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# COMPRESSIVE STRENGTH OF CEMENT STABILIZED SOIL BLOCKS (CSSB) SUBJECTED DIFFERENT CURING CONDITIONS

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## ABSTRACT
The effect of two different curing conditions on the compressive strength of cement stabilized soil blocks (CSSB) was investigated. Cement stabilization of 8% by weight was chosen best on the literature. The study is aimed at determining the optimum curing condition for CSSB. Basic properties of the soil used were determined to find its suitability in making CSSB. The two curing conditions used for the research are tagged 'A' and 'B'. Curing condition 'A' involves complete wrapping of CSSB blocks with tarpaulin and sprinkling with water twice a day to provide moist condition. While condition 'B' involves complete wrapping and spraying with water for each conventional curing ages and removing the blocks there after for open space curing without spraying water. The soil used in the study showed satisfactory performance for the production of the CSSB. Based on the test results, curing condition 'B' is recommended for use in the production of cement stabilized soil blocks, as it showed a better compressive strength after 21 days curing. However the compressive for both curing conditions increase with curing age up to 21 days curing.

**Keywords:** *Cement Stabilized Soil Block; Alternative Curing; Compressive Strength; Stabilization*

## INTRODUCTION
Earth or soil is one of oldest construction material most commonly used for the construction of residential houses the world over. Earth is the most preferred building material for providing shelter for people especially in less economically developed areas (Sofi, Sheikh, Wani, & Manzoor, 2016; Danso, 2017; Daniel, Benjamin, & Tali, 2018). It is used in diverse forms of building construction for the provision of shelters (Daniel, Benjamin, & Tali, 2018)ranging from adobe, rammed earth, cob, wattle and daub, compressed soil blocks etc. (Falceto, Mazarron, &

Canas, 2012; James, et al., 2016)).These diverse forms of earthen constructions depend on factors such as climatic conditions, topography and living standard of the population of the area.

The production and construction of houses with cement stabilized soil blocks can results into massive employment of unskilled labour and rural community driven due its ease of use and associated building techniques. It will enhance self help technology transfer among rural populace thereby eliminating the need for employment and transportation of costly skilled labour, material and equipment which will maximise local economic benefit of the rural areas (Riza, Rahman, & Zaidi, 2011; Abd Halid, et al., 2017). Cement stabilized soil blocks is more economical walling material in itself and accommodate the use of economical construction methods (Nagaraja, Dilmohan, & Bhavin, 2018).

The technology involves in the uses of the cement stabilized soil blocks is eco- friendly and affordable construction practice than tradition methods of constructing earthen structures (UN-Habitat, 2012; Kabiraj & Mandal, 2012; Sofi, Sheikh, Wani, & Manzoor, 2016), It has the advantages of easy and fast construction (Waziri, Lawan, & Mustapha, 2013), less skilled labour requirement good thermal insulations, less carbon emission and has extremely low material waste with less population during its eservice life (Abd Halid, et al., 2017; Nagaraja, Dilmohan, & Bhavin, 2018). It has the ability to absorb moisture thereby creating conducive and healthy condition inside for its occupants (Riza, Rahman, & Zaidi, 2011).

Cement Stabilised soil blocks (CSSB) are compressed blocks made from mixture of soil, cement and water as such the stabilization soil with Portland cement is adequate for making stabilized soil blocks that could meet the desired compressive strength and water absorption (James, et al., 2016). They are compressed either by using manual or mechanically operated machines that produces stabilized soil blocks with the ability to provide adequate bonding without using any cement mortar. The interlocks at edges of the stabilized soil blocks would provide the required bonding between the blocks thereby increases the strength and reduce the amount of cement needed as mortar in construction houses. The understanding of the characteristics of soil to be use for the production stabilized soil blocks is necessary. The production of quality stabilised soil blocks requires soil with mixture of fine gravel, sand, silt and clay

(Gavigan, Goggins, & McCabe, 2012; Abd Halid, et al., 2017), must be suitable with the ratio of the mixture without which the required compressive strength will be achieve. The soil for the production of CSSB should have mix ratio of 30-40% clay and 60-70% sandy soil with soil particle not exceeding 6mm size(Abd Halid, et al., 2017). The silt and clay content act as the binding medium for the sand particles. The analyses of the soil properties are necessary to determine its suitability and adequate quantity of cement for the stabilization of the soil(Ciancio, Beckett, & Carraro, 2014; Chaudhari, Kadam, Kaduskar, Thikekar, & Bharitkar, 2017)

