Determination of Engineering Properties of Locust Bean Waste and Wildvine Use for Construction in Nigeria

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Abstract

The rate of migration into urban cities especially in Africa is a clear indication for increase in shelter for sustainable environment. To create a sustainable built environment, is to improve the use of local construction materials to meet the need of the growing population. In construction, certain admixtures are added to soil to improve its properties depending on the performances desired. This study seeks to determine the engineering properties of locust bean waste and wild vine as stabilizers used for construction. This was achieved through the following objectives to resist the high rate of wear and tear of buildings caused by rain and to determine the suitability of the admixture with less water absorption capacity and hydration process. Lack of proper stabilization is responsible for low strength of laterite in building and roads construction. Engineering performance of soil is enhanced by the addition of stabilizers. The wild vine and the locust bean waste were obtained from Gudum Hausawa, Bauchi and soaked in different concentration which were mixed with laterite. A quantity of the milled wild vine and locust bean were put in a soxholet extractor and extracted with n-hexane. The liquid was purified by drying off the solvent in a rotary evaporator. The wild vine liquor was mixed with 30, 40 50 and 60 litres of water to 10 kg locust bean waste respectively. The results were compared with that of plain laterite soil. It was found that averagely the laterite soil was 0.70N/m^2 and the highest average value of the compressive test was 1.23N/m^2. The average liquid limit value of laterite soil is 40.13% and the plastic limit is 35.63%. The results indicated high performance of strength when compared to plain laterite soil and its suitable stabilizers for construction.

Keywords: Building Construction, Engineering Properties, Locust Beans Waste, Wild Vine

INTRODUCTION

The rate of migration into urban cities especially in Africa indicate the need for increase in shelter for sustainable environment. To create a sustainable built environment, is to improve the use of local construction materials to meet the need of the growing population. In construction, certain admixtures are added to soil to improve its properties depending on the performances desired. Vandhiyan *et al*., (2013) stated in a growing country like India, huge amount of industrial waste pollutes the environment. However, waste can equally improve the properties of construction materials.

Presently, annual global cement production has reached 2.8 billion tons per year (Usman, 2015). They added that cement industry is facing challenges such as cost increase in energy supply, requirements to reduce Carbon dioxide emissions and the supply of raw materials are insufficient. High cost of building materials has affected many Nigerians who engage in cutting corners to achieve building production leading to failure of buildings (Fernandez, 2007; Usman *et al*, 2012; Gupta and Amit, 2004).

According to Usman *et al* (2012), the high and rising cost of building construction in developing countries has been a source of concern to public and private developers. As a result of daily increase in the cost of concrete material (most especially cement, coarse and fine aggregates), it has become imperative to introduce and develop local available materials (Usman *et al*, 2012). Usman (2015) added that people have changed from one type of building materials in a continuing effort to obtain the best possible protection from weather and the environment.

This study seeks to determine the engineering properties of locust bean waste and wild vine as stabilizers used for construction. This was achieved through the following objectives to produce building material that will resist the high rate of wear and tear of buildings caused by rain and to determine the suitability of the admixture with less water absorption capacity and hydration process.

MATERIALS AND METHOD

Compressive strength test: the compressive strength test was carried out on plain and mixed laterite with wild vine (dafara) liquor of different concentration 30, 40 and 50 litres of water to 10kg of locust bean pods respectively. Three cubes were cast for each specimen at different concentration for the average compressive strength to be obtained.

Preparation of Materials

The locust bean pods were collected from Gudum Hausawa village (Industrial Area) Bauchi, Nigeria. The samples were broken into simple particles sizes. The pods were weighed and soaked in 20 litres of water; liquor concentration was obtained for the experiment. Whereas, the wild vine (dafara) was obtained from Unguwan Kanawa, a settlement behind Federal Polytechnic, Bauchi Nigeria. The sample (wild vine) was stored in a shady place to avoid drying out, three days later; the plant was cut into smaller pieces

A mortar and pestle was used to break the fibrous part of the plant. After pounding, quantity of water was added to aid the easy extraction of the plant gum which was used as a binder.

