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# BRICKYARD PRACTISES IN NIGERIA; IMPROVING THE COMPRESSIVE STRENGTH OF CEMENT STABILISED EARTH BRICKS THROUGH SOIL SELECTION

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**ABSTRACT:** There are many variables that determine the final strength of cement stabilized earth bricks. This research considers the soil composition. The soil is the basic material for the production and should be the starting point in the quest to improve compressive strength. Four brickyards were visited in Owode Egba and the general practice is to increase the cement water ratio of the mix by thumb rule once the final product appears to be weak as the excavated soil varies from place to place and depth.

Since the soil used is a sedimentary rock, and the composition varies from site to site and even between layers within the same sedimentary deposit, it may be easier and more cost effective to select the proper mix of soil materials that will give better brick quality and maintain consistent level of comprehensive strength during production.

**Keywords:** Compressive strength, Soil mix, Silica, Silt, Cement, Binding.



## INTRODUCTION

The Nigerian Building and Road Research Institute (NBRRI) is at the fore front of –promoting the use of cement stabilized compressed earth bricks as a cheaper construction material in Nigeria. Both manual and motor driven brick making machines have been developed for the local industry by NBRRI. However, the imported manual machines from India are more common in brickyards in Owode Egba Area of Ogun State. Despite so much penetration of the technology in South – East Asia and East Africa, Nigeria with her pressing need for mass housing is yet to fully tap this potential.

Researches into soil suitability have been carried out on soil samples around Jos in Plateau State [A. Ola, 1979] and Bauchi in Bauchi State [Adepegba, 1989] and Ile – Ife [Meshiba 1987] among others. Researchers have also carried out studies on how cement – water ratio affects workability and compressive strength of cement stabilized earth bricks [O. Alawode and I. Idowu 2011].

A. Garg [2014], reported on the effects of varying cement proportions in the final compressive strength of earth bricks.

Soil selection must be done carefully with expert guidance. The soil used in brick moulding mix shall be free from deleterious contents such as organic matter of vegetable origin, mica, schist and saline impurity. Its grading shall be such as to require the least amount of admixture to make it suitable for stabilization with cement. The most suitable soil should have:
Clay: 20-30%, and
Coarse Sand: 30-50%

Soils like Black cotton soil and similar with very high clay content are practically difficult to handle and uneconomical to stabilize thus should be avoided.

It is always recommended to get particle size distribution analysis and field tests done before the block production is started or whenever soil is changed. Carrying out proper soil selection and achieving a suitable mix design to overcome any major deviations in soil characteristic is expedient in achieving good brick quality

A good brick making process will involve soil selection, sieving to ensure no organic materials or pebbles above 4mm are included, adding coarse sand if required, before the inclusion of cement and water .

With so many variables affecting the strength of bricks, it is expedient to evolve some basic standards that are easily adapted to local brickyard conditions.

The soil is composed of three major components:

1. Organic matter which are present in mostly the top soil. This must be scraped away to reveal better soil quality. Top soil must never be used in brick making.
2. Sand or Silica which is the harder constituent of the soil. It binds with the cement to give the ultimate strength.
3. The clay or silt which is fine particles of the rock must give the initial wet bonding strength and help to keep the brick together so it is easy to carry the brick after molding. Being finer particles, they increase the density of the bricks by filling the spaces between the bigger rock particles. Ultimately the silt is responsible for the higher compressive strength of compound earth bricks over sandscrete bricks.

Ideally, there must be 20 – 30% of silt and clay in a good soil suitable for

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brick making. If the clay and silt content is higher than 35%, sand should be blended with the soil [Hydraform, 2005].

## TESTING SOIL SAMPLES

Six soil samples were taken between Owode and Ashipa all in Owode Egba area and subjected to jar tests.
The jar tests were carried out by taking soil samples from excavated pits being used by brickyards. Outcrops of the earth and small hills are normally excavated from the sites to reveal more workable soil under the hard outer layer. The soil excavated is loose and easily worked. It is further crushed, mixed with water and poured into a glass jar. A little salt is added to the mixture and thoroughly mixed for about 30 minutes before being left to settle for 24 hours. By the next day, the height of the settled layer of materials are measured with Vanier calipers and recorded.

| Sample no | Average depth of sample from top of mound [m] | Height of soil column in jar [mm] | Height of sandy later [rum] | Height of silt [mm] | % of silt |
|---|---|---|---|---|---|
| 1 | 1.0 | 152 | 88 | 64 | 42% |
| 2 | 2.0 | 128 | 96 | 32 | 25% |
| 3 | 2.5 | 121 | 94 | 27 | 22% |
| 4 | 3.0 | 139 | 107 | 32 | 29% |
| 5 | 4.0 | 117 | 103 | 14 | 13% |
| 6 | 5.0 | 126 | 115 | 11 | 9% |

## OBSERVATIONS

Generally, the soils that gave the lowest silt content were generally loose and the damp soil does not cake when squeezed with the palm of the hand. The soils with the higher clay content tended to be lumpier and the damp soil caked easily when squeezed with the palm of the hand, leaving a brownish stain on the palm when released. Within the locality, it can be assumed that the lower strata of soil tend to be more sandy. This will make them more suitable for sandcrete blocks which will require more cement to mix. Larger rock particles in the form of pebbles (gravel) also seemed to increase in quantity with depth. A lot of gravel also came off with the top soil.

Three brickyards were visited and there were no evidence of graduation of different soil batches being used for brick production. This means the quality of the bricks produced cannot be consistent. In one of the brickyards, the bricks were used for fencing and it was observed that most of the fence was being worn out by the weather. This shows that the clay content is so high that the rain easily dissolved the clay particles and in the process wash out the rest of the sand and cement in the bricks.

