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An Intelligent System to Analyze Thermal Effect of Stabilized Soil Block

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Abstract: Masonry units such as burnt clay bricks and stabilised soil bricks are abundantly used for residential or commercial or any infrastructure construction. Clay mineral absorbs water upon wetting. This paper includes the manufacture of stabilised soil brick (SSB) using natural soil and measuring model room temperature built using burnt clay brick (BCB) and stabilised soil brick. The soil was clayey sand of low plasticity. Stabilizer used to make stabilized soil bricks was 7% cement. Results of tests carried on these bricks at 28 days indicate maximum compressive strength, water absorption. The influence of temperature was measured by constructing two model rooms (1.5 m x 1.5 x 1.5 m) of stabilised soil brick and burnt clay brick. Difference in production of SSB and BCB and variation in measured temperature within rooms indicated environment benefits of SSB compared to BCB.A maximum temperature of 33 ^{0}C was attained in the BCB model room during post meridiem whereas a temperature of 29 ^{0}C by SSB model room. The maximum average value of ambient temperature was 30 ^{0}C thus indicating 12.6% decrease in temperature using SSB for construction instead of burnt clay bricks.

Keywords *– soil, stabiliser, cement, burnt clay brick, temperature, soil stabilised brick*

1. Inroduction

Over decades, building construction materials have been utilized for construction in a variety of ways, to provide safe, climatically comfortable, and easy-to-construct habitats and shelters. The versatile natural occurring materials are mud and clay were the first among all the building materials to be used due to its property of moulding nature, texture and ease to bind quickly with natural or artificial fibres. The adhesive quality of clay made it easy to work with and form into shapes. Use of straw, grass, husks and other agricultural waste and fibres to make the structures more durable and provide the strength to cope with severe weather conditions.

According to Pollock (1999), the earth or soil used as a building construction material, dates back to Ubaid period in ancient Mesopotamia (5000-4000 B.C.). Easton (1996) has suggested that at least 50% of the world's population still live in earth houses. Unfortunately all ancient earth buildings have succumbed to the ravages of time due to poor weather resistance. These buildings were not as weather resistant as the modern buildings constructed out of stone or burnt clay bricks. This era commonly used materials are Bricks, cement, steel, aluminium, plastic products, paints, polished stone, ceramic products etc., for construction, requires and consumes exhaustive energy to manufacture and to transport to a farthest construction yard. The usage of newly advent building materials are draining out the energy and causing global warming (Reddy, 2004).

The naturally formed material is Soil and is available entire global widely. This soil consisting of clay as mineral is used for building construction. Thus enhancing the production of masonry units using soil. Different masonry units are extracted from use of soil such as burnt clay bricks, hand moulded bricks, rammed earth wall and stabilised soil bricks, but they vary in the production method. Like, a temperature of 1500 ^{0}C is required to burn the materials for the production of Burnt clay bricks. Whereas other masonry units of Hand moulded, rammed earth wall and stabilised soil bricks does not involve any burning of materials, rather use soil and lime or cement or any other stabilisers.

The paper explains the thermal effect between burnt clay brick and stabilised soil bricks compared with the ambient temperature and the outcome. The main objective of this paper is to measure room temperature of constructed rooms by manufactured stabilised soil bricks and burnt clay bricks and to prove that the room temperature is low compared to burnt clay brick. The room temperature in stabilised clay brick can go low due to some amount of clay minerals present which is not in burnt clay brick. This signifies the effective use of stabilised soil bricks over burnt clay brick. Thus indicating significance use of stabilised soil bricks in construction.

The specific objective includes:

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- Manufacture of stabilised soil bricks (SSB)
- Recording temperature for 60 days continuously in SSB model room, BCB model room and ambient temperature.

2. Literature Survey

As to reach the objective of the work, the strength and durability aspects of stabilised bricks was studied. Reddy and Walker (2005) examined the strength and durability characteristics of cement stabilised soil brick and recommend optimum clay content of 10–12 %.

