



## EFFECT OF WILD-VINE POWDER (WVP) AS ADMIXTURE IN COMPRESSED LATERITIC EARTH BLOCKS (CLEB)

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### ABSTRACT

*In this paper, the effect of wild-vine powder on strength and durability properties of compressed lateritic earth blocks was evaluated through series of laboratory experiments. The wild-vine powder (WVP) used was obtained by crushing roots of wild-vine into smaller particles and then grinding into powder. It was thereafter subjected to chemical composition analysis using standard procedure. The WVP was added to the mixes of the laterite soils at varying percentages of 0, 2, 4, 6, 8, and 10% respectively by weight of the laterite required for the compressed lateritic earth blocks. The mixes were cast in steel fabricated mould of dimension (230mm x 120mm x 100mm) compressed using UTM machine and demoulded using a locally fabricated mould. The samples were thereafter air-dried and subjected to uniaxial compression tests to establish their compressive strength, alongside durability tests to determine their resistance to abrasion and water absorption. The results showed that WVP predominantly contain calcium oxide (44.6%) and potassium oxide (36.1%). The addition of WVP up to 6% in compressed lateritic earth blocks (CLEB) improves the compressive strength, resistance to abrasion, and water absorption for stabilized CLEB-block. The addition of WVP in laterite up to 10% is adequate as it gives compressive strength of 2.21N/mm<sup>2</sup> greater than 2N/mm<sup>2</sup> specified by NBRRI, 2016, and thus recommended for use in building of low-cost earthen buildings.*

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### 1.0 Introduction

Housing is generally recounted as one of the fundamental needs of humans, and its possession is one of the maximum cherished cultural acquisitions. Unfortunately, due to the huge populace of poor citizens, many Nigerians are unable to afford their own houses. Due to the high and continuously increasing cost of construction materials, they have been unable to get ownership of a house. As a result, it has become critical to identify methods of reducing costs of building construction (Raheem et al., 2012). The study conducted by Usman, (2015), shows that sandcrete blocks, though widely used in Nigeria, are more expensive when compared to the cost of blocks made from other materials. Commercially available ones are also known to be, often times, low in compressive strength and less durable and thus mostly used as non-structural materials in buildings. Hence the quest for alternative blocks from other materials to which laterites has found wide application in this regard (Ghoumari, 1989).

The compressed stabilized earth blocks, made from laterites, are known to be low-cost building material owing to the abundance of the soil material used in its production. Laterite earth blocks are known to have good potential of mitigating some of the aforementioned challenges associated with sandcrete blocks and possibly reverse the shelter-demand backlog in communities and nations of the world (Taallah and Guettala, 2016).

Compressed Laterite Earth Blocks (CLEB) are specialized laterite blocks that are produced when earth (laterite) is blended homogeneously with a stabilizing agent, such as cement or lime, and then compressed into block moulds. Owing to its excellent properties and potential, the use of the compressed stabilized earth has been of growing in the provision of low-cost houses of good strength and improved comfort which are appealing parameters as society progresses in the production of eco-friendly or green buildings.

Building with earth (which is an inexpensive material) is cost-effective because of its local availability and abundance in many surroundings. A few analyses have been carried out on the cost-benefit and improved comfort of using earth blocks in building construction. Satprem, (2010) by comparing the cost of a wall made with CLEB and a wall made from fired bricks in India affirms the position of the cost-effectiveness of the compressed earthen blocks. Another comparison of compressed earth block, concrete block, and adobe for a thermal test by the Biology Department of Southwest Texas Junior College (2014), shows that the internal temperature of compressed earth block becomes lower than the adobe and concrete block which offers CLEB advantage, to not only cost but also reduced internal temperature, over the other materials considered in the study.

Nevertheless, due to its high water absorption rate when exposed to water, the use of laterite has suffered some set-back in its utilization for building construction due to the high maintenance cost associated with this effect. Excessive water intake of laterite blocks leads to the deterioration of the construction material within a short period, leaving its surfaces soft which in turn contributes to early cracking in walls where they are used (Harpers 2011).