The stabilized soil blocks produced must be completely covered with jute bags and cured by sprinkling water gently or cured for 7 days in stack and cure for the remaining 14 days when the blocks are used as reported by (Sahu & Singh, 2017). Curing is the last process in the production of CSSB which starts after 24 hours of production. Curing is the process of controlling the setting time cement stabilized soil block in order to gain maximum strength. Early removal or drying of moisture in cement stabilized soil block, it will loses cure to strength. For a cement stabilized block to acquire maximum strength, it must be cure to dry slowly in wet conditions for certain period of time.

To achieve maximum strength, cement stabilized soil blocks should be cure under moist condition for a period of time commonly applicable to all mixtures containing cement material. Various methods curing used are to ensure proper curing of the cement stabilized blocks are to prevent moisture from escaping depending, on the local temperatures. The required duration of curing varies from soil to soil and, more significantly, which type of stabilizer is used. With cement stabilization, it is recommended to cure blocks for a minimum of 21 days, but they should be fully cured and dry before being used for construction. The cement stabilized soil block technology if adopted can provide the needed housing and social facilities for residents and will enable reintegration of internally displaced persons (UN-Habitat, 2012). The objectives being to investigate the optimum curing condition suitability cement stabilized soil blocks for use as masonry units. The crushing strengths of the blocks were tested using the universal testing machine to validate performance of each curing condition used.

## MATERIALS AND METHODS

The materials used in this study were soil, cement, water. The soil sample for the research work was obtained by method of bulk disturbed sampling from an existing borrow pit at depth of 1.5m some hundred metres away from Buniyadi, Gujba Local government area, Yobe state, Nigeria. The soil sample was screened using 6mm diameter mesh to remove large particles prior to the production cement stabilized soil blocks. The suitability of the soil sample obtained was determine by conducting different geotechnical tests to determine the characteristics of the soils in term of its specific gravity, shrinkage limit, atterberg limits, sieve analysis and moisture content. In order to have uniform soil, it is necessary to crush it so that it can pass through a 6mm mesh sieve. The suitability of the soil sample can also be determined on site by consideration the following tests, these: Touching test, Scratch and polish test, tongue test, rolling test and sedimentation jar test. These tests were conducted on site to determine the sand and clay content in the sample of soil taken. The cement used for all the stabilization of the soil was grade 52.5R (NIS 444, 2003) Ordinary Portland Cement (Askaka cement brand) obtained cement deport Damaturu, Nigeria. The water used was a potable drinking water obtained from drinking water tape within the Federal Polytechnic, Damaturu.

### Mixing of Materials

In order to achieve satisfactory mixing, the sample soil was spread as a thin layer of about 150mm in thickness. The quantity of cement stabilizer was spread as a thin layer on the soil. The soil and cement are mixed dry until a uniform colour was obtained. The mixing is completed when the mixture attains a uniform colour. The amount of water for mixing the cement – soil mixture was approximately estimated and was sprinkled on the thin layer of soil – cement mixture which was mixed thoroughly by hand. The mixing process was repeated with remaining water until a workable cement stabilized soil paste was achieved. The adequacy cement stabilized soil paste (workability) was checked by making a ball out of cement stabilized soil pastel. The optimum moisture content can be achieved only if a ball made does not sticking to the hand, but if it is not possible to make the ball cannot be made, tit indicate the mixture is below optimum moisture content it is necessary to add small quantity of water and the checked for the OMC again. This process was repeated several until the required optimum moisture content were achieved.

For this research work, a total of 30 cement stabilized soil blocks were produce and cure under curing condition 'A' by the complete wrapping and water spraying morning and evening for the required conventional curing ages and 'B' by complete curing and spraying water for the conventional curing ages, and remove thereafter for curing without both wrapping and water spraying for the remaining curing ages.