Walker (2004) reached to determine the strength and erosion resistance of cement stabilised blocks. Heathcote and Moor (2000) have extensively reviewed the existing specifications and methods of test for assessing durability of constructed earth walls. In New Mexico and the U.S.A where protective coating is used the question of durability relates more to the permeability of the wall and the effect moisture on the wall strength. In New Mexico the State Code requires a minimum compressive strength of earth bricks to be 2kPa.

A spray test developed by Wolfskill (1970) was adapted by Jagadish and Reddy (1987) to test pressed soil blocks in India. Craterre (1989) also has similar strength requirement for dry bricks but additionally requires that the ratio of wet to dry strength be not less than 0.5 In Israel, Cytryin (1957) recognized that a test that simulated the action of rain was needed to test for resistance to the forces of drying rain.

In 1960 Fitzmaurice carried out comprehensive study on the condition of existing wall buildings and concluded that only stabilized walls should be considered as permanent. In his detailed study of the properties of stabilized earth he used ASTM Standard D559-44 for testing stabilized earth.

In South Africa Webb et al (1950) carried out tests on stabilized pressed earth bricks and fired bricks using a modification of ASTM D559 and concluded that earth bricks made from suitable soils were equivalent to medium quality fired bricks. In Australia a ‘spray test’ (Bulletin 5, 1987) was developed involving water being sprayed horizontally out of a special nozzle at a pressure of 50 kPa. The depth of erosion is compared to an allowable maximum. Modifications made by Heathcote which are included in the N.Z. (New Zealand) Standard NZS 4297: 1988 involves making the limiting erosion depth dependent on local environmental factors such as wind speed, annual rainfall and orientation of the wallwith respect to the prevailing wind driven direction.

3. Materials Used in the Experimental Investigation

3.1 Soil

Abundantly available local soil near the campus of Sri Venkateshwara College of Engineering, Bangalore, designated as natural soil (NS) was used. Soil contained kaolinite clay mineral, 24.7% clay size fraction, fineness modulus of 2.13; liquid limit and plasticity index for the soil are 29.3 and 16.5%, respectively. With these soil physical properties, the soil was classified as Clayey Sand (SC) as per Unified Soil Classification.

Burnt clay bricks (BCB) were carried from the nearby site and used for the model room construction. The soil used for the manufacture of the stabilised soil bricks (SCB) and BCB were similar in physical properties. Thus no deviation in properties of soil. Soil required for the production of SSB was sieved through 4.75 mm sieve. Fig. 1 shows the sieving process of soil through 4.75mm sieve.

Fig. 1 – Soil sieving

3.2 Crushed Sand

Crushed sand or quarry sand was tested for sieve analysis. The sand contains both the silt 8.4% and sand 95.4% size fractions and the fineness modulus is 1.73 (Suwan et al 1995, Gauhar et al, 2016). The use of crushed sand in the production of SSB, to dilute the percentage of clay in the mix.

3.3 Reconstituted Soils

Reconstituted soil composes of soil and sand in different propoartion, based on the percentage of clay mineral in the soil. The natural soil NS was blended with crushed sand to obtain optimum clay of 12%, 9.3% silt and 78.8% sand respectively. Fig. 2 shows the grain size distribution of natural soil, quarry dust and the reconstituted soil.

3.4 Cement

In the production of SSB, binder used was Ordinary Portland cement 53 grade conforming to Indian Standards Code.

4. Production Of Stabilised Soil Bricks

The procedure of production follows a step by step.

4.1 Batching and mixing

Using the gauge box, soil, sand and cement required for particular strength of density 1.72 kN/m^3 was batch out. Soil and sand were mixed in 1:1 proportion with shovels until a uniform colour is obtained. 12% cement as a stabilizer is added to the mix and thoroughly mixed to get uniform mix colour. Fig. 3 indicates mixing and breaking of lumps in the mix.

