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DETERMINATION OF COMPRESSIVE STRENGTH OF BLOCKS MOULDED WITH LOCUST BEAN POD WASTE EXTRACT AND ASH

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ABSTRACT

This paper reported the investigation on compressive strength of clay soil blocks mixed with locust bean pod extract and ash (LBPE&A) as a binder in partial replacement of conventional cement in construction of houses for low income earners. Some locust bean pod wastes were washed with clean water to remove foreign materials and was dried in an ovum at 105 °C for 12 hours and ashed. The remaining locust bean pod waste was soaked in water for 24 hours to extract the active ingredients. Compaction of moulded blocks was carried out using a hydraulic press, while compressive strength test was carried out on treated blocks with LBPE&A using Universal Testing Machine (UTM-TQSM1000). The results showed partial replacement of conventional cement with 5%, 10%, 15%, 20% and 100% of LBPA and concentrations of 0.07 kg/l, 0.13 kg/l and 0.2 kg/l LBPE showed improvements in the compressive strength of the blocks. The blocks were cured in open air under atmospheric condition and their compressive strengths were determined. It was observed that, the higher the concentration of the locust bean pod extract and reduction in cement percentage with locust bean pod ash, the significant increase in the compressive strength of the blocks. Hence, utilizing locust bean pod waste in block production can significantly reduce cost in building houses.

Keywords: Locust bean, extract, ash, compressive strength, conventional cement, housing

INTRODUCTION

Housing is one of the key priority needs of man and as such the demand has remained a challenge to low income earners. One of the factors militating against affordable housing is the high cost of conventional cement as a major precursor in building. Clay soil is one of the cheapest raw materials in building. They are particularly used in rural areas in developing countries like Nigeria. High cost of conventional cement has been a bottleneck and challenge for low income earners to afford standard housings. The need for alternative measure to produced cost effective building materials in developing countries cannot be overemphasized due to high demand for housing and the expensive conventional building materials like cement [1]. Clay soil blocks are sometimes mixed

with biomass (grass, extracts from trees; locust bean wastes and barks, and other local materials) to improve the strength of buildings [2]. Inclusion of extracts of active ingredients from locust bean pod waste extract and ash can significantly improve the strength of clay blocks for affordable housing [2].

Locust bean popularly known as African locust bean with botanical name *Parkia biglobosa* is a leguminous plant commonly found in the Savannah region of Nigeria that grows from 7 to 20 meters high [3,4]. The seeds are embedded inside the fruits which can be separated from the pods while the empty pod and the pulp are may be discarded as wastes. The pod has a composition of: fruit weight, 39%, yellowish pulp and seeds, 61% [3, 5]. The bark of the tree can be used as medicare for toothache, jedijedi, leprosy, eye sores, high body temperature, hypertension, wounds, ulcer and snake bites [3,6]. The fermented seeds are used as seasoning as Uzu (in Koro), Dadawa (in Hausa), Ogiri (in Igbo) and Iru (Yorubas) in soups and stews [3,4].

Study in the use of locust bean pod waste as a binder showed that the extract and the ash from locust bean pod waste improved the compressive strength of clay blocks by 78.5% [4]. Locust bean pod extract and ash contain pozzolans which are materials that consist majorly of silica and alumina. They are able to combine in the presence of moisture and chemically react with calcium hydroxide to form compounds possessing cementitious properties at ordinary temperature as binding agent. They also increase durability, reduce cost of cement in construction, lower heat of hydration, and increase resistance to sulphite attack [3].

Over the years, there has been quite a number of research effort towards possible ways of converting these agro-wastes (locust bean pod) into value added products and also to keep the environment safe and clean [6].

In spite of the abundant locust bean pod wastes generated annually, Nigeria populace are still faced with the challenge of affording standard housing due to high cost of building materials particularly conventional cement.

This work is aimed at studying the compressive strength of clay blocks produced from mixtures of locust bean pod extracts and the ash with clay. Also, the study is aimed at finding alternative source of binding ingredients that would cut down cost of using conventional cement which is one of the major raw material in building. The cost of clay and locust bean pod waste is affordable compared to conventional cement. The raw materials, clay and locust bean pod wastes, are readily available and renewable as it does not deplete with time compared to limestone used in producing conventional cement that depletes with time as mining of the raw material continues.

