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Cement stabilized earth blocks (CSEB): An economic and eco-friendly building material.

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Abstract: *In India housing is still a major problem faced by low class people and adversely suffered by harsh environmental conditions as they are homelessly residing on roads, ordinary homes, open fields etc. Due to high and growing building material cost, construction time, easyland and material availability etc., the eradication of the problem remains a dream. So, in the growing concern of awareness regarding sustainable building material and environmental issue, Cement Stabilized Earth Blocks (CSEB) gives the view of energy efficient, cost reduction and environmental friendly building materials. CSEB's are eco-friendly and as these blocks are un- burnt products, during production no fuel material is used and does not produce any harmful gases during production. In this paper, locally available earth material in Awantipora, J&K which is famous in pottery is taken and mixed with different percentages of Ordinary Portland Cement (OPC)in the production of CSEB's. The CSEB's samples were cured and tested for compaction characteristics, compressive strength under both wet and dry conditions, water absorption. The strength of different blocks were determined and compared to find the optimum dosage of OPC required for improvement of few engineering properties.*
Keywords: *Economy, Karewa soil, OPC, Compaction, Strength, Water absorption.*

I. Introduction

Earth, undoubtedly is the oldest building material known. Even though building with earth once fell out of popularity when the modern building materials and methods were discovered, but then it gains its revival time following the energy crisis. Moreover, growing concern and interest about environmental and ecological issue globally also increased the use of earth as a building material. More than two billion people around the Globe live in buildings constructed of earth alone. The selection of building materials should meet the local conditions of life by improvement in existing structures or by building new structures.

The Cement stabilized earth block (CSEB) is the modern descendent of the moulded earth block, more commonly known as the adobe block.The addition of OPC to soil changes the properties of soil and this is mainly due to the formation of various compounds such as calcium silicate hydrate (CSH), calcium aluminate hydrate (CAH) etc. and micro fabric changes (Pozzolanicreaction).CSH and CAH are cementitious products similar to those formed in Portland cement. They form the matrix that contributes to the strength of Cement-stabilized soil layers.

$$Ca(OH)_2 \rightarrow Ca^{2+} + 2(OH)^-$$

$$Ca^{2+} + OH^- + SiO_2 \text{ (soluble clay silica)} \rightarrow \text{calcium silicate hydrate (CSH)}$$

$$Ca^{2+} + OH^- + Al_2O_3 \text{ (soluble clay alumina)} \rightarrow \text{calcium aluminate hydrate (CAH)}$$

When an adequate amount of OPC is added to the soil, the pH of soil–lime mixture is reached to 12.4. At these high pH levels, the solubility of silica and alumina are largely increased. Thus, as long as the calcium from OPC remains in the soil and the pH remains high enough to maintain the solubility, the pozzolanic reaction continues. As this matrix forms, the soil is transformed from a sandy, granular material to a hard, relatively impermeable layer with significant load bearing capacity. The process begins within hours and can continue for years in a properly designed system. The matrix formed is permanent, durable, and significantly impermeable, producing a structural layer that is both strong and flexible. The idea of compacting earth to improve the quality and performance of moulded earth blocks, and the samples are compacted dynamically as in the same manner as that of Standard Procter Test by giving blows with suitable hammer of fixed weight and height of fall.

This paper presents the results of an experimental research study on the behavior of Karewa soils treated with Ordinary Portland Cement (OPC) .The aim of this work was to investigate the effect of a wide range of Cement content and curing conditions on two important geotechnical properties: the mechanical strength and Water absorption of cement-treated fine-grained earth blocks. For this purpose, soil samples were prepared with different cement content (0%, 3%, 6%, 9%, 12%, 15% and 18%), and assessed at different curing times and temperatures.

II. Methodology

Materials Used:

1. **Soil**: Soil identification can be performed with sieve analysis, Atterberg limits under codal provisions.

