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Performance of CSEB Block alternative to Brick in the context of Bangladesh

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Abstract
In a reinforced concrete (RC) frame structure building, partition wall has very low compressive strength. To replace traditional fired brick, environment friendly Compressed Stabilized Earth Block (CSEB) may be used as partition wall. This study experiment the probability of using CSEB as interior and exterior partition wall. CSEB made of dredged sand and stabilized by Ordinary Portland Cement (OPC). The aim of this experiment is to find out the optimum percentage of cement stabilizer. Different ratio of cement mix with dredged sand proved to be viable options for economical and durable blocks. Different ratios of cement-sand (1:4, 1:5 and 1:6) are tested for three days, seven days and twenty eight days. The observations on different ratios of cement-sand and change of strength with maturity age showed that each composition has its own quality on particular area. It is found that 1:6 cement-sand block gives satisfactory result in terms of durability and strength.
Keywords:*Brick,block,CSEB,eco-friendly,strength.*

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I. Introduction

Rapid development of modern urbanization and industrialization, the uses of construction ingredient such as 'brick' is increasing day by day. Recently in Bangladesh the demand of Bricks are rising by 5% increment. Usually brick is a popular item since it can be easily made without following any rules. Increasing the demand for bricks every year of urbanization, this crisis is getting worse day by day. Here's one more thing to notice that the increasing demand for brick is meet claim by 95 percent of old brick kilos and environmental pollution bricks technology is used.

We are not able to prevent those negative effects. Bangladesh is now working for implementing sustainable development targets. The way bricks coils are running with the soil from agricultural land, destroying environment and harming health hazards, it is the time we need to think about whether it can continue or not. To reduce the greenhouse gas emissions, make brick through burning process should be stopped. Though the process is not quite possible, it can be a useful step to sustainable development even if it can reduce a bit. In this case, using different projects and technologies for making brick soil collected from different rivers and other sources can be protecting the environment play a significant role. Not only that, making the cement, sand and soil mixing brick relatively cost is less. In comparison with another building material, CSEB offered numbers of advantages. Using local CSEB minimizes the production cost, makes affordable quality house for everyone. CSEB also can serve as a thermal insulator and capability to absorb atmospheric moisture which create pleasant and healthy environment for the user [1][2].

One of the limitations of using only earth as a material for construction is its durability which is directly related to its compressive strength [3][4]. In natural condition most of the soils lack its strength, durability and dimensional stability which are pre-requisite for building construction. The technique to improve durability and strength of soil defined as soil stabilization. There are different types of stabilization: mechanical stabilization; chemical stabilization; physical stabilization [5][6].

The first attempts for compressed earth blocks were tired in early days of the 19th century in Europe. The architect François Cointereaux precast small blocks of beaten earth and used hand rammers to compress the moist soil into a small wooden mold held with his feet. Cinvaram was the first steel manual press which had been manufactured in 1950. Africa, India as well as south Asia have been using this technique. In the last 30 years compressed earth blocks become broadly used around the world, not only in the developing countries but also in developed countries like USA, UK and Canada [7].

II. Test Procedure

2.1 Materials

2.1.1. Cement

The cement used in all the mixes was manufactured by Premier Ordinary Portland Cement (OPC) CEM-I 42.5N and 52.5N
Grade and contains

- 95-100% clinker,
- 0-5% gypsum

2.1.2. Soil

The soil used in this study was brought from Turag River, which is around 10km from Dhaka. The soils used for making the blocks were evaluated some tests for classifying and identifying the types of soils. The tests performed were as follows: Sampling and field Classification, Sieve Analysis test, Moisture Content Test, Specific gravity test and finest modulus. All the soil tests were done at AUST geotechnical laboratory. After classifying the soils, compressed stabilized earth blocks were made from the soils. The physical properties of the soil are given in Table 1. The detail test results are given below:

Table 1: Soil properties

	Physical properties	*Values*
1	Specific gravity	2.693
2	Natural moisture content	2.36
3	Fines content	6.2
4	sand content	93.6
5	Finest modulus	1.91