MATERIALS AND METHODS

Material Sourcing and Preparation

The materials for this study included locust bean pod extract and ash, clay, cement and water. Locust bean pod waste (LBPW) were obtained from Uner (Dogon Kurmi) in Kagarko Local Government Area of Kaduna State, Nigeria, while cement was obtained from NARICT, Kaduna State.

Plate 1 shows image of locust bean fruit. The LBPW were washed with clean water to remove foreign materials. About 0.2 kg, 0.5 kg and 0.6 kg of the LBPW were soaked each in three (3) liters of clean borehole water for 24 hours to give concentrations of 0.07 kg/l, 0.1 kg/l, 0.2 kg/l and 0.75 kg/l, respectively.

Plate 1: Locust bean pod fruit

Plate 2 shows sample of locust bean pod extract. Dried pretreated LBPW were burnt and ashed in a kiln at atmospheric condition within a temperature range of 500 – 700 °C measured with a thermocouple for a period of five hours [4, 7]. The ash was sieved using a 300 µm (micrometer) sieve size to get fine particles.

Figure 2: Locust bean pod extract (LBPE)

Plate 3 shows sample of locust bean pod ash. The clay soil used for the study was obtained from NARICT. It was crushed into tiny particle size and sieved using a 300 µm (micrometer) sieve size to get fine particles. While, conventional cement (Dangote product) was purchased off-shelf at Basawa, Zaria, Kaduna State, Nigeria.

Plate 3: Locust bean pod ash (LBPA)

Production of Clay Blocks (LBPE and LBPA)

About 80 ml of each locust LBPE with concentrations 0.07 kg/l, 0.1 kg/l, 0.2 kg/l and 0.75 kg/l as water were mixed with 630 g of clay soil and thoroughly mixed to form a paste using a hand trowel. Two blocks each were moulded using a mould with dimension of 10 cm x 5cm x 5cm and then compacted in a hydraulic press machine to one (1) metric ton (1000 kg) load. The moulded blocks were air dried, cured under shade and sun for seven (7) days before being fired in a muffle furnace for a period of two (2) hours to temperature of 500 ^{o}C. Then it was taken for compressive strength test using a universal testing machine (UTM-TQSM1000) [8].

The Conventional cement was partially replaced with 5%, 10%, 15%, 20% and 100% of LBPA and mixed with 630 g of clay soil. About 80 ml of borehole water was added to the mixtures to form a paste which was then used to mould five (5) blocks each and air dried under shade for seven (7) days. The moulded blocks were cured under the sun and watered in the morning on different number of days (7, 14, 21 and 28 days). Then, they were fired to a temperature of 500 ^{o}C in a muffle furnace for a period of 2 hours before taken for compressive strength test using a universal testing machine (UTM-TQSM1000) [8].

Compressive strength of clay blocks produced using locust bean pod extract and the ash was determined in accordance to the methods of American Standard Testing Methods (ASTM C805).

The block flow diagram for the production of clay blocks using locust bean pod waste (extract and ash) is shown in Figure 1.