Table1.1 Soil classification

PROPERTY	value
1. Sand size (%)	2
2. Silt Size(%)	83
3. Clay Size (%)	15
4. Specific gravity,G	2.65
5. Liquid Limit (%)	38
6. Plastic Limit (%)	23.5
7. Plasticity Index (%)	14.5
8. Plasticity Index-A_{line}	13
9. Plasticity Index-U_{line}	27
10. Shrinkage Limit (%)	12
11. Soil type (ISSCS)	**CI**
12. Clay mineral	Illite

2. **OPC:** Khyber ordinary Portland cement of 43 grade confining to IS 8112 was used throughout the work.
3. **Sample Preparation:** Procedure for making CSEB (Cement Stabilized Earth Blocks)

1. Soil sample collection.
2. Mixing of ingredients/stabilizers with clay soil in varyingpercentage.
3. The various mixes are placed in the proposed block mold.
4. Then it is dried or cured for 28 days.
5. Strength determination in terms ofDry Compressive Strength (DCS)i.e, without curing andWet Compressive Strength(WCS)i.e, with curing on UTM/CTM.

Figure 3.1. Sample preparation and testing

III. Experimental Work And Discussion of Results

3.1. Effect of Cement Content on Compaction characteristics:

Light Compaction test was done on the soil samples and as per IS 2720(VII), 1980. The specimens are prepared with OPC percentages 0, 3, 6, 9, 12, 15 and 18in the mould of volume 1000 cc in 3 layers with 25 blows each with the standard rammer as shown in below figure:

Figure3.1. Compaction test

The observations and graphical variations are shown in table 3.1 and Figure 3.2 below:

Table 3.1 OMC and MDD of samples at various percentages of Cement.

Cement content (%)	0	3	6	9	12	15	18
OMC (%)	16.89	18.85	18.57	20.64	20.98	20.99	21.24
MDD (%)	17.75	17.56	17.14	17.08	16.99	16.87	16.92

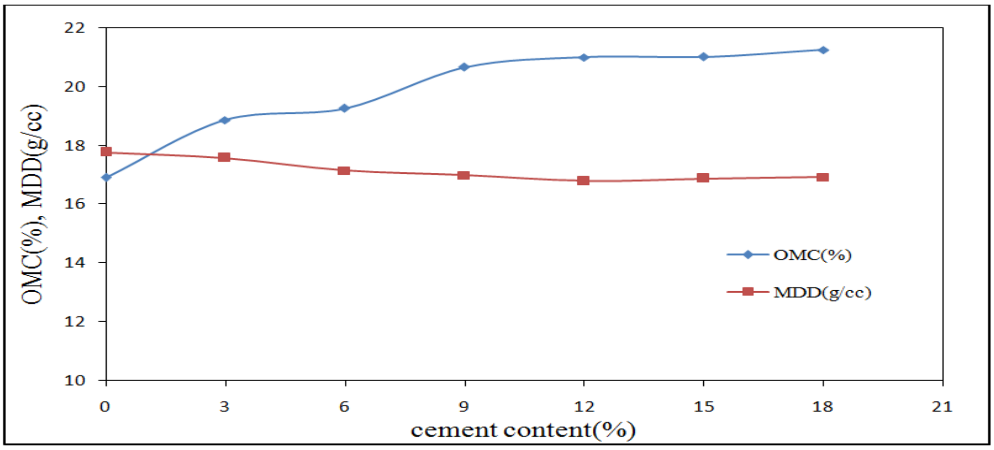

Figure 3.2 Variation of compaction characteristics with cement content

Thus,the maximum dry densities(MDD) and the corresponding water contents(OMC) for the different proportions of OPC in soil is determined from the graphs between dry density and the corresponding water content.The results thus obtained are used as basis for the unconfined compressive tests.

3.2. Effect of OPC Content on Strength of Blocks

The percentage of OPC was gradually increased from 0% to 16%.36 sampleswere prepared for this study. The strength of blocks was checked after 28 days of curing period. Experiment observations and Experimental data are given below table 3.2 and Figure 3.3.

Size of block = 19cm ×9cm ×9 cm**,** Area of the face = 19cm ×9cm = 171cm^2

W/C ratio used = 0.5, No of blows for compaction =30

Table 3.2 Variation of strength with percentage of cement.