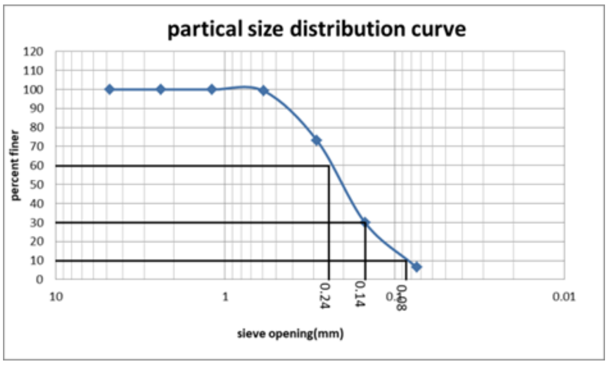


Fig 1: Sieve analysis of soil

2.1.3. Water

Fresh tap water free from all forms of organic is used, which is supplied by the Dhaka water supply system of the city.

2.2 Mixing proportion

Water is mixed with the soil until it is plastic enough to mold. Water content should be less than optimum moisture content of the soil by weight. The water and soil must be thoroughly mixed. In order to analyze the effects of contents of cement and soil three different mix proportion series were prepared. The CSEB blocks were prepared and casted at Housing and Building Research Institute (HBRI). To this effect the following mix proportions are presented in Table 2

Table 2: Mixing proportion

Series	Cement-Sand ratio	Cement	Sand	water
1st series	1:4	20%	80%	12.5%
2nd series	1:5	16.66%	83.33%	12.5%
3rd series	1:6	15.28%	85.71%	12.5%

2.3 Compressed Stabilized Earth Block (CSEB) Production

An earthen block preparation machine Cinvaram was borrowed from HBRI for preparing CSEB block which mold size is approximately (240mm x 110mm x 70mm). CSEB block should be uniform size and density. Mold should be filled with the same amount of mix for each compaction by using measuring weight device. For good neat surface the internal faces of the machine mold with oil which can be applied with a brush. The ram is a steel box with a bottom that moves up and down. The soil mix is placed in the box, and a steel lid is placed on top. A lever is pulled to one side and the bottom moves up, compressing the soil mix against the fixed top. The lever is released, the top removed, and as the lever is pushed into the opposite direction, the bottom moves even further up, and the block is ejected. The machine can be operated by one or two person. Soil and cement were mixed with water until it was plastic enough to mold. The soil mix was placed in CINVA RAM mold and compacted by hand and wooden bar in first layer. Second layer was then placed and compacted again manually. Finally lever was used to press the mixture in the designed mold. By the mechanical lever manually compacted soil was compacted again and its volume was reduced to 85% of original volume. This procedure to prepare CSEB was repeated for every composition of soil. The soil preparation and pressing operation can be best described by the pictures below-

Figure 2: Collect Cement-sand

Fig 3: Mixing cement, sand and water

Fig 4: Mold **Fig 5:** Input mixing and temping

Fig 6: Filling mold**Fig 7:**Giving pressure by hand

Fig 8: CSEB

Fig 9: Collecting CSEB

2.4 Curing

For increasing compressive strength and good production curing is one of most important factor for CSEB[8]. After preparing these blocks they were kept in shaded area. Next day the bricks were move to the AUST. These blocks were cured for 28 days. Blocks were covered with wet jute bag and spraying water twice daily (morning and evening). Figure 9 shows the blocks after 1 days of production at the time of curing.

