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STUDY ON STABILIZED EARTHEN BLOCK REINFORCED WITH STRAW FIBERS

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Abstract - When, trying to establish "Sustainability" within local built environment, it is important to understand prevailing methods that are using. As a result, concentrating on "methods of wall construction", it was found that, "mud", was used over many centuries in traditional architecture. Therefore, concentrating on "mud wall construction", the goal was set to be developed, a "mud block", which has more structural durability, less weight, low cost, together with high performance with respect to indoor air quality. However, as an initial attempt of the ultimate invent of "mud block", this research was carried out to analyses, the correct proportions to invent such block. During the research mainly two types of mud blocks were casted; partially compacted mud block and poured mud block. During the casting process soil, cement, straw were mixed with water in different proportions to understand the best particle mix for the proposed block and compared the compressive strengths of each sample

1. INTRODUCTION

The global concentration was given to establish Sustainable Built Environment as a new concept, which was invented to safeguard scares resources which became highly demanded, due to complicated modern developments which are dealing with extremely multifaceted modern technologies. Sri Lanka, as a country which is developing fast, concentrating more on built environment, it is important to pay attention on this new concept of "sustainability", to overcome most of daunting challenges that can be faced due to new tools and techniques which can be created economically adverse conditions to the country by draining our resources to procure sophisticated technologies from developed countries. Therefore, when trying to establish this new concept within our local built environment, it is important to understand the traditional methods that were used and as a result concentrating on "methods of wall construction", it was found that, "mud", as a wall construction material, which has been used, over many centuries in traditional architecture.

Mud is one of humankind's oldest and most universally used construction materials. Even at the dawn of humanity, people were building with mud, using it to form protective walls shielding the entrances to their caves. Following this stage, the first known cities constructed on open field were built with mud, and were located close to the Tigris River in the southern Mesopotamian Kingdom of Sumer, in the Near East. Mud construction occurs throughout the majority of the world's different cultures, and for many it continues to be the main method of construction in use today. At present, one third of the world's population lives in mud constructions. When developing countries alone are considered, this percentage increases to 50%.

The constructional technologies used for the earth houses change with the geographical zone and with the historical period. The technology called "torchis''is based on the use of branches of shrub to build the frame of the habitation and the mud is used to fill the cavity between the branches.

1.1 Objectives

The key objective of this research is to find out the possibility of inventing a new "earthen block" which has required strength for load bearing walls while satisfying less weight and low cost together with simple manufacturing process, by varying the mixing proportions of mud, cement and straw with water. By this a new sustainable, environmental friendly construction material can be invented. The main objective of this investigation is to study the feasibility of construction of such an earthen block.

1.2 Scope of the work

The scope of this project is to reduce the emission of co2 during the manufacturing process of clay blocks. The properties such as compressive strength, Tensile strength, water absorption of the earthen blocks can be improved, by stabilizing with cement and reinforcing with treated straw fiber. By increasing the properties of blocks, these can be introduced in the construction of buildings, thus an ecofriendly construction is possible.

Further study can be done on finding the optimum percentage of the combination of cement and straw fiber. The maximum percentage of combination of cement and straw fiber that can be added to the earthen blocks without compromising the required strength can also be determine. Thus giving us a better way to dispose the waste straw fiber and manufacture blocks that help keep the environment from being contaminated.

2. PREVIOUS RESEARCH

Mallikarjun S.K, Jyothi D.O., Manjureddy K.H, Sandhya H.B, Anand.S. Amaravati studied about the design of water

Lakshmi sathya babu, et al, (2016) made a stabilized mud block as a construction material. In their study they manufactured blocks and conducted different tests, such as

compressive strength test water absorption test. From the test results they found that, these blocks which are stabilized and reinforced, has a strength in between the range of 2N/mm^2 to 3N/mm^2 (IS 725) and lower water absorption.

Baba shehu waziri,et al, (2013) Made an investigation on properties of compressed stabilized earth blocks for low cost housing construction. They tested suitability of 2 types of soils for the manufacturing of earthen blocks. They found out that the strength of compressed blocks increased when cement was used as a stabilizer. The strength was increased with an average value of .35N/mm^2 with increased stabilization level from 0% through 7.5%. The minimum strength for low rise building construction was less than 28 days strength of two samples.

Ck subramania Prasad, et al, (2012), discussed about plastic fiber reinforced soil blocks. Compressed soil masonry blocks formed using moist soil compacted mechanically to improve physical characteristics have ained popularity recently. The research gave the benefits of earth in this manner include improved strength and durability as compared to adobe while maintaining significantly low embodied energy levels than alternative materials.