%age cement	DCS(MPa)		Avg. DCS(MPa)	WCS(MPa)		Avg. WCS(MPa)
	Sample 1	Sample 2		Sample 1	Sample 2	
0	0.72	0.48	0.6	0.35	0.25	0.3
3	1.33	1.45	1.39	1.11	0.85	0.98
6	2.83	2.68	2.75	1.56	1.34	1.45
9	3.68	4.14	3.91	1.85	1.95	1.90
12	4.25	4.08	4.165	2.1	2.4	2.25
15	3.74	3.98	3.86	2.69	2.7	2.69
18	3.05	3.38	3.215	2.15	2.42	2.28

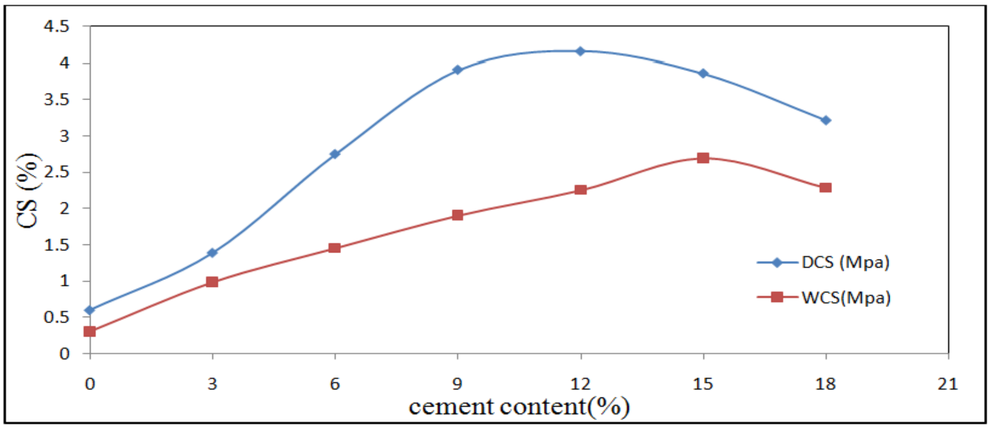

Figure 3.3 Variation of compressive strength with cement content

3.3. Effect of Water Cement Ratio on the Strength

Low w/c ratio is one of the essential parameters which increase the strength under wet curing conditions of the block. Low w/c ratio means that water should be adequate enough to be available for hydration and other process. Low w/c ratio can be achieved by adequate proportioning of the main raw material ingredients i.e., soil, cement and water. A particularly low w/c ratio can also be achieved in mixes by using partial cement replacement materials.

