characteristics	Value	Units
1	Specific gravity	2.32	-
2	Bulk density	-	-
	Loose soil density	1.48	g/cm^3
	Compacted soil density	1.63	g/cm^3
3	Sand fraction (4.75mm - 75µ) [wet sieve analysis]	54	%
4	Fineness modulus	2.94	-
5	Plastic limit	28	%
6	Liquid limit	35	%

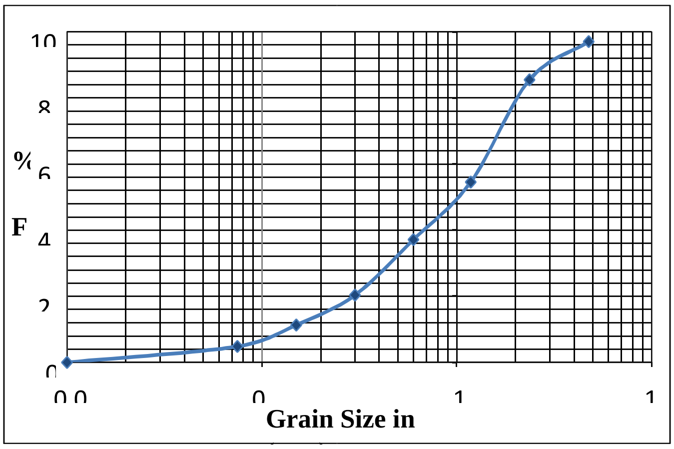

Fig. 1 : Particle size distribution curve of soil

Granite Cutting Dust (GCD) was procured finer than 75µ is rejected and only the from industrial area of Hassan district. In coarser fraction is used. The physical this study GCD is used to increase the sand properties of GCD are tested as per IS code[20] fraction of the soil, hence the granite dust ,and the results are tabulated in **Table 2** and **Table 3.** Particle size distribution curve is plotted for the results obtained from sieve analysis and the same is shown in **Fig. 2.** From **Fig. 2,** it is clear that the granite cutting dust can be classified as uniformly graded fine particles as particles of size greater than 1.18mm are missing and its fineness modulus is in the range 2.2 - 2.6.

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Table 2 : Physical properties of GCD

S/N	Characteristics	Value	Unit
1	Specific gravity	2.52	
2	Bulk density Loose GCD density Compacted GCD density	- 1.90 2.10	g/cm³ g/cm³
3	Fineness modulus	2.26	

Table 3 : Sieve analysis of GCD

Sieve size (mm)	Mass of GCD retained(gm)	% mass retained	Cumulative % mass retained	% mass passing
4.75	0	0	0	100
2.36	0	0	0	100
1.18	50	5	5	95
0.60	402	40.2	45.2	54.8
0.30	366	36.6	81.8	18.2
0.15	122	12.2	94	6
0.075	50	5	99	1
Pan	10	1	100	0

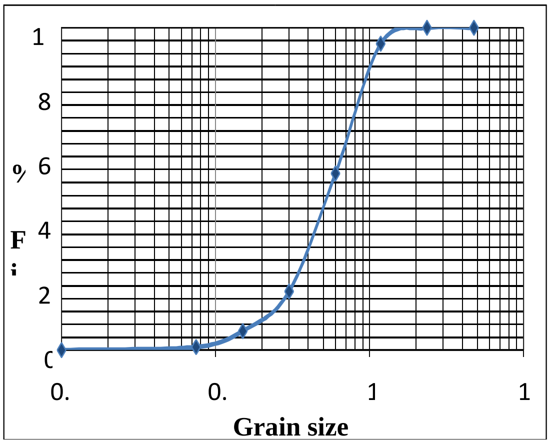

Fig. 2 : Particle size distribution curve of GCD

Ordinary portland cement of 53 grade is used in the present experimental investigation as a stabilizer for soil. Basic tests are conducted on cement as per IS code[21] and the results obtained are tabulated in **Table 4**. From **Table 4**, it is clearthe tested cement satisfies all the criteria of Is code.[22] Coal ash used in the present experimental study is procured from the brick manufacturing kilns of Lakkondhalli, near Hoskote, Bangalore rural district, Karnataka, India.

