Journal of Critical Reviews

ISSN- 2394-5125 Vol 7, Issue 1, 2020

Review Article

LATERITE SOIL FOR MANUFACTURING COMPRESSED STABILISED EARTH BLOCK: A FEASIBILITY STUDY

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Received: 10.11.2019 ***Revised: 08.12.2019*** ***Accepted: 06.01.2020***

ABSTRACT

Soil selected for manufacturing Compressed Stabilised Earth (CSEB) must have adequate compressive strength and resistance to erosion. The suitability of Laterite Soil was studied, in order to assess its suitability for manufacturing CSEB. It was ascertained that stabilization of the Laterite soil with cement imparts the necessary strength to Laterite soil, making it fit for being used as a soil category in the manufacturing of CSEB, when cement in the mix was 7.5% by weight.

Keywords: Laterite Soil-Compressed Stabilised Earth Block - Compressive strength.

DOI: http://dx.doi.org/10.31838/jcr.07.01.112

INTRODUCTION

Compressed Stabilised Earth Block (CSEB) can be considered as an innovative material used in the construction of houses in Rural Areas, in India, as well as in certain Developing Countries in the world. The rate at which the rural housing in developing countries is reported seems to be disappointingly low, as low as 10% (1). It would be, rather possible to speed it up , if efforts can be made to find appropriate technologies in each geographical location, taking into consideration the available material resources in each region (2).

Chemical Stabilization of Soil

Stabilisation is required for enhancing the mechanical properties of the soil mass, when soil is used as a building material, by adding chemical materials, like lime or cement. The binding characteristics among the particles of the soil is enhanced, by adding lime, or cement, along with sufficient quantity of water, and effectively mixing it, before the mix could 'harden' (3).

1. The CSEB, as a building material is categorized as a low-cost product, compared to fired-clay-brick, or concrete block, in which case, emissions of Carbon Dioxide is involved, in the case of burning the clay-bricks using coal as a fuel in the kilns, and in the process of cement production in factories (4).
2. The obvious fact is that cement production and manufacture of fired-clay-bricks are costlier processes than stabilizing the soil-mix with limited quantity of cement or lime and compressing the soil blocks by using hydraulic, or hand-operated mechanical pressing machines. This could help the CSEBs to be considered as 'less' costly, or affordable.
3. It is understood that the Compressive strength of CSEBs depends on two factors, namely, a) the type of soil used, and b) the compaction applied on the blocks in the mould (5).

Advantages of the CSEB-system

On a comparative basis, CSEB-System involves three simpler operations, namely, i) preparation of soil mass, including mixing with Stabilising material and water, ii) Placing the soil-mix in the Mould and compacting it with the use of a Compressing-machine, and iii) Drying the Specimens. It involves the labour from semi-skilled local local persons, self-help groups, or 'build-your-own-wall' beneficiaries, in rural settings(3,6,7)

METHODOLOGY

The soil samples were obtained from two sites, in the same village, namely, Mambakkam, Chennai, Tamil Nadu State (India). Sieve analysis was performed as per the IS-codes. Tests were conducted to evaluate Liquid-Limit, Plastic-Limit, and other relevant parameters, adopting procedures indicated in the IS-codes.

The Moisture Contents were varied in the two sets of soil-samples. Stabilising agent, namely, Cement (Ordinary Portland Cement) was added, ranging from 0.0% (no-cement addition), 2.5%, 5.0% and 7.5%, by weight.

The CSEBs were prepared with the following steps, namely, i) by filling up the stabilized mix in the standard moulds, and pressing the specimen with hands, and,ii) compressing the specimen using the hand operated Compacting Machine, iii) transferring the Specimens to the Drying area, and iv) Testing them for evaluating the Compressive Strength, after the Curing Ages of 3-days, 7-days, 14days, 21days and 28 2ays. The UTM (Universal Testing Machine) available in the Laboratory was used in determining the Compressive Strength of the various specimen.

RESULTS

The properties of soil specimens-1 & 2 are shown in Table-1.

Table 1: Properties of Soil Samples

Description	Sample-I (S1)	Sample-II (S2)
Bulk Density (kg/m^3)	17.11	16.98
Moisture content (%)	14.7	19.2
Liquid Limit (%)	25.8	31.2
Plastic Limit (%)	13.9	16.9
Plasticity Index	11.9	14.3
Specific gravity	2.64	2.61

Table 2: Particle Size distribution in Soil Samples S1 & S2

S. No.	Sieve Size	% finer than Sieve size (Soil – S1)	% finer than Sieve size (Soil – S2)
1	4.75 mm(4750 um)	99.121	100.0
2	1.70 mm (1700 um)	96.38	99.12
3	1.18 mm (1180 um)	92.82	97.3
4	425 um	84.70	92.20
5	300 um	83.55	91.14
6	212 um	69.47	80.22
7	150 um	53.45	59.25
8	75 um	28.68	35.04s

Note *: um=micrometre

The data on Grain Size distribution of the two soil samples are listed in Tables-2, presenting the % finer than the sieve sizes.