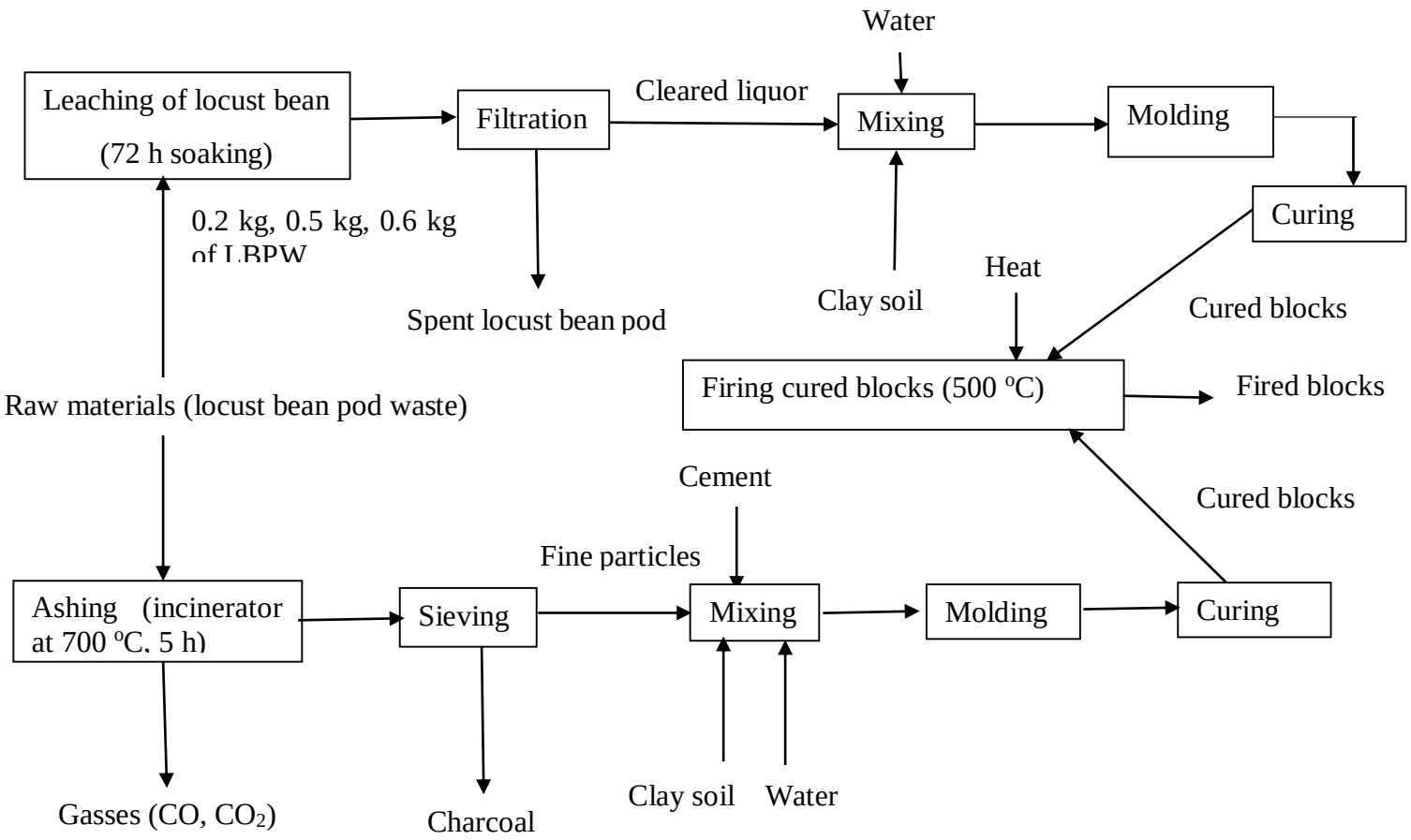

Figure 1**:** Block flow diagram for the production of clay blocks using locust bean pod extract and ash.

RESULTS AND DISCUSSION

The compressive strength of both blocks produced with LBPEA and LBPA were carried out at National Research Institute for Chemical Technology (NARICT), Basawa, Zaria, Kaduna State, Nigeria, with concentrations 0.07 kg/l, 0.1 kg/l, 0.2 kg/l and 0.75 kg/l and curing period of 7, 14, 21 and 28 days as shown in Figures 2 to 4.

