ADVANTAGE OF LATERITE OVER CLAY IN THE MANUFACTURE OF COMPRESSED STABILIZED EARTH BRICKS (CSEBs)

Priji E. Moses

PhD-Scholar, Department of Civil Engineering,
Bharath Institute of Higher Education and Research (BIHER), Chennai, India.

Dr. M.P. Chockalingam*

Professors, Department of Civil Engineering,
Bharath Institute of Higher Education and Research (BIHER), Chennai, India.

Dr. R. Venkatakrishnaiah

Professors, Department of Civil Engineering,
Bharath Institute of Higher Education and Research (BIHER), Chennai, India.

Prof. P. Dayakar

Professors, Department of Civil Engineering
Bharath Institute of Higher Education and Research (BIHER), Chennai, India.

*Corresponding Author : chockalingammp@gmail.com

ABSTRACT

Compressive strength characteristics and Rate of Water Absorption are the two important factors in the choice of soil types for the manufacture of Compressed Stabilised Earth blocks. Cement was used as the stabilizing agent in Laterite soil, in the ratio of cement : soil = 1 : 10. Similar proportion was used in the Clay Soil mix. After thoroughly mixing the soil mass, with sufficient quantity of water for each set of specimens, casting of blocks was carried out using standard moulds. Compaction is done at 14.0MPa, 21.0 MPa and 28.0MPa. The compressed Stabilised Earth Blocks are born. After removing the blocks from the mould, curing is done as per standard procedures. Tests were conducted on the specimens for i) Compressive strength, and ii) Moisture Absorption rate. The compressive strengths were achievable on the 28th day of Curing Age, was 7.45 N/sq.mm at 28.0 MPa of compaction in the case of Laterite Block, and 5.05 N/sq.mm, in the case of Clay Block. The rate of Moisture Absorption was 14.95% on the 28th day, at a compaction of 28.0MPa, in the Laterite Block. The corresponding Moisture Absorption rate in Clay Block was 21.05%.

Laterite Blocks give a compressive strength of 7.45 N/sq.mm, and Clay Blocks give a compressive strength of 5.05 N/sq.mm, when 10% cement is added and a compaction of 28.0MPa is applied, in both cases, in the manufacturing process.

Keywords: Laterite soil-Clay soil-Compressed Stabilised Earth Block- Comparison of Compressive strengths

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1. INTRODUCTION

Earthen structures have been in use in the ancient society all over the world, during the past several centuries. In the present context, more housing requirements are needed, at the advent of the ever-increasing population. Mostly, in rural areas, the earthen structures in a modified form has become popular. The development of compressed Stabilised Earth Block is considered as an innovative material. The main considerations are cost-effectiveness, local acceptability, rural employment, durability of the structure, fire-resistance, thermal insulation, etc . Many researchers have made contributions in this regard (1,2,3,4,5).

Raul Ramirez (6) introduced the concept of Compressed Stabilised earth Blocks, in the year 1950, in Bogota City (Columbia). Rigassi, et.al, (7) published a Manual on Production of Compressed Earth Blocks. Auroville Earth Institute (8), under the auspices of UNESCO-Chair on Architecture, took efforts in India to popularize the Earth Block construction methods, using Laterite soil, with innovative instrument technology.

In all the States of South India, namely, Tamil Nadu, Kerala, Andhra Pradesh, Telangana and Karnataka, there are many areas where Laterite soil is available as a resource. This is an encouraging factor for the promotion of Compressed Stabilised Earth Block system of housing to flourish and become popular in rural areas, in the Government-sponsored housing schemes as well as “Build Your Homes Scheme” funded by Government Agencies with financial subsidies to the beneficiaries.

In Malaysia, manual method of manufacturing earth blocks were in use since the year 1950, and at some stage, the hydraulic compression machine was introduced in the process of making CSEBs, perhaps, in large scale operations (9).