The Liquid Limit (LL) and Plastic Limit (PL), designated as 'Atterberg Limits' were determined by the procedures indicated in IS 2720-5 (1985).

Tests for Specific Gravity, Bulk Density and Moisture Content were carried out as per the relevant IS-codes.It can be seen that the Plasticity Index (PI) of the two soil samples, were 11.9 for Sample S-1, and 14.3 for Sample S-2. The PI-value of the two samples is less than 35.0, and hence the two samples can be considered to be cohesive categories, capable of being compacted , and amenable for acquiring the necessary compressive strength, and exhibiting a reasonable durability characteristic.

The particle size distribution in the two soil samples S-1 and S-2 are shown in Table-2, as represented by the percentages finer than the Standard sieves, namely, 75 um, 150 um, 212 um, 300 um, 425 um, 1.18 mm (1180 um), 1.70 mm (1700 um) and 4.75 mm (4750 um). The percentage finer than the various sieve sizes are depicted in Figure-1.

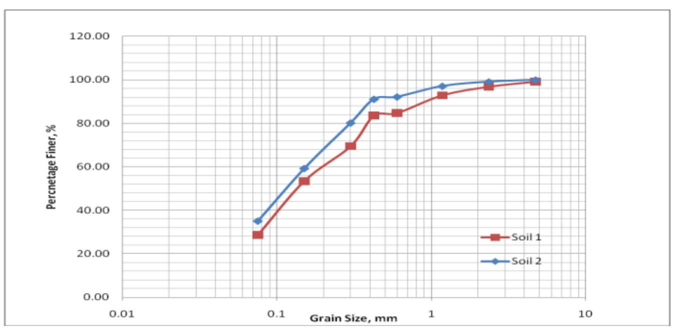

Figure 1: Percentage finer than Sieve Sizes

The Role of Moisture Content (MC)

The relevant IS-codes were used for determining the Dry Density (DD) and Moisture Content (MC) of the two soil samples.

Table-3 presents the data on Dry Density (DD) and Moisture Content (MC) of the Soil Mixes, in the case of Soil Samples S-2, and S-2.

The moisture content from 5.0 % to 22.5 % were tried for both samples.

Figure-2 presents the Compaction Curve for the two soil samples, S-1 and S-2, bringing out the relationship between MC and DD. The Optimum MC is revealed as 10.0% for S-1, corresponding to a DD-value of 1.80 gm/cc; and 20.0% for S-2, corresponding to a DD-value of 1.73 gm/cc. Correspondingly, this optimum MC-value becomes the clue while mixing water with the soil specimens while casting the earth block (8).

Table 3: Relation between Moisture Content of Soil Samples and Dry Densities

MC(%)	Sample-1 (DD 1)	Sample-2 (DD 2)
5.00	1.73	1.45
7.50	1.78	1.48
10.00	1.80	1.55

12.50	1.78	1.58
15.00	1.70	1.60
17.50	1.77	1.70
20.00	1.66	1.73
22.50	1.63	1.65

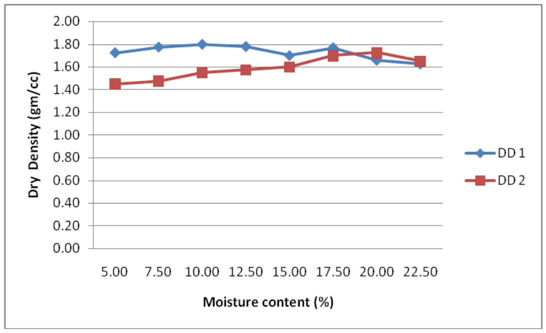

Figure 2 : Variation of Dry Density with Different Moisture Contents of Soil Sample-1 (DD 1) and Soil sample-2 (DD 2)

This is the moisture content with which the CSEBs were cast in the mould.

During the Curing process, tests were conducted for assessing the compressive strength of specimens, in which the cement content was differently mixed as 0.0%, 2.5%, 5.0%, and 7.5%.

The variation of Compressive Strengths of Specimen-1 is presented in Table-4 and Figure-3, applicable to the variation in Curing age upto 28-days, for various percentage additions of stabilizer (cement) to the Soil Sample-1.

Table-4 describes variation of Compressive Strength (N/sq.mm) during Curing Period of 3rd,7th,14th,21st and 28th days for cement addition of 0.0%, 2.5%, 5.0%, and 7.5%, for Sample-1.