Vinu Prakash, et al, (2016), in their paper talks about studies on stabilized mud block as a construction material. Home brick-makers have long been using Fibrous ingredients like straw to improve the tensile strength of mud bricks. However, they don't had a chance to do scientific experimental investigation on the balance of ingredients and the optimization of this production but they made a detailed study. The fibers, which are connected together by mud, provide a tensile strength in mud bricks. The results shows that, the fibers provide a better coherence between the mud layers. The results shows the blocks has significantly less embodied energy, contribute fewer CO_2 emissions and help to promote the local economy and local labour. At first glance they appear to be an ideal candidate for an economically viable sustainable construction material.

3. MATERIALS AND METHODOLOGY

3.1 MATERIALS

The materials used are:-

1. Clay
2. Treated straw fiber
3. Cement

3.1.1 Clay

Clay is a fine grained natural rock or soil material that combines one or more clay minerals with traces of metal oxide and organic matter. Clay are plastic due to their water content and become hard, brittle and containing variable amount of water trapped in the mineral structure. Depending on soil content in which it is found, clay can appear in various colors from white to dully grey or brown to deep orange red. It can easily compact.

3.1.2. Straw

Straw is an agricultural by product of the dry stalks of cereal plants after the grain and chaff have been removed. The presence of lignin and cellulose cause for the decay of straw fiber. If we treat it with NaOH solution the lignin and cellulose remove from straw fiber. The silica absorbed from ground, will impart strength to straw fibers.

3.1.3 Cement

A cement is a binder, a substance used for construction that sets, hardens and adheres to other materials, binding them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement is used with fine aggregate to produce mortar for masonry, or with sand and gravel aggregates to produce concrete.

3.2 METHODOLOGY

3.2.1. Collection of clay

The clay which is used to mold the brick was collected from the brick manufacturing site at Pattambi properties of clay such specific gravity was tested from the college laboratory. The specific gravity of the clay was obtained as 2.64 which was between the permissible limit of specific gravity of clay (2.6 to 2.9), as per IS 2720 part II, 1980.

3.2.2. Casting of stabilized earthen block

The collected soil is mix with cement in proper ratio after the replacement of some percentage of cement. Then casting is done with soil and cement in different proportions. The size of mould used is 254x127x76 mm. proper curing is done for 7days.

3.2.3. Treatment of straw fibers

Straw fibers should be treated before using it as reinforcement. For that, NaOH in the form of crystal is dissolved in water. 4g of NaOH is mixed with 100ml of water. Immerse in straw fiber in the solution and boil it for 15 minutes. After that the straw fibers removed from the solution and allowed to dry under direct sunlight. After complete drying, the fibers cut into the required size.

3.2.4. Casting of stabilized earthen Block with straw

The blocks are casted in the mould after thorough mixing of clay, cement and straw fibers. The mixed proportions are filled with uniform compaction. The surface of the mould filled with the mix were leveled or smoothened and then mould was removed after drying and provide proper curing. The blocks casted with different percentage of straw fiber.

3.2.5. Curing of blocks

The mould is removed and the block is kept for curing. The curing is done by making a wet condition around the blocks. For this wet gunny bags are used.

4. RESULTS AND DISCUSSIONS

4.1 TEST ON SOIL

4.1.1 SPECIFIC GRAVITY OF CLAY

Table 4.1.1 Observations for specific gravity of clay

Sl no	Trial	1	2	3
1	Weight of empty bottle(W_1) in kg	0.560	0.561	0.562
2	Weight of bottle+Clay(W_2) in kg	0.784	0.785	0.783
3	Weight of bottle+Clay+Water(W_3) in kg	1.194	1.195	1.194
4	Weight of bottle+Water(W_4) in kg	1.055	1.057	1.058
5	Specific gravity	2.635	2.604	2.6

Trial 1:-

Specific gravity = $(W_2-W_1) / ((W_2-W_1)-(W_3-W_4))$

= (0.784-0.560) / ((0.784-0.560) - (1.194 - 1.055))

= 2.635

Average value of specific gravity = (2.635+2.604+2.6) / 3

= 2.613

As per is 2720 part II, 1980, specific gravity of clay soil is in the range of 2.6-2.9. Specific gravity of the soil tested was found to be 2.613. So evidently we can conclude that the tested soil is a clayey soil and hence it is suitable for block construction.