Method of Soxhlet Extraction

The liquor was extracted using Soxhlet extractor. 400g of the sample was weighed using an electronic weighing balance and wrapped in a filter paper and was inserted into the center of the extractor. 500ml of normal hexane was poured into the round bottom flask (1litre) the Soxhlet was heated at $70^{o}C$ for 6 hours. When the solution was boiling, the vapour rose through the vertical tube into the condenser at the top. Liquid condensed and dripped into the filter paper through the pores of the thimble and fill the siphon tube, where it flows down into round bottom-flask. This was allowed to continue for over 5 hours, the sample was removed from the tube, dried in an oven and cooled in the desiccator and weighed again to determine the amount extracted. The resulting extract containing the liquid was heated to recover the solvent from the liquid at the end of the extraction.

Mixing of Materials

A head pan full of 25kg dry laterite was mixed for each of the following concentration of liquor proportions:

a) Locust bean mixed with wild vine extract.
b) Locust bean extract only.
c) Water without any stabilizing agent.

After mixing laterite soil with the additives, each mixture produced five sets of block. This was done at different proportion with the mixture, a total of 15 blocks specimen were produced. Curing was done by air-drying for 21 and 28 days respectively.

Particles Size Distribution Test (Sieve Analysis)

The particle size distribution of soil is a major classification test which is helpful in making any engineering judgement about the strength of soils. The soil sample was collected and wet sieved to remove the clay and silt size particles less than 0.06mm. The sample was oven dried at a temperature of 130^0 C, and then dry sieved to determine the percentage of coarse particles (greater than 0.06mm).

The oven dried sample was weighed and place on the larger BS sieve. The material passing through 20mm sieve was riffled to about 2kg and the mass was noted. It was later sprayed out on a larger tray and sprayed over with water. The material was thoroughly stirred to wet the soil completely. Then the soil was washed gradually and passed through 2.0mm BS sieve resting on 63 micrometre BS sieve. At each stage, the appropriate mass retained was recorded and expressed as a percentage of the whole sample.

Hydrometer Analysis

Before the actual operation, the soil had undergone certain stages of pre-treatment in order to remove organic matters, calcium carbonate and other soluble salts. The carbonates were removed by washing the soil sample with diluted hydrochloric acid (HCL). Hydrochloric acid is effective in removing carbonate and it fastens the oxidation process of the organic matter. The centrifugal bottle that contains the mixture of the sample was shaken vigorously in a reciprocal order to dislodge the carbonates. The sample of the soil which might have contained some organic matter was heated with 20 ml hydrogen peroxide on a hot plate for about four minutes.

RESULTS AND DISCUSSION

Based on the sieve analysis results, the particle size distribution of laterite soil used were 27% silt and 60.6% sand and falls within the recommended proportion: Sand 40 – 75%, Silt 10 – 30%, Clay 15 – 39% respectively (Nortion, 1986). The result of the specific gravity of the laterite soil was 2.65 which were also found within the recommended standard laterite soil.

From the atterberg limit test, the result revealed plastic limit of plain laterite 40.5% which confirmed to the standard proportion of sub-base material (Nortion, 1986). The liquid limit of stabilized laterite with 10 kg to 30 litres, 10 kg to 40 litres and 10 kg to 50 litres were 32.9%, 37% and 44.9% respectively. The plastic limit test with 10 kg to 30 litres, 10 kg to 40 litres, 10 kg to 50 litres and 10 kg to 60 litres were 44.9%, 35% and 27% respectively.

The result of compressive strength of stabilized laterite for 21 days curing period were 10 kg to 30 litres, 10 kg to 40 litres, 10 kg to 50 litres and 10 kg to 60 litres concentration (dafara, locust bean waste, dafara and locust bean waste) were found to be 0.70 N/mm^2, 0.89 N/mm^2, 1.23 N/mm^2 and 1.21 N/mm^2 respectively However, BS 2028 (1978) specified a maximum compressive strength of 5 N/mm^2. Usman *et al* (2012) reported from a study conducted on cement – bonded composite boards extra stalks that the effects of extractives were more than the initial stages, but at 28 days, the strength was almost similar for low concentration of extractives. They added that at higher concentration, the effect is significant on the hydration of cement which prevents strength gain. In a similar study, Akor *et al* (2008) found that an increase in the percentage of stabilization improved the characteristics of the material, that is, the higher the compressive strength of the cubes, the lower the absorption capacities. They buttressed that materials selected for construction must perform its purpose. He added that a building should perform the function for which it is designed. Usman (2015) stated that the availability of these building materials varies with locality, region and country. Professionals should devise a means of exploiting alternative construction materials.