Laterite soil has also been ranked as one of the historical building materials and its use has already made history in most countries in Africa, especially in Nigeria. Ella (2003) reported that in most rural parts of Northern Nigeria, majority of residential houses are built with mud. The walls and dome-shaped roofs of these houses are normally rendered periodically with suitable mud renders such as “farinbirji” (clayey lateritic soil), “jarkasa” (fine red soil) and the likes mixed with straw, horse, or cow dung. But because these materials do not stand the effects of harsh weather conditions, it becomes necessary to incorporate some other materials known as rendering admixtures to improve their performance. Some of these admixtures include:

1. “makuba” (powdered locust bean pod);
2. “katsi” (dye residue): a by-product of indigo dyeing. It improves the strength of the Laso plaster.
3. “gabarua”: it is obtained from the fruits of the acacia tree.
4. “gashinjima”: goat hair mixed with the grease of previously soaked skins gives the plaster waterproofing qualities
5. “dafara”: a gumlike material obtained from the root of a wild vine (*Cissus populnea*) also called dafara, serves as a binder.

The wild vine (*Cissuspopulnea*) is a parasitic plant that belongs to the family Ampelidaceae (Vitaceae). It is readily found in most forest areas of tropical Nigeria especially the middle belt area and other African countries like Senegal, Sudan, Uganda, and Abyssinia (Irvine, 2011). The wild-vine is commonly known as 'UroOkoho' by the Idomas, Igbo, and Igala tribes of Nigeria, 'Dafara' in Kano and Zaria, 'latutuwa' in Katsina by Hausas of the indicated towns of Northern Nigeria (Irvine, 2011). Extract from the roots of wild-vine plants has been pragmatically used in the rendering of mud-based structures as admixtures, similar to the use of makuba (powder locust bean pod) (Ella, 2003), katsi (dye residue), gabaruwa (from the fruits of the acacia tree) which have been widely reported to improve on the stability of the soil materials (Ella, 2003).

It is against this background that this study seeks to evaluate the effect of wild-vine powder (WVP) as an admixture in compressed lateritic earth blocks (CLEB) with a view to improve the strength, and durability of CLEB as well as to minimize the cost of materials used for building and block production.

## **2. Materials and Methods**

### **2.1 Materials**

The materials used in this research include; wild vine powder (WVP), lateritic soil, and water. The roots of the wild vine were collected from wild vine plants (Figure 1) in Falgore forest in Doguwa Local Government Area of Kano State. The laterite soil sample was collected from Janguza borrow pit with the GPS UTM Coordinates latitude 11.970894 and longitude 8.376062. The water used in this research was clean portable water obtained from Civil Engineering Laboratory, Bayero University, Kano

### **2.2 Experimental Methods**

#### **2.2.1 Assessment of Material Properties**

The oxide composition of wild vine powder (WVP) was carried out by ASTM C114 (2018) standard at the laboratory of the National Steel Raw Materials Exploration Agency, Kaduna State using X2 RANGER model XRF equipment made by BRUKER equipment. The roots of the wild vine (Figure 2) were cut vertically to expose the inner part for easy drying. They were dried in the open air under the sun on a clean and dust-free surface (Figure 3) to ensure faster grinding of the roots. Thereafter, the roots were crushed into smaller particles using pestle and mortar and then ground into powder (Figure 4). The samples were air-dried for seven days in a cool, dry place. After drying, grinding was performed using a punner and a hammer to break the lumps present in the soil. The sample was sieved through a 6 mm sieve size. An Atterberg limit was carried out to determine the Plastic Limit, Liquid Limit, and Plasticity Index based on BS 1377 -2 (1990). The test provides a method for measuring the soil's plasticity and is also useful in soil classification.