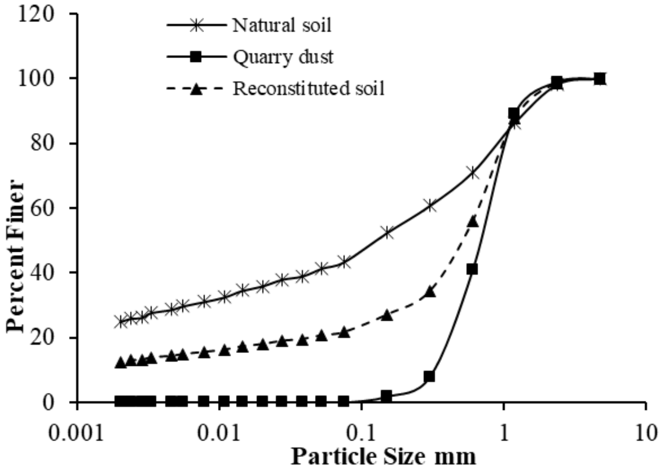

Fig. 2 – Grain size distribution curve

Fig. 3 – Mixing of soil, sand and cement uniformly

4.2 Moulding water content

Moulding water content (MWC) is 12% of total mix to manufacture SSB. The CSB required a static compaction process. Reddy and Jagadish (1993) investigated on static compaction of soils. Wet side of the compaction test curve generate better results of stabilised compacts, work of Reddy and Kumar (2011a).

Water was gradually sprinkled on the dry mix of soil, sand and cement. Mason trowel was used to mix uniformly and obtain a good cohesion such thatwhen a lump of wet mix was squeezed in hand no water should ooze out between in between the fingers.

4.3 Loading the press

CSB of size 230 x 108 x 75 mm was manufactured by loading oiled mould. Specific weight of wet mix was weighed for desired density of 1.72 kN/m^3. Filling mould with soil, crushed sand and cement wet mix, the mould cover was dropped to cover the mould box. Fig. 4 shows the mix being loaded into the mould.

Fig. 4 – Loading the mix to the mould

4.4 Compacting the block

The handle of the brick making machinewas brought to the vertical position ensuring that the rollers fit intheir curved positions. The lever latch was opened as the person on the other side takes over thehandle to compact the brick. The handle was brought down by the person compacting the block until thelever arm touches the compaction stopgear.At this point the maximumcompaction has been achieved.

4.5 Ejecting the block

The handle was passed over to the person standing on the oppositeside of the press machine to start the ejection stroke.The lever latch was locked in position, while the handle was moved from thevertical position so that the cover can be opened. The handle was brought all the way down as the brick was ejectedall the way up as shown in Fig. 5.The brick was removed gently by holding it along the long sides andtaken to a well sheltered area for curing.

Fig 5. - Ejection of brick

4.6 Curing

It is a process of controlling the setting of cement in order to acquire maximum strength. This was the last process whichstarts 24 hoursafter production. Fig. 6 shows the curing of blocks by burlap method.

Fig. 6 - Curing of blocks

4.7 Construction of model rooms

Fig. 7 - Excavation and concreting for the foundation of size 1.5m x1.5m

Model rooms of size 1.5 x 1.5 x 1.5 m height was constructed to measure the temperature using BCB and SSB. Foundation depth of approximately 1Feet was excavated and concreting of M10 was used to fill foundation as shown in Fig. 7.

Fig. 8 –Construction of masonry wall of size 1.5m x1.5m x 1.5m

Construction of masonry for both model rooms of BCB and SCB was stretcher bond type with a wall thickness of 108 mm. Care was taken to maintain a cement mortar joint thickness of 10 mm as shown in Fig. 8. Burlap curing for 28 days was done. During curing, temperature and relative humidity was referred to work of Latha and Venkatarama Reddy, 2017.After completion of rooms, as a roofing material, thin laminated sheets were placed on top of rooms and wall opening of 0.5m x 1.5m was provided in both the rooms as shown in Fig. 9.

CSB model room **BCB model room**

Fig. 9 – Constructed model rooms of size 1.5m x1.5m x 1.5m

5. Testing

5.1 Compressive Strength

The bricks both SSB and BCB, each six in number were tested for wet and dry condition of compressive strength. Frogs on the bed surfaces of the bricks were filled with rich cement mortar. The bricks were soaked in water for 48 h prior to testing and compressive strength test was performed as per IS 3495-Part I.

5.2 Water Content

Water content for the bricks (six in nunber), SSB and BCB was determined as per IS 3495-Part II.