Abdullah, et.al (10) concluded that Laterite soil was found satisfactory as a raw material in the production of CSEBs, in a mix ratio of Cement: Soil : Sand = 1: 8 : 2, with water absorption ratio of 14.5% on 28th day of curing.

Soil requirement for making compressed Stabilised Earth Blocks (CSEBs) are, in general terms, i) gravel @15%, ii) sand@50%, iii) silt@15% and iv) clay@20%, plus Ordinary Portland Cement (OPC). However, the soil requirement differs between dry climate regions and tropical climate regions (10). This factor necessitates the need for experimental trials at each site.

Laterite, as a soil category, contains clay and iron particles. Clay and Laterite have got differences in quality characteristics of porosity, moisture holding capacity, hardening, compressibility, etc (11). Ordinary Portland Cement (OPC) is considered as a good stabilizing ingredient used for making CSEBs (12).

Sand, as a material used in the manufacturing of CSEBs, must be free from organic substances, and must be of finer size (passing through 2 mm sieve), and be clean (without impurities).

Ordinary Portland Cement (OPC) has been identified as a good stabilizing agent, as it can be used in any type of climatic conditions (12).

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Water, as an important ingredient in the soil mix, must be of satisfactory qualities, such as neutral pH-value, freedom from organic or chemical impurities, especially freedom from sulphates. Impurities in water would affect the hydration of cement. The role of water is very important during the hardening process, especially during the Curing Age. The quantum of water needed in the manufacturing of CSEBs varies from 10.0% to 20.0% (10, 11).

2. AIM OF THE STUDY

The Study was aimed at evaluating the merits of using Laterite soil in manufacturing Compressed Stabilised Earth Blocks, in comparison to Clay, in respect of Compressive Strength and Moisture Absorption Rate.

3. METHODOLOGY

The Laterite soil is mixed with sand and cement as Specimen-1. Clay is mixed with sand and cement as Specimen-2. Water is mixed up to the point of optimum consistency in each case. Ordinary Portland Cement (OPC) is used in both cases. The Cement : Soil : Sand ratio of 1:8:2 was used for Laterite Specimen. The Cement : Soil : Sand ratio of 1:5:5 was used for Clay Specimens. The soil grain sizes in Laterite and Clay were in such a way that the particles passed through 0.425mm sieve.

Laterite soil contained 5.7% of Clay, 78.7% of sand and 15.7% of gravel. The Clay specimen consisted of 18.1% of clay, 73.0 % of sand and 8.9 % of mud.

The Plasticity Index (PI) of Laterite specimen was 21.70, with liquid limit of 44.5% and Plastic Limit of 22.8%. The Plasticity Index (PI) of Clay specimen was 35.72, with Liquid Limit of 67.75% and Plastic Limit of 32.03%.

The soil mixes were prepared in each case of Laterite Specimen and Clay Specimen. The soil pastes were filled up in the mould, and compacted adopting three levels of compaction, namely, 14.0MPa, 21.0MPa, and 28.0MPa, on the two sets of Specimens. A standard mould of 230mm x 115mm x 76mm, was adopted to simulate the size of Chamber Brick used in Chennai City (India).

The Compressed Stabilised Earth blocks were removed from the Moulds, and laid over a flat surface on the floor of the curing yard, under the shade of a sloped-roof shed. Mild water spray was used in the curing process.

Tests were conducted to determine the Compressive Strength and Moisture Absorption Ratio in the two categories of soil Specimens, namely, Laterite CSEBs and Clay CSEBs, on the 3rd day, 7th day 14th day, 21st day and 28th day.

4. RESULTS

Results of Compressive strength for Laterite CSEBs are shown in Table-1 and Figure-1. On the 28th day of Curing Age, the Laterite CSEBs attain a compressive Strength of 7.45 N/sq.mm, under a compaction of 28.0MPa.

Referring to Table-2 and Figure-2, it can be seen that the Clay-CSEB attains a Compressive Strength of 5.05N/sq.mm, on the 28th day.