**Figure 1:** wild vine plants with white stem



**Figure 2:** Roots of wild vine plant



**Figure 3:** Wild vine powder after drying



**Figure 4:** Wild vine powder (WVP)

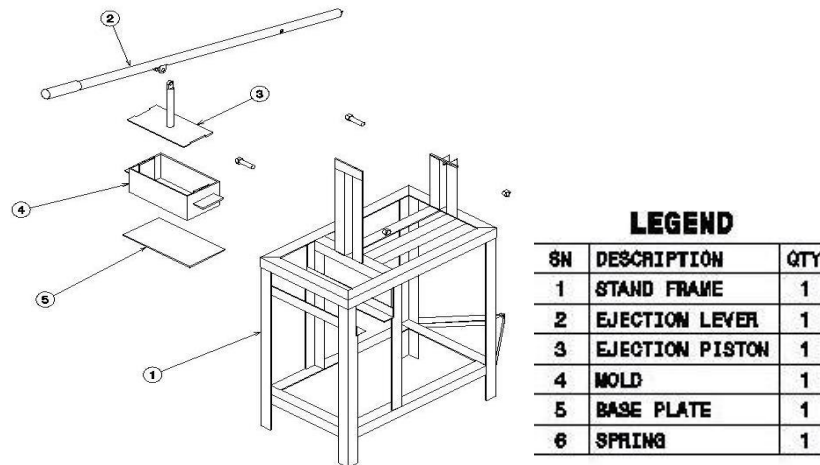
### **2.2.2 Production of compressed lateritic Earth bricks**

The production process of CLEB comprised the batching, mixing, and casting. The materials used for the production of lateritic blocks were measured by weight and stabilized with addition of 0, 2, 4, 6, 8, and 10 % of the WVP measured by weight of the lateritic soil.

The stabilized soil was mixed uniformly with a gradually increasing amount of water equivalent to the optimum moisture content of the soil. A handful of the moist soil, compressed firmly with the palm to form a lump was allowed to drop from an approximate height of 1.10 m on a hard and flat surface. This process was repeated for the gradual increasing moisture until the soil lump breaks into 4 - 5 parts. At this stage, the optimum moisture content is attained. The mixing procedure was repeated for all other mixes. This mixing procedure adopted was from the National Building Code (2006) and this was also employed by Raheem et al. (2012).

The casting procedure is similar to that used by Raheem et al. (2012). Prior to casting, a mould and demoulder were designed and drawn as shown in Figure 5 before taking to the Technology Incubation Centre, Kano for fabrication.



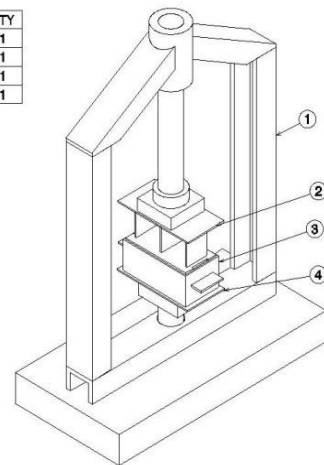


**Figure 5:** Mould, Demoulder and its parts

A steel fabricated mould (230 mm x 120 mm x 100 mm) was cleaned neatly to remove dirt or impurities and oiled to enhance the demoulding of the blocks. The wet mixture was filled into the mould in 3 layers, with each layer being compacted with 35 blows of 4.5 kg rammer. The soil was compressed using HSM36 model Cussons made Universal Testing Machine at loading rate of 0.4 kN/s until 20 kN force is reached as shown in Figure 6. This helps to remove the entire void trapped in the earth brick Figure 7 is isometric drawing of UTM Machine, with the , mold, and base plate set up.



LEGEND		
SN	DESCRIPTION	QTY
1	UTM	1
2	PRESSING PISTON	1
3	MOLD	1
4	BASE PLATE	1



**Figure 6:** Compressing CLEB using UTM **Figure 7:** Isometric drawing of UTM Machine

Lastly, the brick was gently and carefully demoulded using the demoulder shown in Figure 8. Here the compressed earth block in the mould was removed from the UT machine and placed in its compactment in the frame of the fabricated demoulder. Thereafter, with the aid of the ejection lever, efforts were applied, manually, at the free-end of the lever to push the sample out of the mould as shown in Figure 8.



**Figure 8:** Demoulding lateritic earth block using the demoulder designed and fabricated by the author

Identification marks were inscribed on the compressed earth bricks to allow easy reference. The bricks were allowed to dry for 7 days in the open air as shown in Figure 9.