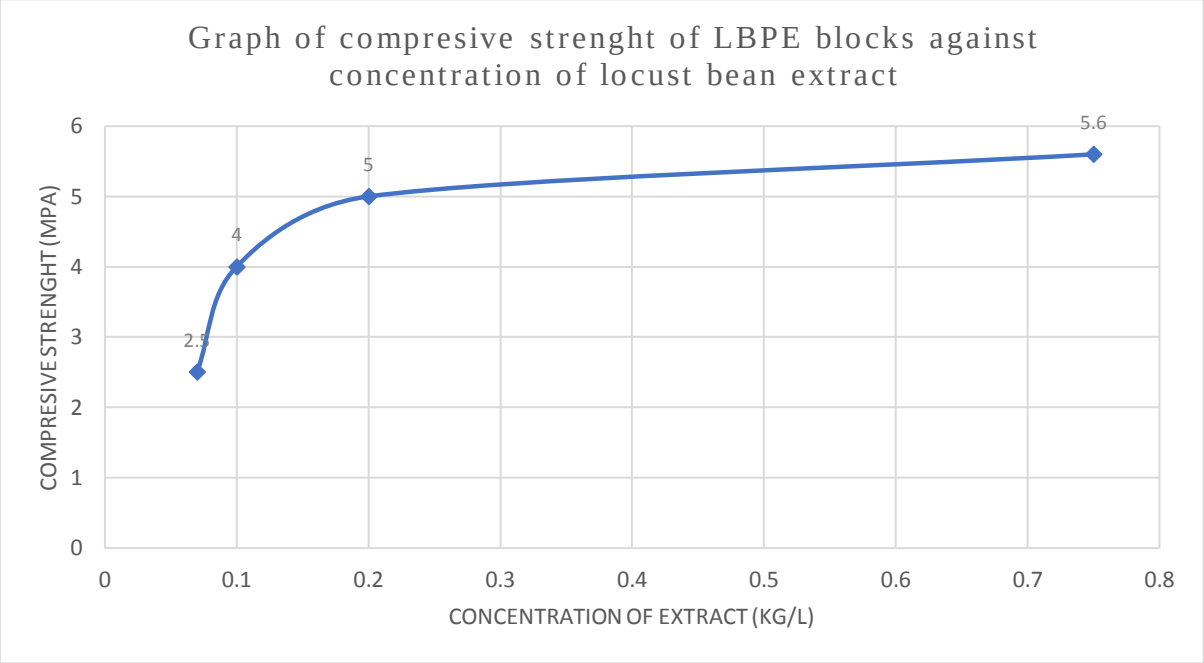

Figure 2: Plot of compressive strength of LBPE blocks against concentration of locust bean extract.

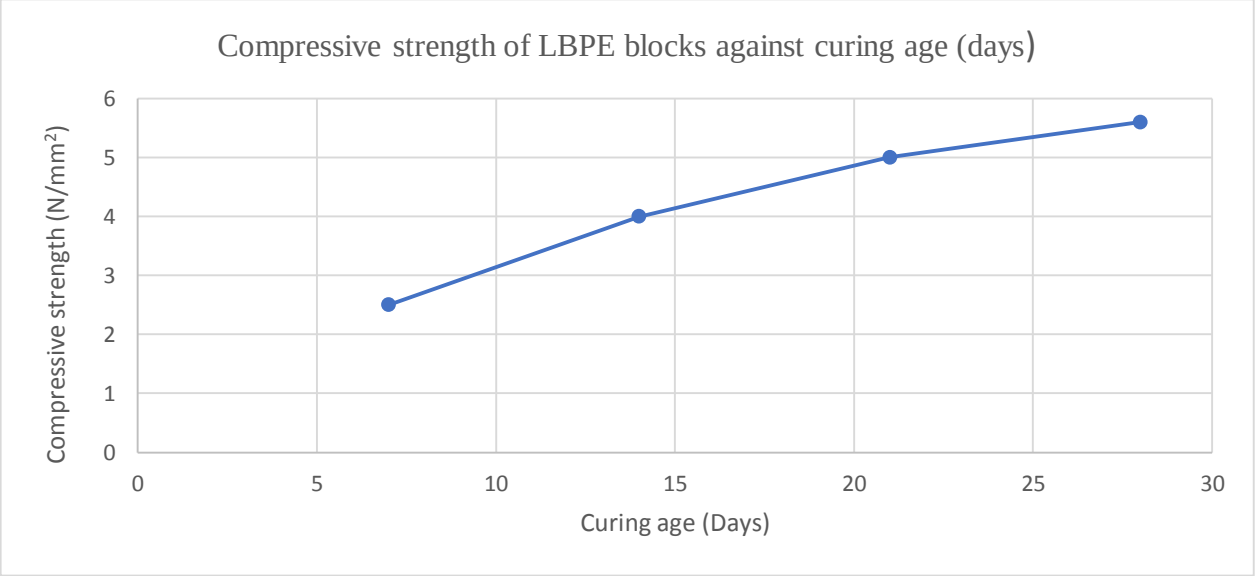

Figure 3: Plot of compressive strength of LBPE blocks against curing age (days)