5.3 Temperature measurement of model rooms

Two Model rooms each of size 1.2m x 1.2m and height 1.0m were constructed using SSB and BSB bricks in open area of Sri Venkateshwara College of Engineering, Bangalore, campus. The ambient condition of both rooms were maintained equally same. Digital data logger was used to measure the room temperature at regular interval for a period of two months.

6. Results and Discussion

6.1 Compressive strength of SSB and BCB

The dry and wet compressive strength was determined of six specimens each. The maximum compressive strength of wet and dry of SSB was 4.42 and 9.84 MPa respectively. BCB experienced a maximum compressive strength of 3.26 and 7.82 MPa under wet and dry condition.

6.2 Absorption Characteristics bricks

Influence of soil composition on the absorption characteristics of SSB and BCB was examined by conducting saturated water content. Saturated water content values found to be 14.3% for SSB and 8.2% for BCB

6.3 Temperature variation

Manufacture of SSB requires less energy compared to BCB as in BCB soil is burnt at 1500 ^{0}C, converting clay mineral into sand size particles, whereas soil undergoes unburnt in the manufacture of SSB, proving energy efficient.Influence of temperaturewas determined using a data logger at regular interval. This temperature was compared with ambient temperature (AT). With the measurement of temperature after construction and curing for 28 days temperature was measured during after meridiem and post meridiem for a period of 60 days (during April, 2017). The average graphs were plot and shown in Fig. 10, Table 1 gives the values of time interval and temperature details. Following discussions are made below.

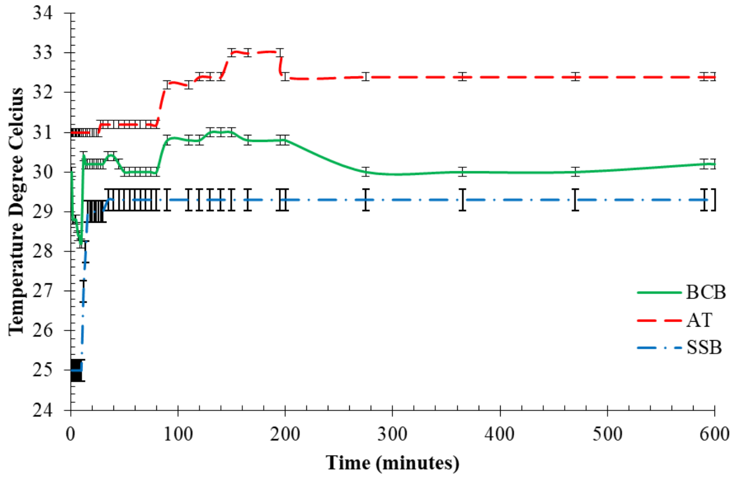

Fig. 10 – Plot of temperature against time

Table 1 – Average Values of Time, Ambient Temperature (AT), Burnt Clay Brick (BCB) room temperature and Stabilised Soil Brick (SSB) room temperature

Time in minutes	AT in ^{0}C	Standard Deviation	BCBin ^{0}C	Standard Deviation	SSBin ^{0}C	Standard Deviation
1	30	0.5	31	0.4	25	0.8
2	28.8	0.5	31	0.4	25	0.7
3	28.8	0.5	31	0.3	25	0.7
4	28.8	0.5	31	0.4	25	0.7
5	28.8	0.4	31	0.3	25	0.7
6	28.6	0.5	31	0.4	25	0.6
7	28.4	0.6	31	0.4	25	0.7
8	28.4	0.7	31	0.4	25	0.7
9	28.2	0.5	31	0.3	25	0.7
10	28.2	0.4	31	0.4	25	0.8
12	30.4	0.5	31	0.4	27	0.7
14	30.2	0.5	31	0.4	28	0.7
16	30.2	0.5	31	0.4	29	0.7
18	30.2	0.5	31	0.4	29	0.7
20	30.2	0.5	31	0.4	29	0.7
22	30.2	0.5	31	0.5	29	0.7
24	30.2	0.7	31	0.4	29	0.7
26	30.2	0.4	31	0.4	29	0.7
28	30.2	0.5	31.2	0.4	29	0.7