Table 1: Particle Size Distribution (Sieve Analysis)

S/N	Sieve Sizes (mm)	Mass Refined (g)	Percentage Retained (%)	Percentage Passing (%)
1	2.00	6.2	12.4	87.6
2	1.18	8.6	17.2	70.8
3	600	9.8	19.6	50.8
4	300	4.8	9.6	41.2
5	150	3.0	60	35.3
6	63	1.9	3.8	31.4
7	< 63	15.7	31.4	

Table 2: Compressive Strength of plain Laterite

Brick No	Curing Period (Days)	Mass of Brick (kg)	Brick Density	Crushing Load (KN)	Compressive Strength (N/mm^2)
A1	21	7.95	2115	19.5	0.50
A2	21	7.90	2102	19.5	0.50
A3	21	7.95	2115	19.6	0.50
Average	21	7.90	2110	19.5	0.50

Table 3: Compressive Strength of plain laterite (10 kg to 30 litres) locust bean waste concentration

Brick No	Curing Period (Days)	Mass of Brick (kg)	Brick Density	Crushing Load (KN)	Compressive Strength (N/mm^2)
B1	21	8.21	2185	28	0.72
B2	21	8.10	2155	26	0.62
B3	21	8.21	2185	28	0.72
Average	21	8.17	2175	27.33	0.70

Table 3: Compressive Strength of plain laterite (10 kg to 40 litres) wild vine concentration

Brick No	Curing Period (Days)	Mass of Brick (kg)	Brick Density	Crushing Load (KN)	Compressive Strength (N/mm^2)
C1	21	10.05	2674	38	0.98
C2	21	10.0	2661	38	0.98
C3	21	10.05	2674	36	0.93

Average	21	10.0	2669.7	37.33	0.89

Table 4: Compressive Strength of plain laterite (10 kg to 50 litres) Locust bean waste and wild vine concentrations

Brick No	Curing Period (Days)	Mass of Brick (kg)	Brick Density	Crushing Load (KN)	Compressive Strength (N/mm^2)
D1	21	15.50	4125	47	1.21
D2	21	15.03	3999	48	1.24
D3	21	15.50	4125	48	1.24
Average	21	15.34	4083	47.67	1.23

Table 5: Compressive Strength of plain laterite for 28 days curing period

Brick No	Curing Period (Days)	Mass of Brick (kg)	Brick Density	Crushing Load (KN)	Compressive Strength (N/mm^2)
F1	28	7.91	2121	19.8	0.51
F2	28	7.89	2117	19.8	0.51
F3	28	7.90	2126	20.2	0.52
Average	28	7.89	2121	19.9	0.51

Table 6: Compressive Strength of plain laterite (10kg to 30 litres) stabilized with Locust bean waste concentration for 28 days curing period

Brick No	Curing Period (Days)	Mass of Brick (kg)	Brick Density	Crushing Load (KN)	Compressive Strength (N/mm^2)
G1	28	9.7	2612	39	1.0
G2	28	10.0	2602	40	1.03
G3	28	9.5	2621	39	1.0
Average	28	9.73	2611	39.3	1.01

Table 7: Compressive Strength of plain laterite (10kg to 40 litres) stabilized wild vine for 28 days curing period

Brick No.	Curing Period (Days)	Mass of Brick (kg)	Brick Density	Crushing Load (KN)	Compressive Strength (N/mm^2)
E1	21	15.40	4098	46	1.19
E2	21	15.40	4098	46	1.19
E3	21	15.0	3991	48	1.24
Average	21	15.27	4062	46.67	1.21

Table 8: Compressive Strength of plain laterite (10kg to 50 litres) stabilized with Locust bean waste and wild vine for 28 days curing period

Brick No.	Curing Period (Days)	Mass of Brick (kg)	Brick Density	Crushing Load (KN)	Compressive Strength (N/mm^2)
H1	28	13.50	4026	50	1.29
H2	28	12.96	4011	50	1.29
H3	28	13.46	4122	48	1.24
Average	28	13.31	4053	49.3	1.27