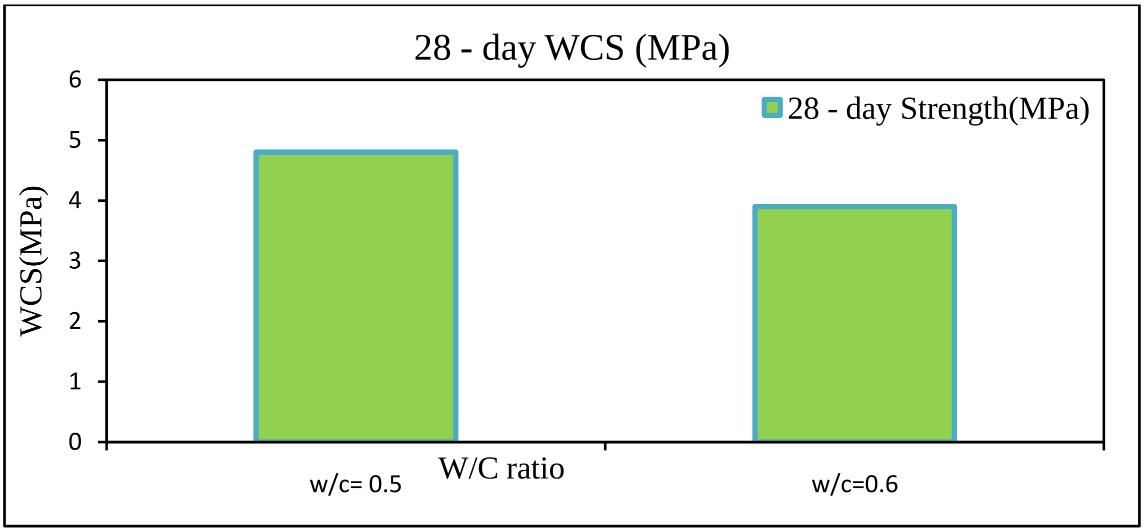

Figure 3.4. Variationof WCS with w/c ratio

The graph 3.4 is based on experimental data .With w/c =0.5, WCS equals 4.8MPa and with w/c=0.6, WCS equals 3.9MPa.

3.4. Effect of Compactive effort on strength of Blocks

Since compaction using machines like CINVA RAM wasn't possible,the effect of compaction was understood on the comparative basis. Two sets of blocks were prepared and different no of blows were given for compaction. The effect of compaction was understood by comparing the 28-day strength of these two sets of blocks. It can be understood by the below graph 3.5.

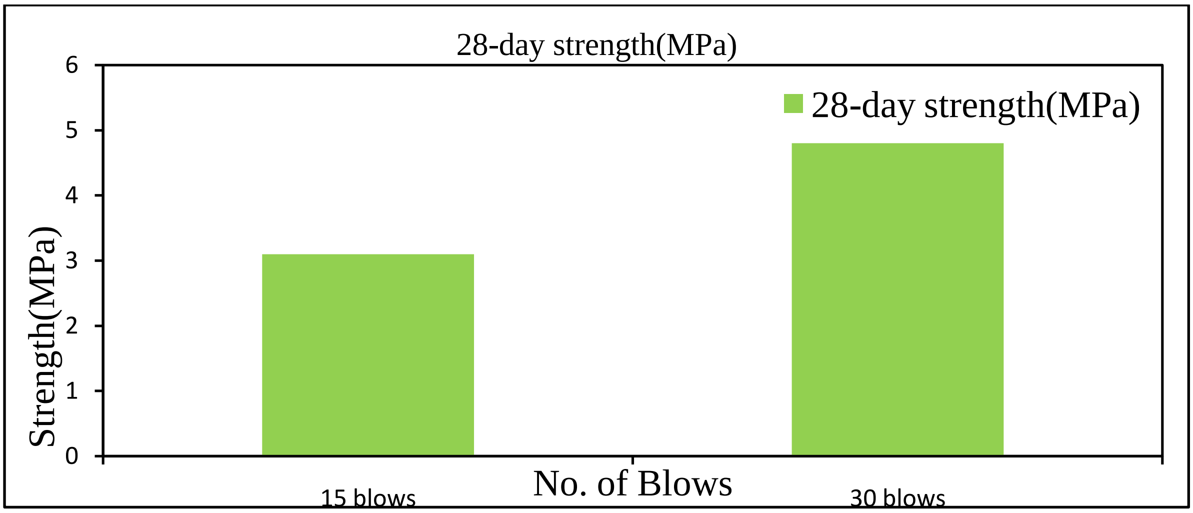

Figure 3.5. Variation of DCS with compactive effort

3.5. Effect of Curing Time on Strength

As already mentioned , with increase in the curing period both DCS and WCS of the blocks is increased .In this experiment 3 batches of blocks were tested for 3,7,14& 28 day DCS. The Experimental data of DCS when compared with curing period is given in the table 3.3. below

Size of block used = 19cm ×9cm ×9 cm, Area of the face = 19cm ×9cm = 171cm^2

W/c ratio used = 0.5, No of blows for compaction =30

Table 3.3 Showing DCS for different curing periods

Batch no.	3-day DCS	7-day DCS	14-day DCS	28-day DCS
01	1.1MPa (23.9%)	2.25MPa (48.9%)	3.7MPa (80.4%)	4.6MPa
02	1.57MPa (33%)	2.59MPa (54.5%)	3.3MPa (69.4%)	4.75MPa
02	1.68MPa (34.5%)	2.47MPa (50.8%)	3.79MPa(77.9%)	4.86MPa