### Curing of CSSB

Curing of the cement stabilized bocks starts after 24 hours of production. For this research work, two different conditions were adopted tagged condition 'A' and 'B'. Condition 'A'involves complete wrapping for the conventional curing ages of 7, 14, 21, 28 and 35 days while condition 'B' involves complete wrapping for each curing age, remove and cure openly for the remaining curing ages, but the initial 7 days were cured without wrapping. The curing of the cement stabilized soil blocks is aimed at ensuring adequate hydration of the cement paste within the CSSB matrix and preparing for compressive strength testing procedures to ensure they have achieve the maximum compressive strength performance requirement for walling.

### Compressive Strength

The compressive strengths test was conducted on the cement stabilized soil blocks at different curing ages under the two different curing conditions tagged conditions 'A; and 'B' to determine the rate of strength gain at a particular point in time. The crushing strengths of the blocks were tested using the universal testing machine, where a metal plate that of 12mm thick was placed on top and bottom of the sample to allow for even distribution of the applied load. The load was then applied automatically until failure of the blocks specimen occur where crushing peak load and crushing strength are displaced and recorded. The average Compressive strength for 7, 14 21, 28 and 35 days curried using the both conditions would be use to analyses and validate the optimum curing condition

## RESULTS AND DISCUSSIONS

The results of the study revealed that the specific gravity, shrinkage limit, moisture content, liquid limit, plasticity limit and plasticity index of the sample showed satisfactory performance. The results of these tests are shown in the table 1 below. These results show that the soil is clay of medium plasticity and thus it is suitable for the making of cement stabilized soil block.

The results of the Atterberg limit test on the soil sample are all below the maximum value of 35% specified in the literature. This indicates that the soil is satisfactory and has cohesive characteristics which will accommodate proper compaction of stabilized soil mixtures in enhancing strength and durability characteristics of cement stabilized soil blocks.

**Table 1: Results of the Geotechnical Properties of Soil Sample.**

| Properties of soil sample | Results |
|---|---|
| Colour | Reddish brown |
| Natural moisture content (%) | 16.57 |
| Specific gravity | 2.74 |
| Shrinkage limit (%) | 14.40 |
| Liquid limit (%) | 42.7 |
| Plastic limit (%) | 27.3 |
| Plasticity index (%) | 16.3 |
| Optimum moisture content (%) | 20.3 |

The result of particle size distribution test shown in figure 1 below indicates that the soil samples are greater in the fine category (600 μm - 75μm) which shows that the sample is very clayey sand and it is well graded because it is distributed over a wide of soil particles. This sample of soil falls into group A2-6 clayey gravel and sand which is adequate for making the cement stabilized soil block. For using cement as a stabiliser, a soil that a good mixture of particle sizes is more preferably because soils with higher clay contents can be stabilised but need more cement and is uneconomical. The quality of soil sample considered prove to be adequate and very satisfactorily for the production of the cement stabilized soil blocks. The results of the on- site tests also shows that the soil smooth and powdery with of clay and silt. It sticks to the tongue and the polish surface showed a nice shine, it can be shape into any desired shape and roll into a thin thread. All these qualities are common with soil with appreciable percentage of clay content which indicates that the soil sample has clay content adequate for cement stabilization. From the results of the tests obtained it was concluded that the soil used is satisfactory for the production of the cement stabilized soil blocks.