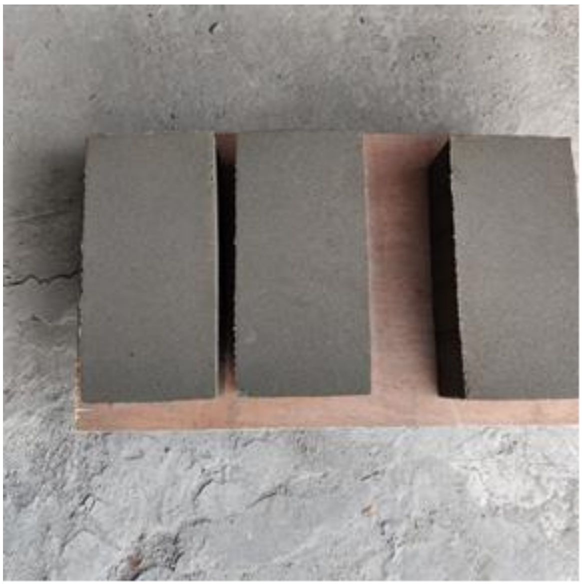


Fig 10: Curing of CSEB

III. Test Result Analysis And Discussion

3.1 Strength Properties of CSEBs

A Universal Testing Machine (Tinius Olsen Testing Machine Co. USA) at Ahsanullah University of Science & Technology the SM Laboratory, capacity 60000 lbs, was used to measure the unconfined compressive strength of the CSEB. Since there is no standard testing for CSEB, testing method used for fired clay brick and concrete masonry block such as ASTM 1984, BS 6073-1:1981, BSI 1985, BS EN 772-1, BS 1924-2:1990. [9][10].

Compression tests were performed upon block specimen to compare the physical properties of CSEB. Three groups of specimens Block different soil-cement ratio CSEB were tested. Photographs of tested specimens are shown.

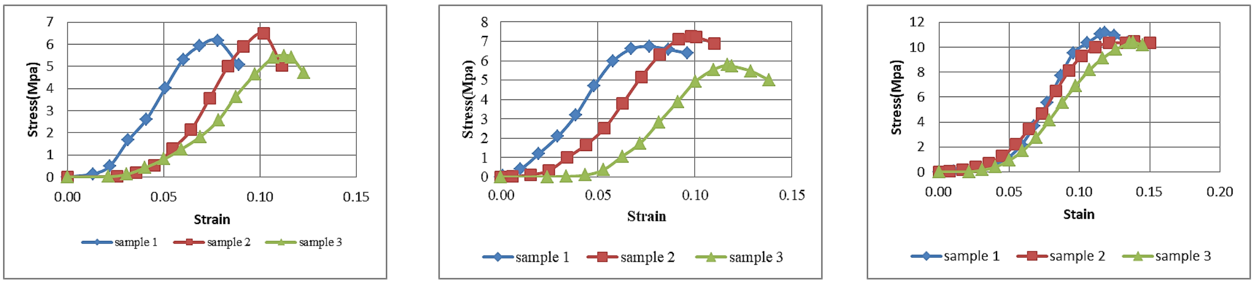
Fig 11: Placed CSEB in UTM machine

Physical properties of the tested specimens from the above mentioned groups are presented. Here stress-strain relationships of three groups mentioned are presented.

Table 3: Physical properties of tested CSEB (cement: sand=1:4)

Sand-Cement ratio	Days	Specimen ID	Ultimate compressive strength (MPa)	Failure Strain
Cement sand ratio 1:4	3 days	Sample 1	6.1735	0.0779
		Sample 2	6.4772	0.1017

		Sample 3	5.4834	0.1124
	7 days	Sample 1	6.7340	0.0766
		Sample 2	7.2795	0.0981
		Sample 3	5.7791	0.1167
	28 days	Sample 1	11.1469	0.1179
		Sample 2	10.4850	0.1386
		Sample 3	10.4091	0.1383

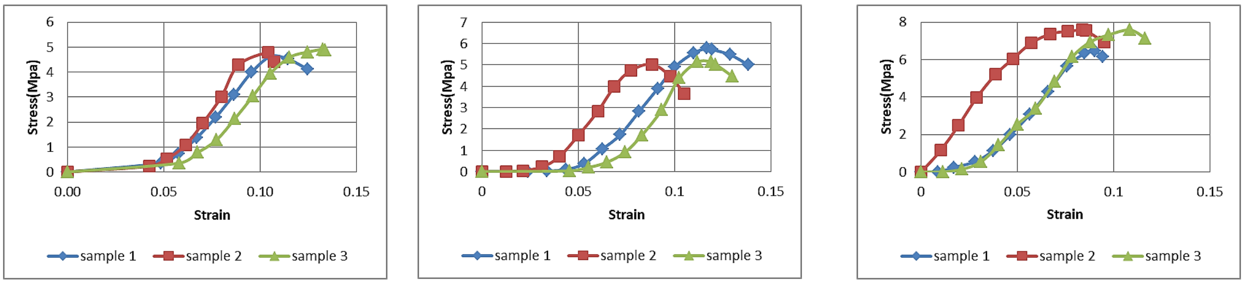


(a) (b) (c)