**Figure 9:** Lateritic earth blocks in an open-air for drying

### **2.2.3 Compressive strength**

Compressive strength tests were carried out to determine the load-bearing capacities of the blocks as shown in Figure 10. The bricks were taken to the laboratory two hours before the test to normalize the temperature and to ensure that the surfaces of the bricks were free of moisture relatively dry. The weight of each brick was measured and then compressed using HSM36 model Cussons made Universal Testing Machine loading rate of 0.4 kN/s until the brick is crushed (showing visible cracks) as can be seen in Figure 10. The maximum crushing force was recorded. The compressive strength was computed by dividing the crushing force by the sectional area of the blocks.



**Figure 10:** Crushing of Lateritic Earth Block

#### **2.2.4 Durability of the compressed lateritic Earth bricks**

The durability test conducted on the compressed lateritic Earth bricks is the water absorption and abrasion tests.

##### **2.2.4.1 Water absorption**

The water absorption test was conducted in accordance with BS 1881-122 (2011) standards using the complete immersion test method. Three dried blocks were randomly selected from each group of the specified WVP content and weighed on a balance. These blocks were then immersed completely in water for 30 minutes, after which they were removed and weighed again. The percentages of water absorbed by the blocks were estimated as follows:

$$W_a = (W_s - W_d) / W_d \times 100 \quad (1)$$

Where:

$W_a$  = percentage moisture absorption

$W_s$  = weight of soaked block

$W_d$  = weight of dry block

##### **2.2.4.2 Abrasion resistance**

The abrasion was carried out as described by Raheemet al. (2012) using the scratching method. Air-dried brick was weighed and then placed on a smooth and firm surface. The surfaces of the brick were subjected to wire brushing in a back-and-front motion for 50 strokes. Where one back and front motion is considered as a single stroke. After being brushed, the bricks were weighed again to determine the number of particles lost. This procedure was repeated for all the bricks produced with various WVP contents. The percentage of weight loss obtained was taken as the abrasion resistance capacities of the bricks.

### 3. Results and Discussion

#### 3.1 Geotechnical Properties of Lateritic Soil

Table I presents the results of Geotechnical properties of laterite soil obtained from the Janguza borrow pit. The results show Liquid Limit, Plastic Limit, Plasticity Index, Linear Shrinkage, Moisture Content, Dry Unit weight, Cohesion, and Friction Angle. The soil based on a unified soil classification system (USCS) is classified as SL (Clay of low to medium plasticity.)

**Table I:** Summary of Geotechnical Properties of the Laterite

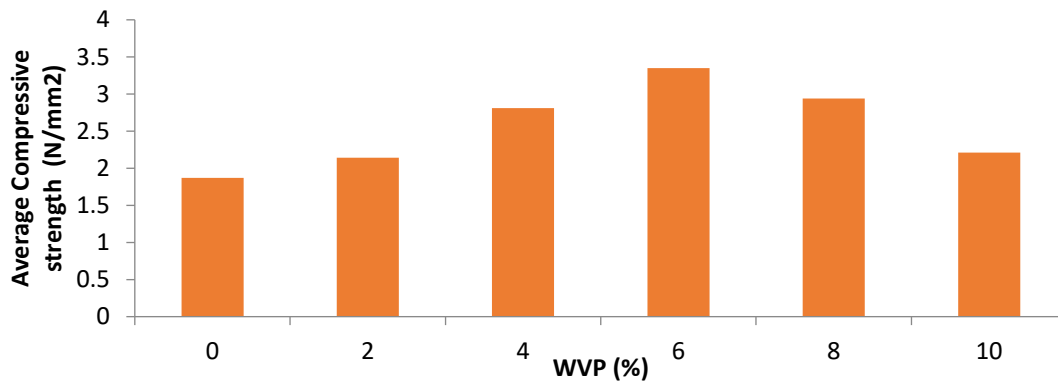
Atterberg and Shear-box tests Results	
Natural Moisture Content (%)	7.4
Liquid Limit (%)	39
Plastic Limit (%)	20
Plasticity Index (%)	19
Linear Shrinkage (%)	8
Moisture Content (%)	14.8
Dry Unit Weight $\gamma$ (kN/m <sup>3</sup> )	17.46
Cohesion C (kN/m <sup>2</sup> )	21.7
Friction Angle $\phi$ (Deg)	35.4