Table 4 : Variation of Compressive Strength for various percentages of cement for Sample-1

Curing Age (Days)	A (0.0%)	B (0.25%)	C (5.0%)	D (7.5%)
0	0.00	0.00	0.00	0.00
3	0.90	1.40	1.50	1.70
7	1.25	1.50	1.65	2.15
14	1.35	1.70	1.80	2.40
21	1.45	1.75	1.90	2.50
28	1.50	1.80	2.00	2.71

Note: A=0.0 % of cement; B=2.5%; C=5.0%; D=7.0%.

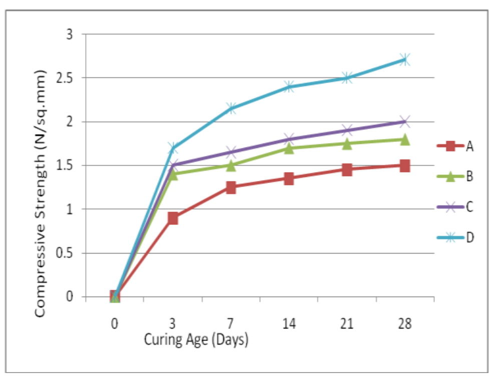

Figure 3: Variation o Compressive Strength during Curing Days for Sample-1

Note: A=0.0 % cement mix; B=2.5 % Cement; C=5.0%; D=7.5%.

The maximum Compressive Strength of 2.71 N/sq.mm is achieved in Soil Sample-1, on the 28th day of curing, for a cement-stabiliser addition of 7.5%.

The variation of Compressive Strengths of Specimen-2 is presented in Table-5 and Figure-4, applicable to the variation in Curing age upto 28-days, for various percentage additions of stabilizer (cement) to the Soil Sample-2.

Table-5 describes the Variation of Compressive Strength (N/sq.mm) during Curing Period of 3rd,7th,14th,21st and 28th days for cement addition of 0.%, 2.5%, 5.0%, and 7.5%, for Sample-2.

Table 5: Variation of Compressive Strength for various percentages of cement for Sample-2

Curing Age (Days)	A (0.0%)	B (2.5%)	C (5.0%)	D (7.5%)
0	0.00	0.00	0.00	0.00
3	0.90	1.40	1.50	1.60
7	1.25	1.50	1.65	2.15
14	1.35	1.60	1.80	2.40
21	1.40	1.70	1.85	2.50
28	1.45	1.73	1.90	2.81

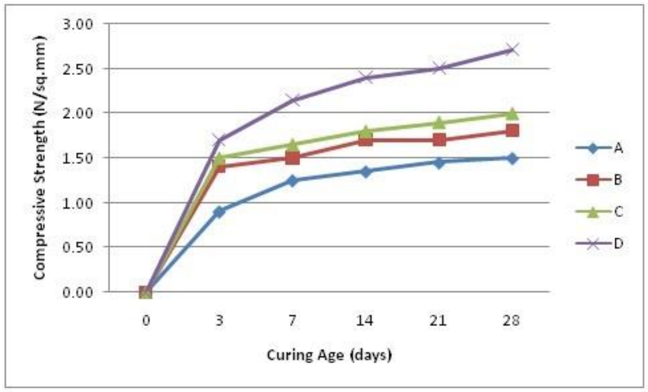

Figure 4: Variation of Compressive Strength during Curing Days for Sample-2

The maximum Compressive Strength of 2.81 N/sq.mm is achieved in Soil Sample-2, on the 28th day of curing, for a cement-stabiliser addition of 7.5%.

A comparison between the two cases, it is found that the maximum Compressive Strength of 2.81 N/sq.mm occurs on the 28-th day curing, with 7.5 % of Stabiliser addition to the soil-mix, as exhibited in Figure-4, relevant to Soil Sample-2.

CONCLUSIONS

The laboratory-level studies conducted on the fitness of Laterite Soil for the use of manufacturing Compressed Stabilised Earth Blocks (CSEBs) indicate the following results:

1. Specimen-1 gives a Dry Density of 1.8 g/cc, with a moisture content of 10.0%; Specimen-2 attains a Dry Density of 1.73 g/cc, with moisture content of 20.0%.
2. Specimen-1 attains a Compressive Strength of 2.71 N/sq.mm, on 28-days of curing, with OPC- addition of 7.5%, added for stabilization.
3. Specimen-2 attains a Compressive Strength of 2.81 N/sq.mm, on 28-days of curing, with OPC-addition of 7.5%, added for stabilization.
4. Specimen-1 and Specimen-2 give a satisfactory performance in being used for making CSEB.
5. Higher percentage of OPC may have to be optimized, for improving the Compressive strength of the Laterite soil specimens, to make it fit for being used for making CSEB.

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