Fig 12: Stress-strain relationship of block at (a) day 3 (b) day 7 (c) day 28

Table 4: Physical properties of tested CSEB (sand: cement=1:5)

Sand-Cement ratio	Days	Specimen ID	Ultimate compressive strength (MPa)	Failure Strain
Cement sand ratio 1:5	3 days	Sample 1	4.6267	0.1053
		Sample 2	4.7771	0.1043
		Sample 3	4.9174	0.1326
	7 days	Sample 1	5.7791	0.1167
		Sample 2	5.0227	0.0881
		Sample 3	5.1405	0.1190
	28 days	Sample 1	6.4660	0.0900
		Sample 2	7.5844	0.0837
		Sample 3	7.5813	0.1083

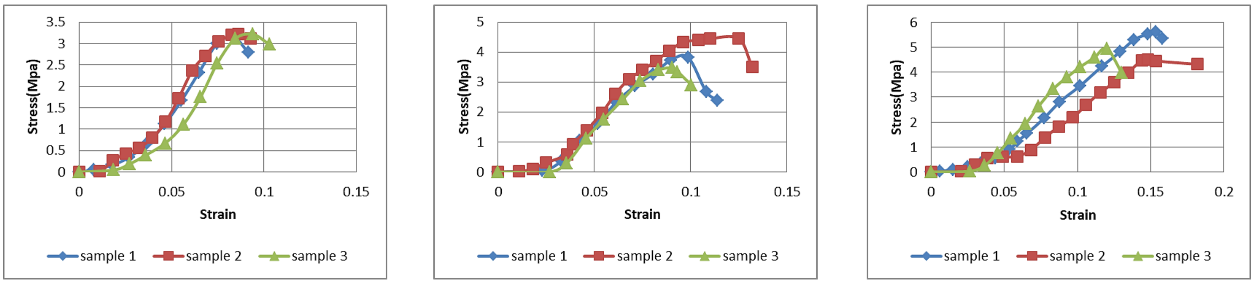


(a) (b) (c)

Fig 13: Stress-strain relationship of block at (a) day 3 (b) day 7 (c) day 28

Table 5: Physical properties of tested CSEB (cement: sand=1:6)

Sand-Cement ratio	Days	Specimen ID	Ultimate compressive strength (MPa)	Failure Strain
Cement sand ratio 1:6	7 days	Sample 1	3.1409	0.0837
		Sample 2	3.2153	0.0860
		Sample 3	3.2186	0.0939
	14 days	Sample 1	3.8245	0.0987
		Sample 2	4.4550	0.1250
		Sample 3	3.4790	0.0904
	28 days	Sample 1	5.6155	0.1534
		Sample 2	4.5121	0.1481
		Sample 3	4.9504	0.1199

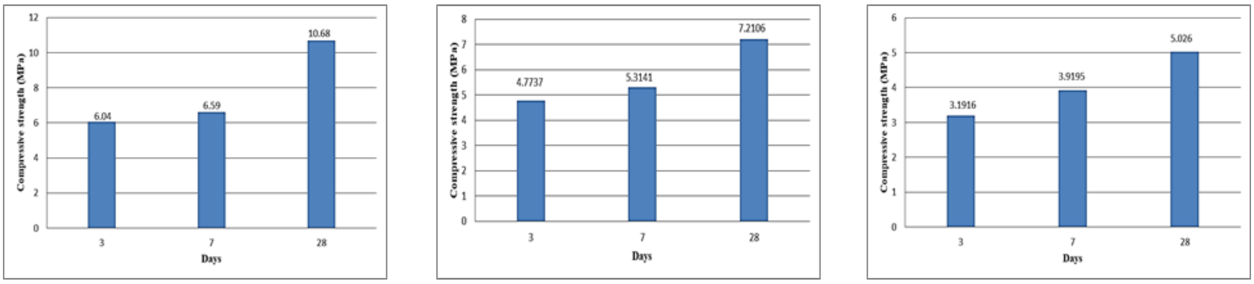


(a) (b) (c)