Table 4 : Test results of cement

Characteristics	Unit	Value
Fineness (Retained on 90µ IS sieve)	%	3
Soundness	mm	2
Standard consistency	%	31
Setting time Initial setting Final setting	- Min min	- 105 250
28 days compressive strength	N/mm²	54.22
Specific gravity	-	3.15

Initially the coal ash consisted of lumps of burnt obtained after sieving is in amorphous form and coal and some brick powder, as coal ash is used suitable to be used as a pozzolana. Suitable for cement replacement all the lumps are broken physical tests are done on coal ash and the down and passed through 90µ IS sieve. Coal ash obtained results are tabulated in **Table 5**.

Table 5 : Physical properties of coal ash

S/N	Physical properties	
	Colour	Brownish white
	Physical nature	Amorphous
	Specific gravity	2.49
	Grain size	< 90µ

For the present study clean potable water is prepare or cure the blocks it may induce used to prepare coal ash based stabilized mud efflorescence. In order to produce stabilized blocks and to cure the blocks for 28 days mud blocks of good quality, the selected soil under wet burlap. It is very important to use should have a sandy fraction (4.75mm - potable water because if saline water is used to 0.075mm) of more than 65%.[13] If a soil does

IV. EXPERIMENTAL PROGRAMME

Testing of individual materials and design mix Individual materials were first sieved and then blended in appropriate proportions to yield a good soil. Typically, the good soil consists of 15 percent gravel, 50 percent sand and 35 percent silt and clay together.

The various physical properties of the blended soil used for investigation were:

- Grain size distribution:- Gravel (stone chips) 14.23%, coarse sand 1.88%, medium sand 33.89%, fine sand 14.96%, silt & clay 35.04%
- Atterberg limit – Liquid limit 41.3%, Plastic limit
  25.7%, P.I =15.6
- Standard proctor test: OMC 16.0%, MDD 1.85gm/cc.
- Specific gravity - 2.67 Ordinary Portland cement is used and the full process is done in light compaction.

A. Experimental Procedure

The soil, sand, clay and stone grits were first air dried by spreading them in an open space and then, the required quantities of samples were weighed and mixed. Next, the blended soil was mixed with the required quantity of cement (5 percent; 7.5 percent, 10 percent by weight of dry soil) 9, 10 till the soil cement blend attained a uniform colour. The required quantity of water were weighed i.e. equal to the quantity of water corresponding to OMC of the soil by weight of blended soil plus the quantity of water corresponding to a water-cement ratio of 0.5. The total quantity of water to be added to the mix was decided through trials by varying Experimental investigation and feasibility study on stabilized compacted earth block using local resources. water content in the mix to attain maximum dry density (MDD) of blocks when compacted in a mould. The water was then gradually added by sprinkling it over the mix. The mixing was done manually and continued until a homogeneous mix was obtained. The soil-cement mix was then transferred to the block mould and compacted into three layers with the 2.6 kg Standard Proctor Density Hammer. The number of blows required was standardized by trial method to get above 95 percent compaction to it's maximum dry density.

V. CONCLUSION

Based on the review of both experimental and filed investigation on clay bricks and stabilized compressed earth blocks, the following concluding remarks can be drawn:

1) Major usage in the world for construction is clay bricks; many researchers are presently looking for newer options because they need low cost

materials, which are also environmentally friendly. The process of manufacturing clay bricks also requires high energy to burn due to the emission of CO2 gas from this process.

2) Stabilized compressed earth blocks include; uniformed building component sizes, use of locally available materials and reduction of transportation. Uniformly, sized building components can result in less waste, faster construction and the possibility of using other pre-made components or modular manufactured building elements. Such modular elements as sheet metal roofing which can be easily integrated into a CEB structure.

3) The use of natural, locally-available materials makes good housing available to more people, and keeps money in the local economy rather than spending it on imported materials, fuel and replacement parts.

4) The earth used is generally subsoil, leaving topsoil for agriculture. Building with local materials can provide employment for local people, and definitely considered more sustainable in times of civil economic difficulties.

5) People can often continue to build good shelters for themselves regardless of the political situation of the country.

6) The reduction of transportation time, cost and attendant pollution can also make CEB more environmentally friendly than other materials.

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