30	30.2	0.5	31.2	0.5	29	0.7
35	30.4	0.5	31.2	0.4	29.3	0.7
40	30.4	0.5	31.2	0.4	29.3	0.7
45	30.2	0.5	31.2	0.4	29.3	0.7
50	30	0.5	31.2	0.4	29.3	0.7
55	30	0.6	31.2	0.5	29.3	0.7
60	30	0.5	31.2	0.4	29.3	0.7
65	30	0.5	31.2	0.5	29.3	0.7
70	30	0.5	31.2	0.4	29.3	0.7
75	30	0.5	31.2	0.4	29.3	0.7
80	30	0.6	31.2	0.3	29.3	0.7
90	30.8	0.5	32.2	0.4	29.3	0.8
110	30.8	0.5	32.2	0.4	29.3	0.7
120	30.8	0.5	32.4	0.4	29.3	0.7
130	31	0.5	32.4	0.5	29.3	0.7
140	31	0.5	32.4	0.4	29.3	0.7
150	31	0.5	33	0.4	29.3	0.7
165	30.8	0.3	33	0.5	29.3	0.7
195	30.8	0.3	33	0.4	29.3	0.7
200	30.8	0.3	32.4	0.4	29.3	0.8
275	30	0.3	32.4	0.3	29.3	0.7
365	30	0.4	32.4	0.4	29.3	0.7
470	30	0.3	32.4	0.4	29.3	0.7
590	30.2	0.3	32.4	0.4	29.3	0.7
600	30.2	0.5	32.4	0.5	29.3	0.7

- Temperature in Degree Celsius and Time in minutes show soil stabilised brick undergo minimum room temperature compared to burnt clay brick and ambient temperature over 600 minutes (10 hours).
- The maximum temperature of 33 ^{0}C was attained in the model room during post meridiem by room constructed with burnt clay brick. Whereas a temperature of 29 ^{0}C by soil stabilised bricks and maximum ambient temperature was 30 ^{0}C. Indicating 12.6% decrease in temperature using SSB for construction instead of burnt clay bricks.
- It is observed that ambient temperature is 3.4% more than room temperature of SSB model room.
- During initial 100 minutes (after meridiem), room temperature in SSB reflected minimum temperature compared to BCB and AT.
- Minimum temperature in SSB model room is due to the presence of clay mineral intact in soil of SSB. Clay mineral being expansive in nature absorbs

moisture from the environment and maintains low temperature.

7. Conclusion

Process of manufacture of SSB can be done at anylocation or hard toreach areas at a low cost of both labour and materials.The mostcrucial element isthe availability of materials especiallycement as soil is foundeverywhere and in abundant.This paper show soil based construction uses easily adaptable and transferable technology and energy effective material.

Construction using soil requires much less energy and is less polluting than using burnt clay bricks ENERGY EFFECTIVENESS. Hence production of stabilized soil bricksconsumes less energy than burnt clay bricks.

A temperature decrease was found by using stabilized soil bricks of 12%, thus indicating use of stabilized soil bricksfor masonry wall in room construction is highly preferred than burnt clay brick with curing temperature and relative humidity being a limitation. Hence enabling the benefits of stabilised soil bricks over burnt clay bricks.

References

[1] Pollock, S. (1999). *Ancient Mesopotamia*, Cambridge University Press

[2] Easton. (1996). *The rammed Earth House*, Chelsea Green Pub Co, White River Junction.

[3] Reddy, B. V. V. (2004). Sustainable Building Technologies. *Current Science*, 87(7).

[4] Walker, P. (2004). Strength and erosion characteristics of earth blocks and earth block masonry. *J Mater Civil Eng(ASCE)*, 16(5),497–506.

[5] Reddy, B. V. V., Walker, P. (2005). Stabilised mudblocks: problems, prospects. In: *Proceedings of internationalEarth building conference*. Earth-Build, Sydney, Australia, 63–75.