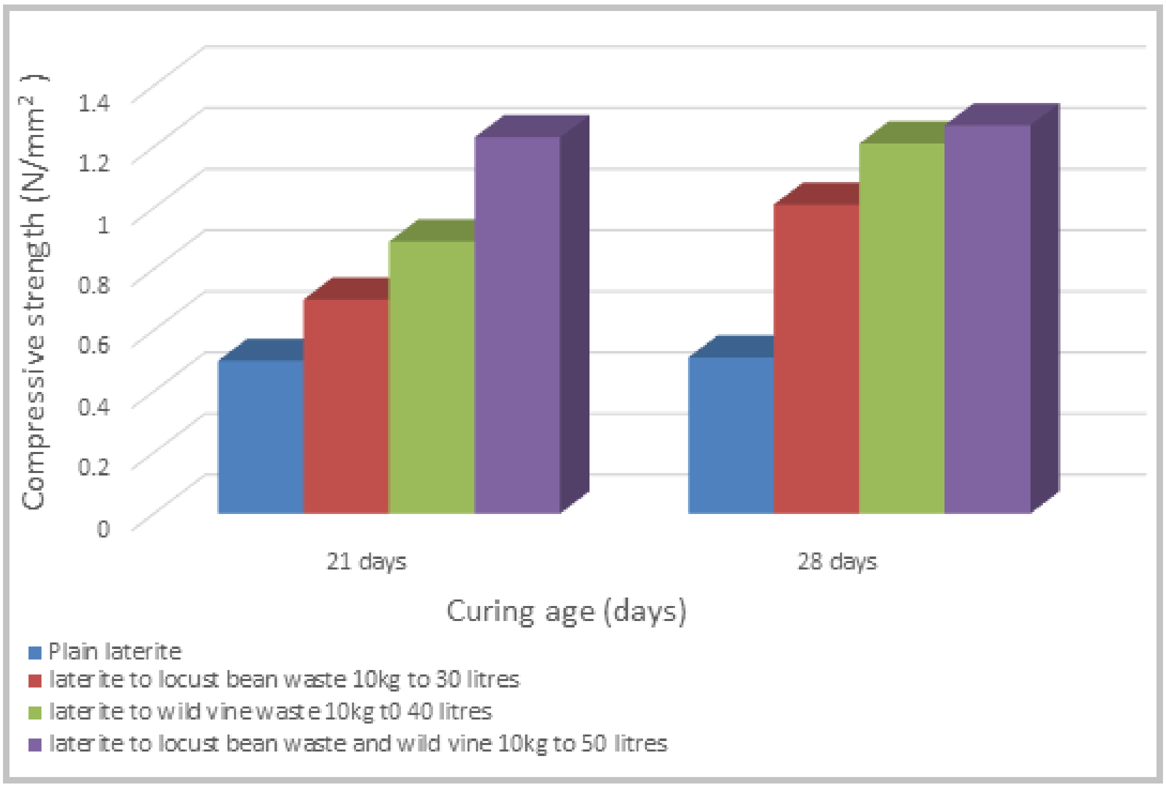

Figure 1: Effect of locust bean waste and wild vine on the compressive strength of laterite

CONCLUSION

From the results, locust bean pods and wild vine stabilized laterite increased in strength with number of days and decreased in weight with the number of days of curing respectively. Lack of proper stabilization is responsible for low strength of laterite in building and roads construction. Engineering performance of soil is enhanced by the addition stabilizers.

The strength possessed by the stabilized laterite revealed that the values obtained from the entire samples exceeded the suggested minimum strength for normal laterite soil brick $0.1N/mm^2$ (Usman *et al.*, 2012). These shows that the liquor concentration extracted from locust beans and wild vine (dafara) are very good stabilizers, especially laterite soil used for local walls. It possesses the engineering properties needed for load bearing capacity.

From the findings, laterite stabilized with locust bean waste (liquor/makuba) and wild vine (dafara) possessed adequate compressive strength required. Consequently, this can be used as an alternative construction material especially with mud walls.

Recommendation

a) It is recommended for road construction because it has high bonding strength which cannot be easily eroded.
b) The wild vine is far better in compressive strength than locust bean extracts; whereas, locust bean extract was better than plain laterite.
c) Wild vine extract and locust bean liquor has a lower compressive strength than sand crete blocks.
d) It is also suitable for housing construction.

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