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Strain in Compressed Earth Block with Increase in Stress

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Abstract: **In the process of compressive strength testing of Compressed Earth Blocks, displacement is usually observed to be high at the early stages of application of stress on compressed earth block specimens. This paper sets out to study this behaviour. A strain test was conducted on compressed earth blocks produced from the same soil type with 9 per cent optimum moisture content. The results revealed that the high displacement is usually due to inadequate compaction pressure during the production process. A minimum production compaction pressure for compressed earth block was deduced from the study to be 2.5N/m^2 on both bed faces of the block.**

Keywords: **Compressed earth, Stress and strain, Compressive strength, Durability, Sustainability.**

I. INTRODUCTION

Compressed earth technology is mainly about the compaction of soil for strength and reduction in water absorption. An optimum compaction is required to produce an earth block of adequate density and strength and reduction of porosity and water absorption. Compaction on site, for compressed earth block is usually executed by a compressed earth press. Laboratory compaction tests are required to provide the basis for control procedures used on site [1]. It further listed the basic data for soils, which are obtainable from laboratory compaction tests as: (a) relationship between dry density and moisture content of a given compression. (b) the optimum moisture content for maximum dry density with a given compression, and (c) value of maximum dry density achieved. The extent to which voids/porosity can be reduced to a minimum determines the density and strength of the product. The compressibility of a soil is defined as its maximum compression to a given amount of compaction energy and at the optimum moisture content [2]. Void ratio is the ratio of the volume of voids to the volume of solid particles [3]. Compaction of compressed earth block is achieved with an efficient block press. The compressive strength, weather resistance and water absorption are functions of density of an unbaked earth masonry. ARS 670:1996 [4] classified compression pressure for compressed earth block production as in Table 1.

TABLE I: CLASSIFICATION OF COMPRESSION PRESSURE [5]

Classifications	Compression Pressure (N/mm2)
Very low pressure	1 – 2
Low pressure	2 – 4
Medium pressure	4 – 6
High Pressure	6 – 10
Hyper pressure	10 – 20
Mega pressure	20 and over

The African standard however noted that the highest compression pressures are not necessarily the most efficient [5]. The ability of earth walls to resist wear due to weather is improved when stabilised with cement [6], [7]. It is expected that with adequate stabilisation of earth a surface resistance performance can be improved in addition to the sustainable properties of earth. This paper studies the strain of compressed earth blocks with increase in Stress.

II. MATERIALS AND METHODS

Six Laboratory Specimens of each unstabilised CEB were produced from Aviele laterite soil [8]. The test point 3 of the Compressive Strength machine (250 KN CONTROLS) was adapted to carry out this experiment as shown in Figure 1. A firm Steel platform was built up at the base area of the machine to elevate the block specimen to the action level of the hydraulic stress head. Platen steel blocks were introduced to the top and bottom of the block specimen to ensure a perfect contact. Load was exerted at the rate of 0.1 N/mm^2 and in steps of 2kN with 60 seconds of rest to take displacement reading. A digital displacement gauge was attached to the top steel block. Stress and strain were calculated from the following equations:

Stress $\sigma_e = \frac{P}{Ao}$ Strain $\epsilon_e = \frac{\delta}{Lo}$

P = Load, A_o = Cross-sectional area, L_o = Original Length of specimen, ϵ_e = Strain,