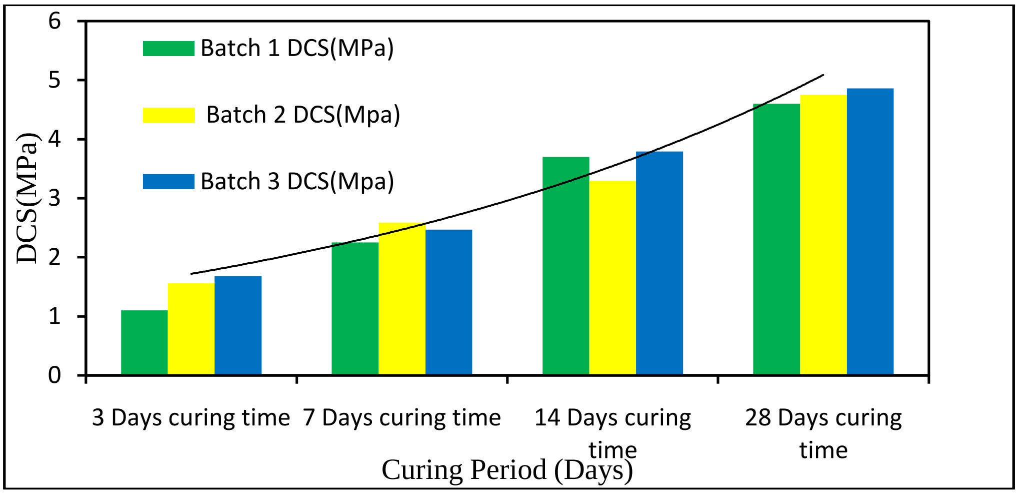

Figure 3.6. Variation of DCS with curing time

The result shows that with increase in the curing time, the dry compressive strength increases almost exponentially(shown by exponential line in black on the graph).The data obtained gives us the rough idea about the percentage of strength obtained along the course of time.

1. 3days – (25% to 35 %).
2. 7days –(50% to 55%).
3. 14 days – (70% to 80%).

3.6. Determination of Water absorption at optimum cement content

The blocks after curing for 28 days(w/c =0.5,12%cement & 30 blows for compaction) were tested for water absorption. After immersion in cold water for 24 hours, average water absorption data was found. The water absorbed is expressed as the percentage of weight of block, as shown below table 5.3.

Table 5.3 Water absorption for 3 different blocks

Block no	Initial weight	Final weight	Weight of water absorbed	%age of water absorbed
01	2878 gm	3178 gm	300	**10.42**
02	2913 gm	3206 gm	293	**10.05**
03	3010 g	3298gm	288	**9.56**

The maximum percentage of water absorbed was found to be 10.42% which is less than maximum accepted value i.e. 15% (as per IS:1725-1982)

IV. Conclusions

1. From the basic soil tests, the soil isidentified as **CI** type as per ISSC and the clay mineral is Illite.
2. With the increase in cement content the OMC of the soil increases upto 10% addition and after that OMC remains constant, MDD decreases upto 10% addition and after that it remains constant.
3. With the increase in cement content both DCS and WCS show increase with a maximum value of DCS as 4.05 MPa at 10% addition and maximum value of WCS as after that OMC remains constant, MDD decreases upto 10% addition and after that it remains constant 2.69MPa at 15% cement addition.
4. With the increase in W/C ratio the 28-strength shows decrease with two typical values w/c =0.5, WCS equals 4.8MPa and with w/c=0.6, WCS equals 3.9MPa, While the increase in compactive effort the strength shows increase.

5. The soil samples are cured for different curing periods as 3,7,14, and 28 days, with the increase in curing time the strength increases in the order 3days – (25% to 35 %), 7days – (50% to 55%), 14 days – (70% to 80%) and 28 days- (99.8%).
6. The maximum percentage of water absorbed was found to be 10.42% for 24 hour period which is less than maximum accepted value i.e. 15% (as per IS: 1725-1982)

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Apart from expensive conventional building materials, low cost building units can be made from raw earth of the kashmir valley merely by little chemical improvement. The explained study will be helpful in eradication of housing problems of the low class people of the state.