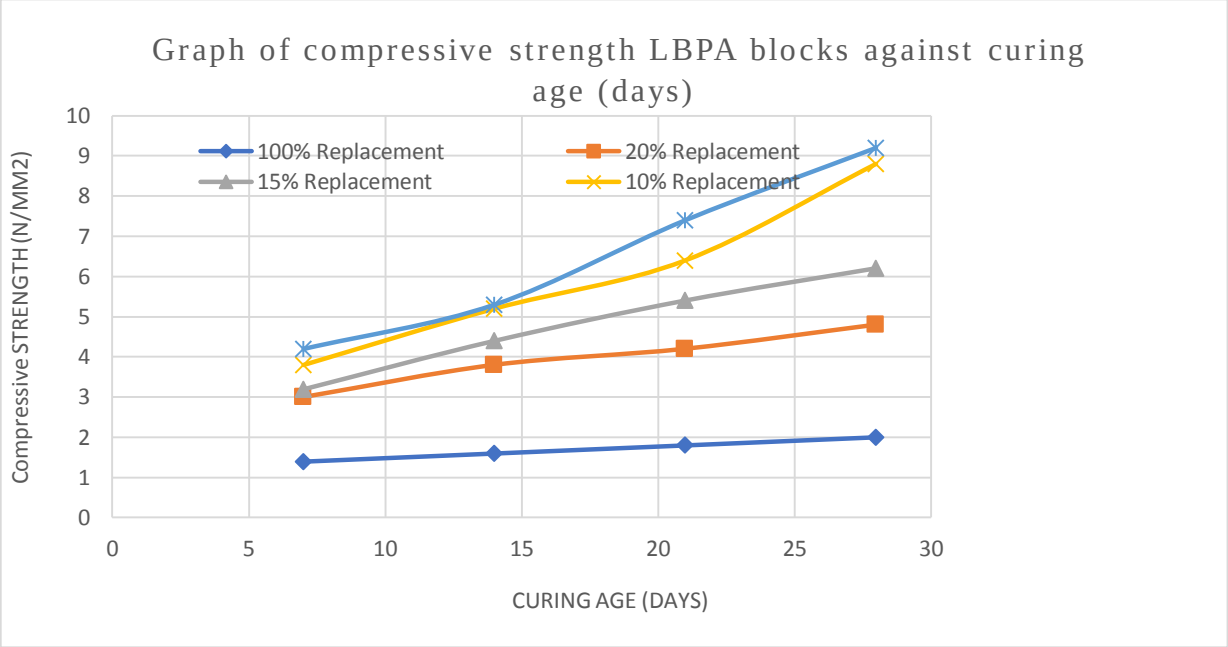

Figure 4: Plot of compressive strength of LBPA against curing age (days)

Figure 2 shows the compressive strength of clay blocks produced against concentrations of locust bean pod extract of 0.07 kg/l, 0.1 kg/l, 0.2 kg/l and 0.75 kg/l. At concentration 0.07 kg/l to 0.2 kg/l the compressive strength of the blocks increased sharply. Between concentrations 0.2 kg/l and 0.75 kg/l the compressive strength was insignificant in spite the increased in concentration of locust bean extract.

Figure 3 shows that the compressive strength of LBPE blocks produced increased with curing age (days), but as curing age increased the compressive strength was insignificant. While Figure 4 shows the compressive strength of clay blocks produced from reduction of percentage of conventional cement with locust bean pod ash at a curing period of 7, 14, 21 and 28 days respectively. The longer the curing days of the clay blocks produced from both LBPE and LBPA the insignificant increase on the compressive strength. Hence there is no need for longer curing days.

From Figure 2, it was observed that the compressive strength increases simultaneously with concentrations of the locust bean pod extract and is in agreement with the findings of [1, 2]. Also, Figures 3 and 4 shows that the compressive strength of blocks produced from LBPE with curing period of 7, 14, 21 and 28 days and that produced from LBPA with reduction of conventional cement decreased with percentage increase in LBPA and was insignificant with increase in curing days for all the mixes and it is in agreement with some research findings [4, 5]. It is possible that increase in compressive strength of both block samples produced from locust bean pod extract and ash can be

attributed to the presence of pozzolans in the locust bean pod waste which constitute of silica and alumina as a binding agent in the presence of moisture as reported by Aguwa and Okafor [2]. It was also observed the compressive strength increases gradually with increased in concentration and reduction in cement at each curing days.

CONCLUSION

Locust bean pod extract and Locust bean pod ash can effectively be used to produce clay blocks for housings, with some appreciable reduction in cost of cement usage. The concentration of locust bean pod extracts up to 0.1 kg/l and percentage reduction in amount of cement mixtures can be up to 20% without any appreciable reduction in the compressive strength of the blocks which are within the standard specified compressive strength of clay blocks of 2.5 N/mm^2 with bearing load and minimum of 3.45 N/mm^2 [9]. Hence, utilizing locust bean pod waste in blocks production by mixing locust bean pod extracts soaked for not more than 24 hours and producing ash in an incinerator can significantly reduce cost of cement usage. The higher the concentration of the locust bean pod waste extract, the greater the compressive strength of the clay blocks. The raw materials are renewable, available and also serves as environmental clean-up.

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