δ = displacement

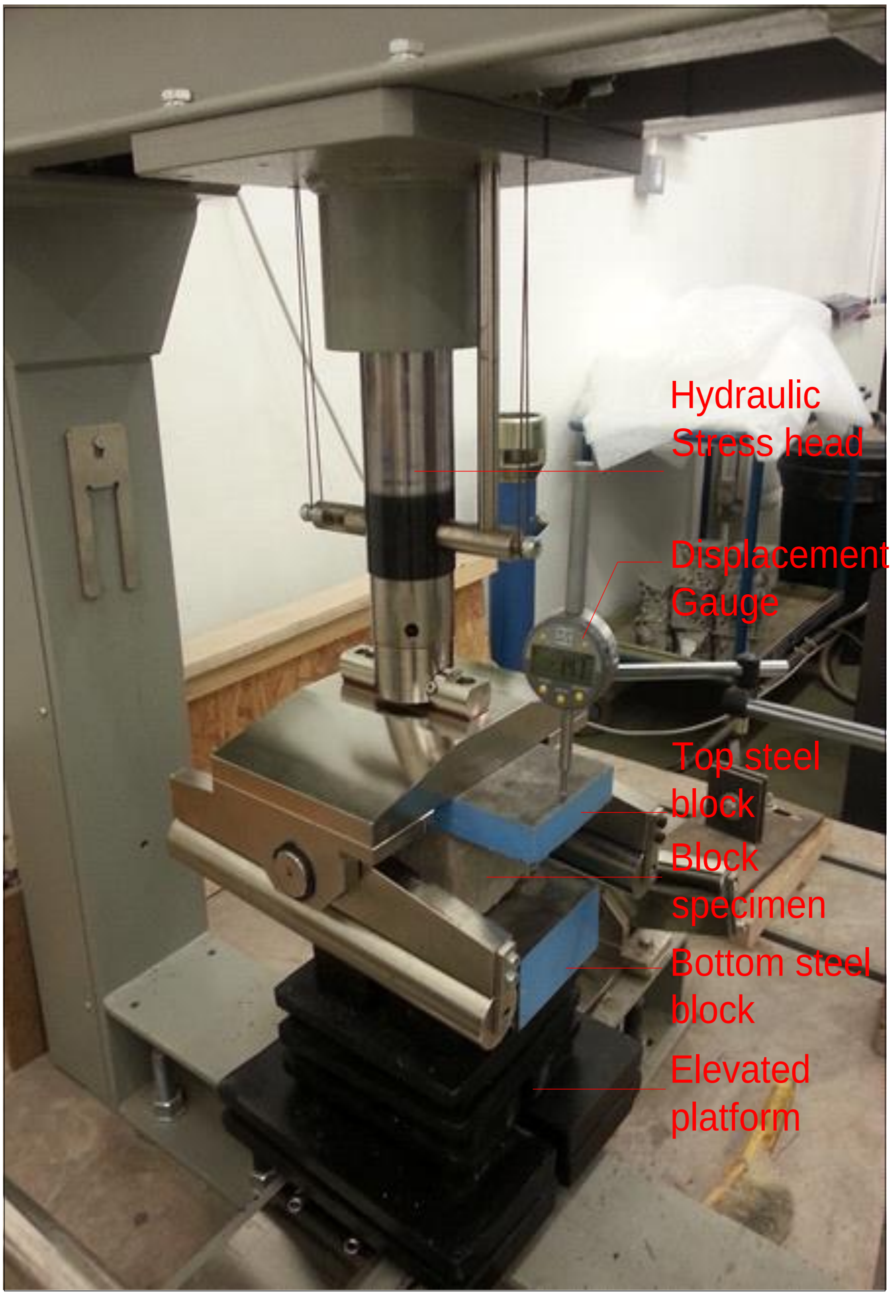

Figure 1: The Stress and Strain test arrangement

III. RESULTS AND DISCUSSIONS

The results of average measured displacements of different block type with increase in stress is shown in Table 2 and Figure 2.

TABLE II: DETAILS OF DISPLACEMENT WITH PROGRESSIVE STRESS APPLICATION

Block Type	Average displacements with progressive Stress application of 0 to 8.1 N/mm^2 (δ) mm													
	0	0.67	1.33	2	2.67	3.33	4	4.67	5.33	6	6.67	7.33	8	8.1
R/0/-	0	0.96	1.83	2.54	2.96									
R/10/-	0	0.94	1.86	2.42	2.84	3.11	3.32	3.51	3.67	4.1	4.31	4.68	4.83	4.86

R/0/- = Unstabilised CEB; R/10/- = CEB of 10% cement content.

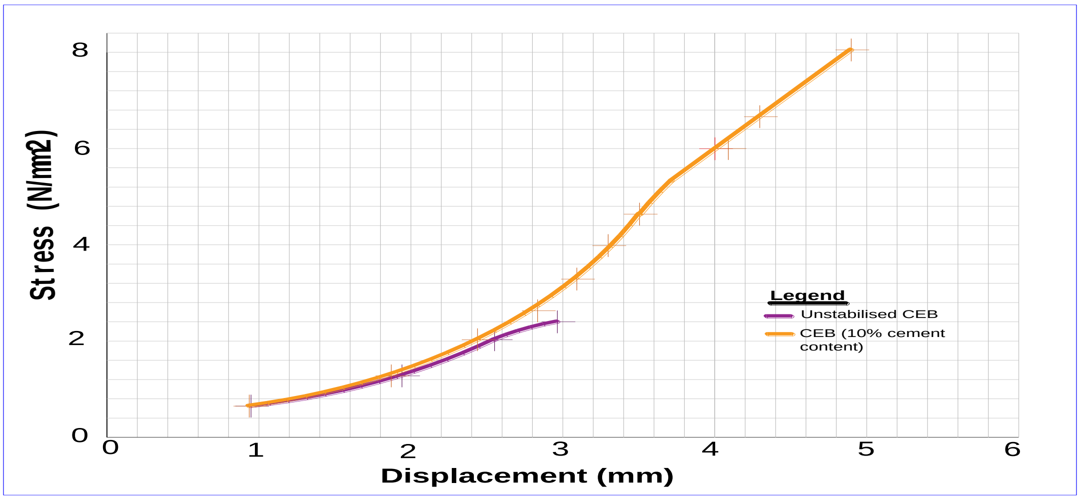

Figure 2: Stress and displacement of different block types

The results of strain with the progression of applied stress until failure is shown in Table 3 and Figure 3.