Table 1 Compressive Strength in Laterite Soil Block

S.No.	Curing Age(days)	14.0MPa	21.0MPa	28.0MPa
1	3	6.3	6.6	7.05
2	7	6.60	6.65	7.10
3	14	6.65	6.75	7.20
4	21	6.85	7.05	7.35
5	28	7.00	7.20	7.45

Figure 1 Variation of Compressive Strength of Laterite CSEB With Curing Age

Table-2 describes the variation of Compressive Strength with Curing Age, when compaction pressures are applied at 14Mpa, 21MPa and 21MPa.

Table 2 Compressive Strength in Clay Soil Block

S.No.	Curing Age(days)	14MPa	21MPa	28MPa
1	3	4.00	5.50	5.60
2	7	3.80	5.40	5.55
3	14	3.45	5.10	5.35
4	21	3.10	4.85	5.20
5	28	2.75	4.55	5.05

The Figure-2 describes the variation of compressive strength with Curing age when compaction pressures of 14Mpa, 21MPa and 28MPa are applied to Clay-CSEBs.

Figure 2 Variation of Compressive Strength during Curing Age, in the case of Clay-CSEBs.

Table-3 presents the variation of Moisture Absorption rate (%) during the curing ages of 3-days, 7-days, 14-days, 21-days and 28-days, under the compression level of 14MPa, 21MPa and 28MPa, for the Laterite Block. On the 28th day, the Moisture Absorption rate was 14.95% under the compaction of 28MPa.

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Table 3 Moisture Absorption Rate in Laterite Soil Block

S.No.	Curing Age(days)	14.0MPa	21.0Mpa	28.0Mpa
1	3	15.60	15.75	16.05
2	7	15.40	15.65	15.90
3	14	15.10	15.35	15.65
4	21	14.85	15.05	15.30
5	28	14.50	14.75	14.95

Figure-3 presents the variation of Moisture Absorption rate (%) during the curing ages of 3-days, 7-days, 14-days, 21-days and 28-days, under the compression level of 14MPa, 21MPa and 28MPa, for the Laterite Block. On the 28th day, the Moisture Absorption rate was 14.95% under the compaction of 28MPa.

Figure 3 Variation of Moisture Content against Curing Age, In the case of Laterite-CSEBs.

From Table-4 and Figure-4, it can be seen that the Moisture content on the 28th day of Curing Age, was 21.05%, in the case of Clay-CSEBs.

Table 4 Moisture Absorption in Clay Soil Block

S.No.	Curing Age(days)	14.0MPa	21.0MPa	28.0MPa
1	3	17.05	18.70	19.50
2	7	17.25	19.00	19.75
3	14	17.70	19.60	20.20
4	21	18.10	20.15	20.70
5	28	18.50	20.70	21.05

Figure 4 Variation of Moisture Content against Curing Age, In the case of Clay-CSEBs.

The Clay-CSEBs show an upward increasing trend of moisture absorbing rate, whereas in the case of Laterite-CSEBs, the Moisture Absorbing rate showed a decreasing trend toward the Curing Age.

5. CONCLUSIONS

- Moisture Absorption rate varies from 15.90% on the 7th day of curing, in the Laterite CSEBs to 14.95%, at a steady state, under the Compaction of 28.0MPa, showing a decreasing trend with time during the curing process. On the contrary, the Clay CSEBs indicate a Moisture Absorption rate variation of 19.75% on the 7th day of curing to 21.05% on the 28th day of curing under the compaction pressure of 28.0MPa, registering an increasing trend during the curing period.
- Laterite CSEB gives a compressive strength of 7.45 N/sq.mm, and Clay CSEB gives a compressive strength of 5.05 N/sq.mm, when cement is added at 10% in both cases, and when a compaction of 28MPa is applied while manufacturing the CSEBs.
- The Laterite soil is found to be a better choice for making CSEBs wherever the Laterite soil is available as a natural resource.

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