Fig 14: Stress-strain relationship of block at (a) day 3 (b) day 7 (c) day 28

Table 6: Physical properties of tested CSEB of different cement-sand ratio

Cement-Sand ratio	Days	Average Ultimate compressive strength (MPa)	Average Failure Strain
1:4	3 days	6.0447	0.0973
	7 days	6.5975	0.0971
	28 days	10.6803	0.1316
1:5	3 days	4.7737	0.1141
	7 days	5.3141	0.1079
	28 days	7.2106	0.0940
1:6	3 days	3.1916	0.0879
	7 days	3.9195	0.1047
	28 days	5.0260	0.1405



(a) (b) (c)

Fig 15: Bar chart of compressive strength vs Days (a)Cement-sand ratio=1:4 (b) Cement-sand ratio=1:4 (c) Cement-sand ratio=1:4

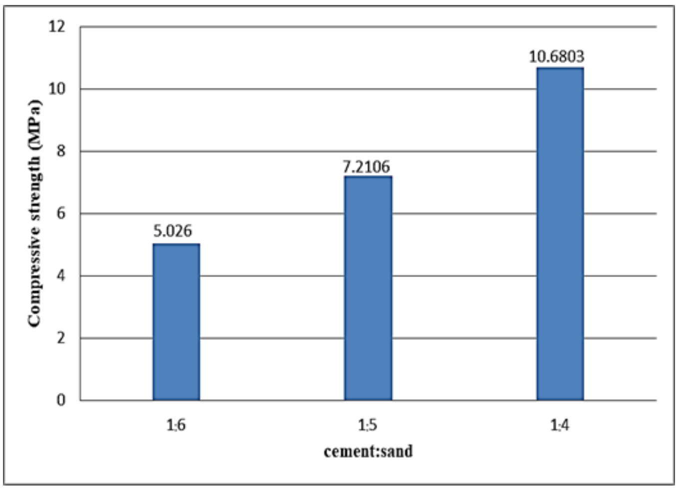


Fig 16. Bar chart of Compressive strength vs cement: sand (at 28 days)

3.2 Absorption Capacity

Table 7: Absorption Capacity of CSEB

Cement-Sand ratio	Dry weight of the specimen ,W_d (kg)	Saturated weight of the specimen after submersion in cold water,W_s(Kg)	Absorption Capacity (%) $=\frac{w_s-w_d}{w_d}\times 100\%$	Average Absorption Capacity (%)
1:4	3.76	3.99	6.12	6.52
1:5	3.92	4.19	6.88	
1:6	3.81	4.06	6.56	

3.3 Analysis of compressive strength test result

From the table and the figure we can see that compressive strength increases with increasing of cement-sand ratio. It was observed that 1:4 cement-sand ratio CSEB's compressive strength is superior to any other composition. This was obvious because of high ratio of cement bt it also more costly than other two ratio. On the other hand, the 1:6 ratio CSEB also perform well. Also from figure it was observed that for 3 and 7 days compressive strength shows good result but finally at 28 days compressive strength provide better result for all cement-sand ratio. Hopefully all cement-sand ratio gives satisfactory result comparing the compressive strength.

3.4 Analysis of Absorption capacity test result

From the table 7 we can see that absorption capacity of CSEB is 6.52 which is very low compare to clay brick. So all cement-sand ratios CSEB give satisfactory result

IV. Conclusion

1. Soil composition influences the making of CSEB block. All type of soil is not suitable for making earthen blocks. For certain types of soil it is necessary to add stabilizer.
2. Soil from Turag River shows acceptable properties regarding its physical compositions for the production of compressed stabilized earth blocks as alternative wall making materials.
3. Due to emission of CO2 and high energy required for manufacturing clay bricks, now it high time to look for alternate options like CSEB. For making CSEB, low cost materials are available locally which are also environmentally friendly and reduce the transportation time and cost.
4. CSEB also creates opportunity for unemployed person because it does not need much capital for starting production of CSEB.
5. The earth used in CSEB is generally from subsoil and protect the topsoil for agriculture and also when durability was taken into account, soil-cement proved cheaper than all other materials considered, if used as a wall or foundation material.

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