#### 3.2 Compressive strength of lateritic earth bricks

The behaviour of compressive strength of lateritic earth bricks as presented in Figure 11 shows that the compressive strength increases with the increase of WVP of up to 6%. However, beyond the 6% addition of WVP, the compressive strength of the lateritic earth bricks decreases. The increase in compressive strength with the addition of WVP up to 6% may be due to the presence of fibrous material contained in the WVP in form of fibres (see Plate 4) which increased its structural integrity; this observation is similar to the findings of the experimental work reported by Mostafa and Uddin (2016) on experimental analysis of compressed earth block (CEB) with Banana fibre resisting flexural and compressive forces, and the gummy properties of the root of wild vine which act as a binder.

The increase in compressive strength could be due to stabilizing agent (WVP) which binds the soil particles together and then reduces the pores space in the brick. The decrease in compressive strength beyond 6% could be due to saturation of WVP in the mix. In addition, the results show that the addition of WVP at all the percentages, ranging from 2% up to 10% content in the WVP-bricks, satisfied the minimum 28days compressive strength of 2N/mm<sup>2</sup> stipulated by Nigerian Building and Road Research Institute (NBRRI, 2016) for blocks. The compressive strength of CLEB decreased beyond 6% addition of WVP, this could be due to the saturation of WVP in the mix.

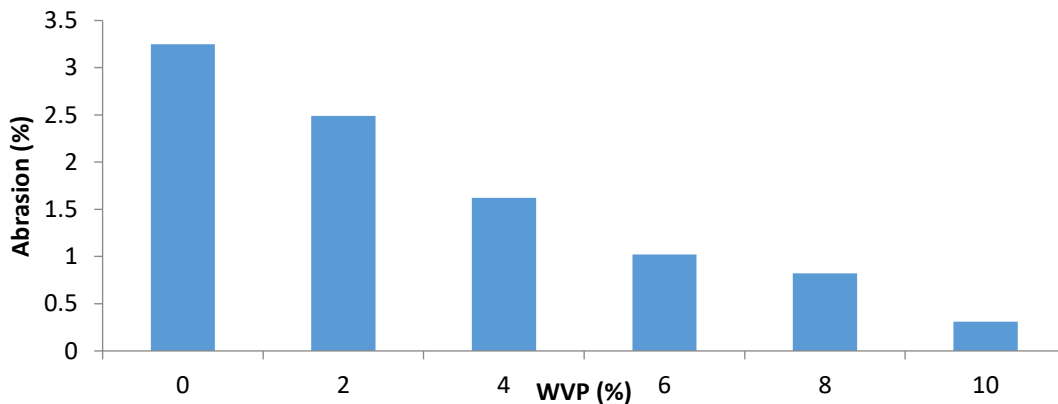




**Figure 11:** effect of WVP on compressive strength of lateritic earth blocks

### 3.3 Abrasion test on Lateritic earth brick

The results of the abrasion test presented in Figure 12 shows that the rate at which WVP stabilized brick resist abrasion increases with an increase in the percentage of WVP content. The increase in abrasion resistance could be attributed due to the stabilizing ability of WVP which binds the soil particles together.