TABLE III: DETAILED STRAIN DATA FOR DIFFERENT BLOCK TYPES

Block Type	Average Strain with progressive Stress application of 0 to 8.1 N/mm^2 (δ) mm													
	0	0.67	1.33	2	2.67	3.33	4	4.67	5.33	6	6.67	7.33	8	8.1
R/0/-	0	1.4	2.7	3.8	4.4									
R/10/-	0	1.4	2.8	3.7	4.3	4.7	5	5.4	5.6	6.3	6.6	7.1	7.3	7.4

R/0/- = Unstabilised CEB; R/10/- = CEB of 10% cement content.

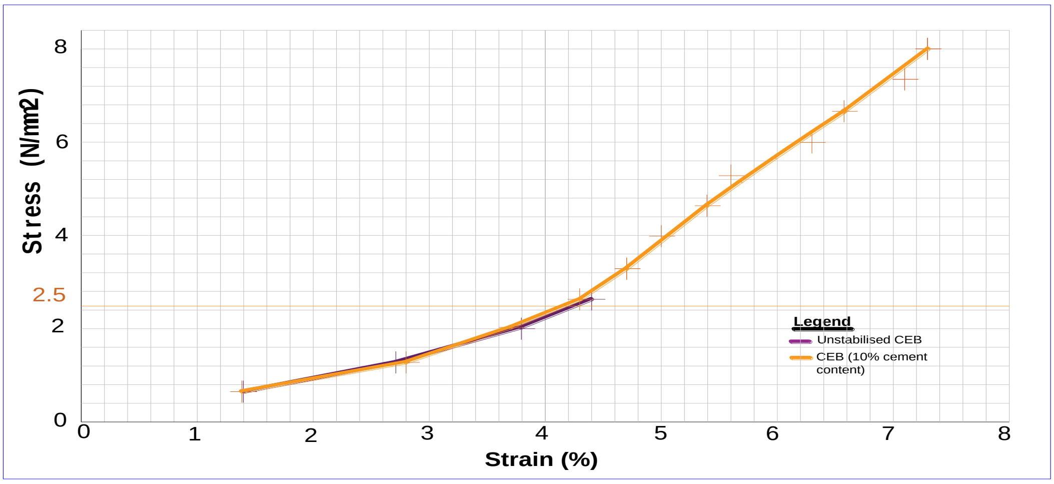

Figure 3: Stress and strain of different block types

Figures 2 & 3 reveal a higher rate of displacement and strain at a lower range of stress (below 2.5 N/mm^2). Above 2.5 N/mm^2 the strain is relatively reduced as specimens proceeded to failure. The initial high strain can be explained as displacement due to incomplete compaction of earth particles at the point of production. This is normal to compressed earth blocks produced with, the commonly used, one sided stress application. Thus, earth particles were displaced with the early compressive force as shown in Figure 4. Thereafter, upon complete compaction, there is a reduction in displacement with increase resistance of the specimen against further displacement. The Unique finding of this experiment is that this transition took place at about 2.5 N/mm^2 as shown in Figure 3.

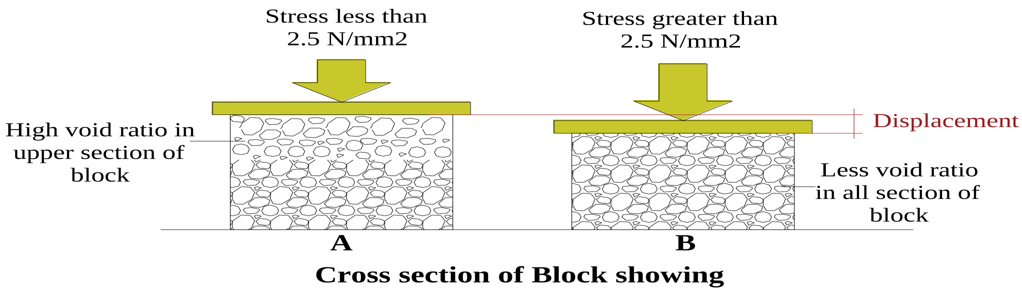

Figure 4: Illustration of the mechanics of initial stress and displacement

The minimum compaction pressure for earth block as specified in the Nigerian National building code is 3N/mm^2 [9].

IV. CONCLUSION

The high displacement usually experienced during compressive strength testing of compressed earth blocks was investigated and found to be due to incomplete compaction of earth. This is most common with one sided earth block presses, where the lower sides close to the pressure point is closely packed while area farther from the pressure point is less packed. For the Aviele laterite soil of optimum moisture content of 9 per cent, the high rate of displacement is reduced from stress application of 2.5 N/mm^2 and above. This is indicative of an effective compaction pressure of 2.5 N/mm^2 and above. However, results may vary with types of soil and moisture content.

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