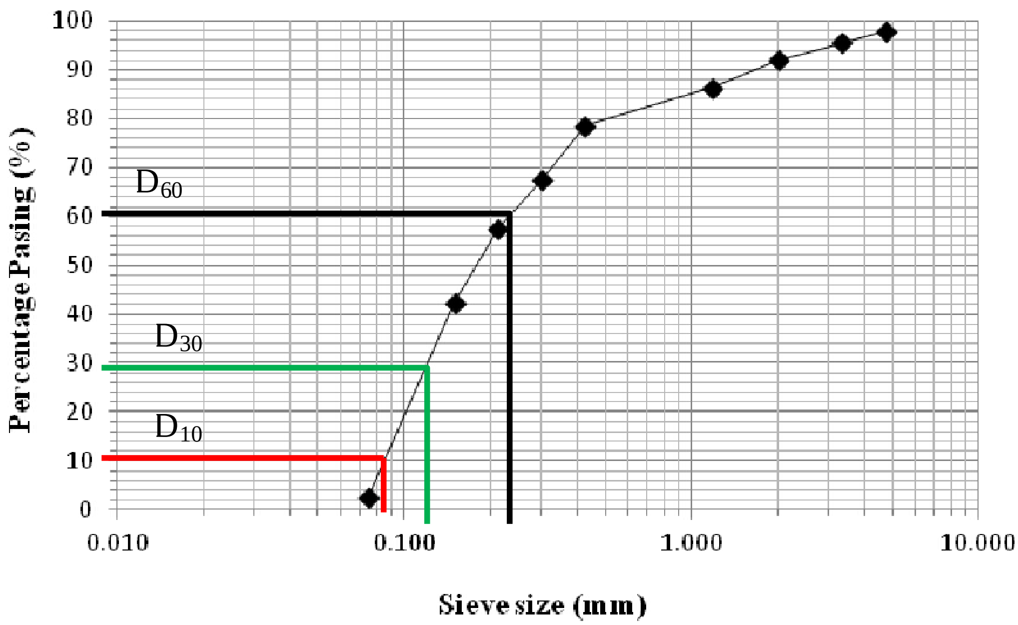


**Figure 1: Particle size distribution curve**

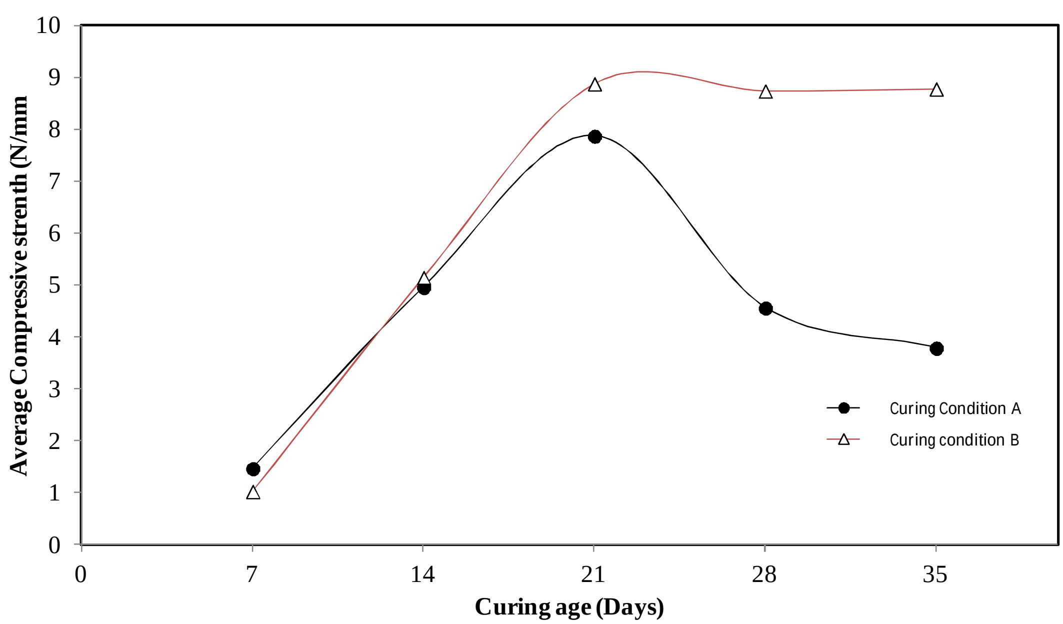


**Figure 2: Graphical Presentation of Average Compressive Strength**

The result of average compressive strengths test conducted on the cement stabilized soil blocks at 8% cement stabilization are presented in the figure below. The graph shows a gradual increase in strength with curing ages up to 21 days curing period for both methods of curing conditions adopted.

However, the compressive strength showed a sharp reduction for curing condition 'A' and gradual reduction for curing condition 'B' as indicated in the figure.

As shown in the Figure, the average compressive strength depict almost the same increasing values of compressive strength except that; there is a slight increase in the average compressive strength gained at 21 days curing ages for condition 'B' than the average compressive strength in curing condition 'A'. The reduction in average compressive strength noticed after 21 days in curing condition 'A' may be due to the continues wrapping and moisture curing for to the next curing ages. This may be as the result of complete hydration of the cement during the first 21 days of curing.

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