4.1.2 ATTERBERG LIMITS

4.1.2(A) LIQUID LIMIT

Table 4.1.2(A) observations for liquid limit

container number	1	2	3	4
Number of blows	37	30	22	17
Mass of wet soil (M1)	10g	10g	10g	10g
Mass of dry soil (M2)	7.45g	7.4g	6.2g	6.79g
Mass of water (Mw=M1-M2)	2.55g	2.6g	3.8g	3.21g
Water content(w=Mw/M2)	34.228%	35.135%	61.29%	47.275%

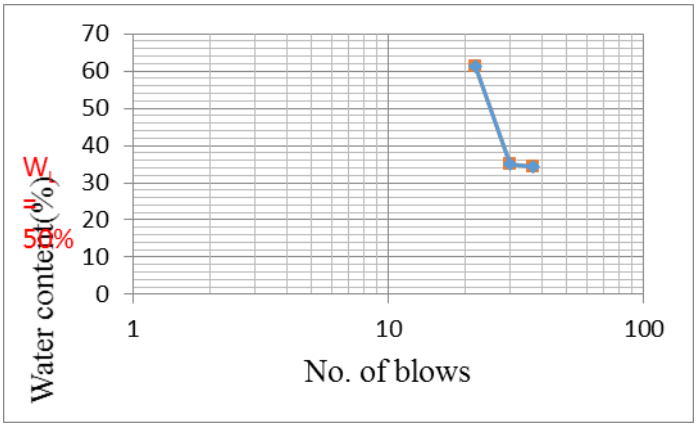

Chart 4.1.2(A) Liquid limit

Water content corresponding to 25 blows:-52%

4.1.2(B) PLASTIC LIMIT

Mass of wet soil (M_1)	8g
Mass of dry soil (M_s)	6.3g
Mass of water (M_w)	1.7g
Water content(M_w/M_s)x100	26.98%

Water content = (M_W/M_S) X100

= (1.7/6.3)X100

=26.98%

4.1.3 FREE SWELL INDEX

Calculations for free swell index

Free Swell Index, (%) = $\frac{Vd - Vk}{Vk}$ X100

= $\frac{26-20}{20}$ X100

=30%

V_d = Volume of the soil specimen read from the graduated cylinder containing Distilled water.

V_k = Volume of the soil specimen read from the graduated cylinder containing Kerosene.

5. TEST PERFORMED ON BLOCKS

5.1 COMPRESSIVE STRENGTH OF STABILIZED BLOCK

Sl no	Proportions of cement in%	Compressive strength(N/mm2)
1	6	1.55
2	8	2.325
3	10	2.48
4	12	2.542

When adding 6% of cement the compressive strength is 1.55N/mm². Increasing cement content by 2% the strength is 2.325N/mm², which means the strength increased by 50%. Again increasing cement contents by 2% the strengths are 2.48N/mm2 and 2.542N/mm2, which means strength increased by 60% and 64%.So we adopted The proportion of cement as 10%.

5.2 STABILIZED EARTHEN BLOCK WITH STRAW FIBER

Stabilized earthen block with straw fiber shown in table 5.2.1(B)

Sl no	Proportions of straw with 10% of cement	Compressive strength(N/mm²)
1	0.5	2.635
2	0.75	3.56
3	1.00	4.185
4	1.25	4.34

Table 5.2 Obtained compression test values

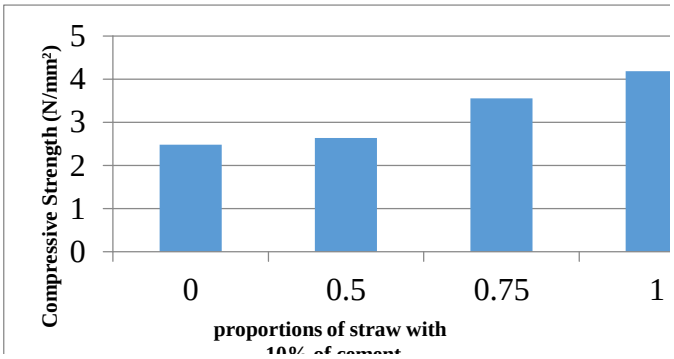

Chart 5.2 Compressive strength after 7 days

CONCLUSION

The key objective of the research is "to find out the possibility of inventing a new "mud block" which has required strength for load bearing walls while satisfying less weight and low cost, by varying the mixing proportions of mud, cement and straw". From the investigations carried out during the research, though the correct proportions of mud, cement and straw, for such block could not found, the research was capable of obtaining important findings that can be further improved in future research, on inventing the "mud block". it was found that even the cement percentage increases, compacted mud blocks have higher strength from the weight comparison, it can be concluded that, by mixing straw the weight can be drastically reduced and by reducing clay and water can be further achieved high strength blocks. Therefore, there is a high possibility of introducing a block with law weight and having enough strength by selecting a proper mix on cement, straw, soil and water.

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