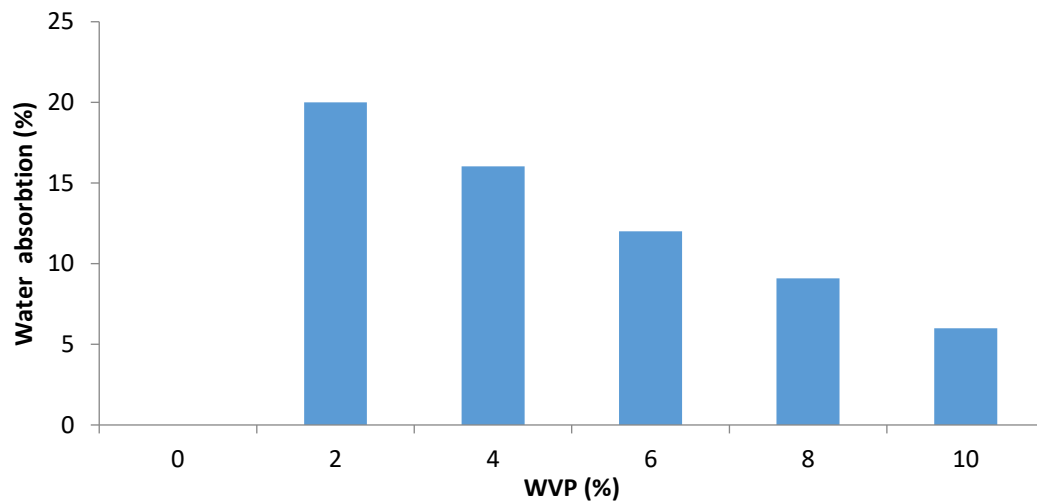


**Figure 12:** Effect of WVP on Abrasion Resistance of Lateritic Earth Bricks

### 3.4 Water absorption

The effects of the water absorption capacity of lateritic earth brick stabilized with WVP are presented in Figure 13. The figure shows that the water absorption decreases with an increase in the percentage of WVP content. This could be a result of the reduction of pores space as the stabilizing agent (WVP) increases. However, at 0% WVP, the bricks disintegrate leaving spread lateritic soil particles in the water. The water absorption of lateritic earth brick with up to 4% of WVP content is above the maximum limit specified by the Nigerian Industrial Standard (2004).

Figures 14 and 15 show the visual nature of the un-stabilized and stabilized earth blocks after the water absorption test.



**Figure 13** Effect of WVP on the water absorption of lateritic earth block as compared with the standard of 10%



**Figure 14:** Unstabilized CLEB



**Figure 15:** Stabilized CLEB

Plate 13 and Plate 14 show lateritic earth block removed from Water tank.

### 3.5 Effect of WVP on average weight and density of CLEB

The dry mass and density of WVP-stabilized CLEB are presented in Table 2.

**Table 2:** Effect of WVP on average weight and Density of CLEB

Content of WVP %	Av. Dry Mass of CLEB (Kg)	AV. Density of CLEB (Kg/m <sup>3</sup> )
0	5.02	1889.01
2	4.76	1791.14
4	4.54	1708.02
6	4.28	1609.06
8	4.00	1504.26
10	3.71	1393.15

The densities of the bricks presented, range from 1889.01kg/m<sup>3</sup> for unstabilized CLEB to 1393.15kg/m<sup>3</sup> for 10% WVP-stabilized CLEB, these values obtained fall within the ranges of 1200kg/m<sup>3</sup> - 2400kg/m<sup>3</sup> specified by Shestoperov (1983), as the density of special masonry. In addition, Debouncha and Hashim (2011) reported that the dry density of most compressed stabilized bricks could vary between 1300kg/m<sup>3</sup>-2400kg/m<sup>3</sup>. The introduction of WVP brought about a sharp decline in the value of the densities, with the highest content of WVP (10%) producing the least density of 1393.15kg/m<sup>3</sup>, this could be due to saturation of WVP in the mix. The densities of stabilized-CLEB decrease with an addition of WVP in all the percentages, which shows that the density of WVP-CLEB was lower than that of the unstabilized blocks. This is possible because the fibres reduce the compact and dense nature of the blocks as the fibres are less dense, this is consistent with the research reported by Danso (2017) who reported his findings on the properties of coconut, oil palm, and bagasse fibres as potential building materials.

#### 4. Conclusions

Base on the results of this study, the following conclusions were drawn. The wild-vine powder is predominantly composed of calcium oxide (44.6%) and potassium oxide (36.1%). The addition of WVP in the compressed lateritic earth blocks (CLEB) improves its compressive strength and resistance to abrasion when a 6% addition of WVP is used. The water absorption of CLEB decreases with an increase in percentages of WVP stabilizers. The recommended optimum dosage for WVP in lateritic earth blocks is 6% by weight of laterite.

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