**SOIL SELECTION**

For a given soil-cement mix, strength can be increased by adding more cement up to a certain level. Given that the use of soil rather than river sharp sand has cost reduction as a major reason for such a choice, the use of additional cement stabilized bricks should ideally use less cement than sandcrete blocks since the bricks are moulded solid and sandcrete blocks are mostly hollow. Cement will normally form between 8% and 12% volume of the brick [hydrafoam, 2005].

If the soil is not well selected, it will not have it will not have the required strength. After finding a good soil, it is important to keep testing the soil even after you start making bricks to ensure quality [W.Neslon 2002].

Clay content of between 20% and 30% will make good bricks at 1: 12 cement – soil ratio. This range requires about a quarter of the soil volume to be clay. To confirm this, it is important to run the requisite tests to determine the soil constituents. Of all the field tests available like the Dry Shrinkage Test, the Slump Test, the Wash Test etc. the Jar Test is perhaps the most accurate as moisture content may affect the results of the other tests.

Soil testing is a continuous exercise in the brickyard and soil obtained is normally from surrounding areas, it may be less cumbersome to carry out a pre-test with the slump test and visual observation before embarking on the jar test. Heaps of the tested batches should be labelled and only the very good ones be used for direct brick production. Based on the results from the tests, others can be mixed in different ratios and sometimes with sharp sand to achieve the designed

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range so that no soil heap is wasted after excavation. A general guide for visual examination is provided below.

| SOIL APPEARANCE | PROPERTIES | |
|---|---|---|
| 1. Very loose soil and damp sample squeezed in the palm doesn't cake | High silica content | May not be suitable for cement stabilized earth bricks. Can be mixed with more clayey soil for use |
| 2. Fairly loose soil. Damp sample cakes when squeezed with the palm but disintegrated easily when proded | Medium silica content | Should be subjected to further tests to determine the clay content before use |
| 3. Lumpy soil with cracks. Damp sample squeezed with palm cakes easily and wont disintegrate when proded | Low silica content. Too much clay in the soil | Not suitable for brick making. Sharp sand or high silica content soil may be mixed with it after thoroughly crushing it to make it loamy before being tested and used. |



**BASIC DATA ON COMPRESSED STABILIZED EARTH BRICKS**

| PROPERTIES | SYMBOL | UNIT | CLASS A | CLASS B |
|---|---|---|---|---|
| 28 day dry compressive strength (+20% after 1 year) | σ d 28 | MPa | 5 -7 | 2 - 5 |
| 28 day wet compressive strength (after 24 hours immersion) | σ w 28 | MPa | 2 - 3 | 1 - 2 |

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| | | | | |
|---|---|---|---|---|
| 28 day dry tensile strength (on a core) | τ 28 | MPa | 1 - 2 | 0.5 - 1 |
| 28 day dry bending strength | β 28 | MPa | 1 - 2 | 0.5 - 1 |
| 28 day dry shear strength | S 28 | MPa | 1 - 2 | 0.5 - 1 |
| Poisson's ratio | μ | - | 0.15 - 0.35 | 0.35 - 0.50 |
| Young's Modulus | E | MPa | 700 - 1000 | - |
| Apparent bulk density | γ | $Kg/m^3$ | 1900-2200 | 1700-2000 |
| Coefficient of thermal expansion | - | mm/m°C | 0.010-0.015 | - |
| Swell after saturation (24 hours immersion) | - | mm/m | 0.5 - 1 | 1 - 2 |
| Shrinkage (due to natural air drying) | - | mm/m | 0.2 - 1 | 1 - 2 |
| Permeability | | mm/sec | $1.10^{-5}$ | - |
| Total water absorption | - | % weight | 5 - 10 | 10 - 20 |
| Specific heat | C | KJ/Kg | ~ 0.85 | 0.65 - 0.85 |
| Coefficient of conductivity | λ | W/m°C | 0.46 – 0.81 | 0.81 – 0.93 |
| Damping coefficient | m | % | 5 - 10 | 10 - 30 |
| Lag time (for 40 cm thick wall) | d | h | 10 - 12 | 5 - 10 |
| Coefficient of acoustic attenuation (for 40 cm thick wall at 500 Hz) | - | dB | 50 | 40 |

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| | | | | |
|---|---|---|---|---|
| Fire resistance * | - | - | Good | Average |
| Flammability * | - | - | Poor | Average |

**Notes**

- 1 MPa = ~ 10 Kg / $cm^2$
– These values are the result conducted in laboratories by recognized authorities. They give an idea of what can be reasonably expected of a product made in accordance with the rules of the art.
– The soil quality, the nature of stabiliser, the percentage of stabiliser and the compression pressure influence a lot these values.
– These value can be obtained with 5 to 10 % cement stabilisation and a compression pressure of 2 – 4 MPa.

Source: Auroville Earth Institute

## CONCLUSION

Several studies have focused on improving the properties of soil bricks due to perceived and real strength and durability limitations. Binders showed a continual improvement with greater concentrations, so much greater improvements can be obtained if the economic and social costs can be justified. The Nigerian brickyard is a cottage industry basically run by entrepreneurs with minimum formal education and financial strength. Brick making in Nigeria is seen more as a trade rather than a production enterprise. Earth brick production is mostly carried out in the rural areas where patrons view the earth brick as an elevation from the adobe mud wall bricks where sandcrete blocks are out of reach for their building construction. Where these cement stabilised earth bricks are structurally inadequate and yield to the weather like the adobe walls, the economic sense of the technology is defeated. Evolving very simple and adaptable improvements to the local technology is of great importance. Proper soil selection and management will definitely enhance the compressive strength and other requisite properties of the locally produced cement stabilised earth bricks.

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