[6] Hearthcote,K. A. and Moor, G. J. (2000). Durability of cement stabilized earth walls, *Fifth CANMET/ACI International Conference on durability of concrete, Barcelona, Spain.*

[7] Wolfskill, L. S. Dunlop, W. A. B. M. Callaway. (1970). *Handbook for Building Homes of Earth*, Department of Housing and Urban Affairs, Office of International Affairs, Washington, D.C.

[8] Jagadish, K. S. Reddy, B. V. V. (1987). Spray Erosion Studies on Pressed Earth Blocks. *Building and Environment*, 22(2),135-140.

[9] CraTerre. (1989).*General Specifications for Compressed Earth Blocks*. CraTerre, Villefontaine.

[10] Cytryn, S. (1957). Soil Construction, State of Israel, Ministry of Labour, Housing Division. *The Weizman Science Press of Israel*, Jerusalem.

[11] Fitzmaurice, R. (1960). *Manual on Stabilized Soil Construction for Housing*", Technical Assistance Program, United Nations.

[12] ASTM (American Society for Testing and Materials) Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures, ASTM D559. Conshohocken. PA.

[13] Webb, T. L. Cilliers, T. F. and N. Stutterheim. (1950). The Properties of Compacted Soil-Cement Mixtures for use in Building. *National Building Research Institute*, Pretoria, 1950.

[14] NZS 4297: 1988.*Engineering Design of Earth Buildings*.Standards New Zealand.

[15] N. Suwan tukroad. C. Pawattana.K, Moobombat. (1995). Effect of fineness modulus of sand on compressive strength of concrete, *Engineering and Applied Science Research*, 22, 1.

[16] Gauhar Sabih.Rafiqu,l A. Tarefder. Syed M Jamil. (2016). Optimization of gradation and fineness modulus of naturally fine sands for improved performance as fine aggregate in concrete. *Procedia Engineering*, 145, 66 – 73.

[17] Reddy, B. V. V. Prasanna Kumar, P. (2011). Cement stabilised rammed earth. Part A: compaction characteristics and physical properties of compacted cement stabilised soils. *Materials and Structures (RILEM)*, 44 (3), 681–693.

[18] Reddy, B. V. V. Latha, M. S. (2014). Influence of soil grading on the characteristics of cement stabilised soil compacts. *Materials and Structures*, 47(10), 1633-1645.

[19] Reddy, B. V. V. Richardson Lal. NanjundaRao, K. S. (2007). Optimum soil grading for the soil – cement blocks. *Journal of Materials in Civil Engineering, ASCE*, 19 (2), 139 – 148.

[20] Walker, P. J. (2004). Strength and erosion characteristics of earth blocks and earth block masonry. *Journal of Materials in Civil Engineering (ASCE)*, 16 (5), 497 – 506.

[21] Walker, P. J. Stace, T. (1997). Properties of some cement stabilised compressed earth blocks and mortars. *Materials and Structures (RILEM)*, 30, 545 – 551.

[22] Reddy, B.V.V. Jagadish,K.S. (1993).THE STATIC COMPACTION OF SOILS, Geotechnique, 43(2), 337-341.

[23] Reddy, B.V. V. Latha, M. S. (2014). *Retrieving clay minerals from stabilised soil compacts.* In: APPLIED CLAY SCIENCE, 101, 362-368.

[24] IS 8112. (1989). 43 GRADE ORDINARY PORTLAND CEMENT – SPECIFICATION, Bureau of Indian Standards.

[25] Latha, M. S. Reddy, B. V. V. (2017). *Swell-Shrink Properties of Stabilised Soil Products.* Construction Materials, 170, 1.

[26] Arularasan, A. N. ., Aarthi, E. ., Hemanth, S. V. ., Rajkumar, N. ., & Kalaichelvi, T. . (2023). Secure Digital Information Forward Using Highly Developed AES Techniques in Cloud Computing. International Journal on Recent and Innovation Trends in Computing and Communication, 11(4s), 122–128. https://doi.org/10.17762/ijritcc.v11i4s.6315

[27] Mei Chen, Machine Learning for Energy Optimization in Smart Grids , Machine Learning Applications Conference Proceedings, Vol 2 2022.