Enhancing the Strength Properties of Clay Block for Building Construction using Locust Beans Pod (Makuba) as Local Additive in Kano State, Nigeria

by

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Abstract

The study enhanced the properties of clay block for building construction using Locust Bean Pod (Makuba) as local additives. Research and development (R&D) were adopted for the study. The study was carried out in Kura town, Kura local Government in Kano State which is located at the North Western Geopolitical Zone, Nigeria. Five research objectives, five corresponding research questions and three null hypotheses guided the study. The population for the study was 200 cubes of clay blocks. The tests conducted for the study were mix ratio, setting time, compressive test, water absorption and binding strength. Data were collected based on experimental researchprinciples by observation and recording values. Specimens will be tested atdifferent times and for different proportion of the additives for strength, binding capacity, mix ratio and water absorption. Readings foreach specimen were recorded until the entire specimens subjected to 28days curing period are tested.The conventional clay blocks used for building construction in Kano were tested first and strength, binding capacity, mix ratio and water absorption level in the products would be recorded. Subsequently, the clay blocks with the additives were also be tested of the same properties to see whether there will be any change in the strength and water absorption. The findings were based on known industrial standard; ASTM, C1825, C1601, C1314, and E84. The study found among other things that the mix ratio of 7:14:4 was found suitable for the production of enhanced Makuba clay block for building construction purposes. The setting time of sample with the highest content of the additive was found to have set for construction within fourteen days of production unlike the other two samples. The sample which was produced using the additive and undergo firing treatment has the highest compressive strength going by the international standard of 2.73mpa.The rate of water absorption based on the analysis indicated that, the burnt clay enhanced clay blocks absorbed less water compared to the other two samples. The binding capacity of ordinary clay block with cement as binding agent was more efficient compared to that of Makuba enhanced clay block but when used in moderation, Locust bean pod can serve as a partial replacement for cement. It was recommended among other things that Ideally, a major initiative to enhance the use of Makuba as building material could be mass planting of locust beans tree wherever they can take root and thrive. That various government agencies should engage in the use of Locust beans pod powder rather than campaigning to developers. That every state should establish cottage building industries to improve the supply, and that more researches should be engaged on for more discoveries of varieties of Locust Beans Pod Trees.

Keywords: Block, Clay, Building, Building construction, Locust bean.

Introduction

Industrial and technological activities are on the increase globally, giving rise to a significant increase in industrial and agricultural wastes. Poor waste management has impacted directly on the environment leading to environmental degradation. The adverse effects of degradation of the environment brought about by incessant agricultural and industrial waste disposal system has prompted engineers and scientist to embark on researches geared towards possible ways of recycling these wastes in order to keep the environment safe and ecologically habitable for human beings. Recycling of agricultural by-products for concrete mixes

such as block production is now recognized as one of the meaningful ways of transforming solid waste to wealth. The use of clay block for building construction has passed from one civilization to another, experiencing modifications and improvement along the way. Jegele and Adanikin (2018) stated that, in Nigeria, the art of using Clay blocks (bricks) can be traced to the eighteenth century.

By the beginning of the 19th century, the first British Governor of the then Northern Nigeria, Lord Lugard had his house built with clay bricks in the village of Baro (Niger State) and such houses built then in towns like Kano, Kaduna, Ilorin and Baro are still intact and habitable (Jegele et al., 2018). The provision of Shelter is one of the basic needs of man. Unfortunately, the means for possessing a building structure has become a problem in recent time in this country especially among the teaming low-income earners, partly because of high cost of cement, blocks and other building materials.

The over dependence on the utilization of cement and Sandcrete blocks for buildings have kept the cost of these materials and by implication the cost of buildingsunbearably high (Aguwa,2010). In modern construction practices, common clay blocks are categorized according to their component materials and method of manufacture (Cesaretti, Dini, Kestelier, Colla, & Pambaguian, 2014). Regrettably, common clay block for construction lacks the sufficient strength to withstand load for a long period of time, hence the need to improve the quality with local additives that are not only affordable by low-income earners but are readily available, eco-friendly and relatively cheaper than conventional building materials. One of such local agricultural waste is Locust been pod (Makuba).

The African locust bean tree, *"Parkiabiglobosa*" is a perennial tree legume, belonging to the sub-family '*Mimosodeae*' and family *'leguminosae*'.*Parkiabiglobosa* is an important multipurpose tree from the savannah zone of West Africa. The plant increases soil fertility, grows to about 15 m in height and has dark, evergreen, pinnate leaves (Mason & Donovan, 2015). Its fruit is a brown, leathery pod of about 10 to 30 cm long and contains gummy pulp of an agreeable sweet taste, in which lies a number of seeds (Aguwa, Alhaji, Jiya, & Kareem, 2016). The pods are edible and are often used for livestock feed. It is a widespread savanna tree and it is recognized easily by its bright red pendulous flowers.

The locust bean seed produced by the parkia tree is embedded in a yellowish, sweet tasting edible (Aguwa & Okafor, 2012). Makubarefers to the brownish fruit pods of the locust bean (*parkia filicoidea*) known as "*Dorawa*" in Hausa, *Ogiri* or *Dawa-Dawa* in Igbo and *Iru* in Yoruba. Locust bean pod husk 'Makuba' is a waste by-product of agricultural processing of the African locust bean fruit (Saleh, 2014).

The pod of the locust bean is then collected and grinded making it to be powdered, so that, after a building construction is completed, the soaked grinded powdered pod is spread all over the wall and the floor of the completed structure. This is done in the olden days, usually to prevent water penetration. On the other hand, the pod is soaked into water producing 'sour water' produced from steeping and boiling. The Makuba is mixed with mud to produce a plaster to paint the walls of houses. This plaster is also used to paint tamped earthen floors. The tannins present in the *Makuba* act to bind the soil, their polymeric nature, and render the surface impervious to water. The Makuba contains 27-44% tannins and are also used for dyeing and curing (Saleh, 2014). Considering these good characteristic properties, the utilization of Makuba as a local additive in clay bricks production could enhance construction of houses for the citizens, since it will reduce the demand for

cement particularly in Northern Nigeria. The Makuba is in the form of empty pods from the ripped fruits of locust bean plant after the seeds have been removed. Makuba also required no tedious processes for its production. There is availability of Locust bean tree in the north western parts of Nigeria (Salau, Deba, & Yusuf,2012)

The alternative materials used to improve the strength of clay blocks have compelled researchers to intensify work on substitutes of cement with a view to investigating their usefulness wholly as construction material or partly as substitute for cement in construction. There is imbalance between the expensive conventional building materials coupled with depletion of traditional building materials. To address this situation, attention has been focused on low-cost alternative building materials (Pacheco-Torgal & Labrincha, 2013).

A block is a building material used to make walls, pavements and other elements in masonry construction. Building construction industries contributes immensely to technological development of any nation. For the overall economy in Building Construction industry to be achieved, cost of each element in construction of shelter has to be realized (Akindapo, Binni, & Sanusi, 2015). Investigating local building materials for construction has therefore become inevitable to reduce the overall cost of Building Construction so that shelter can be affordable for the people. This could be achieved by enhancing clay blocks production for Building Construction using Locust Bean Pod (Makuba) as a local additive.

The need to enhance clay Block as a building construction material in the developing countries such as Nigeria cannot be overemphasized due to imbalance between the demand for housing and the expensive conventional Building materials (Musibau, & Oladimeji, 2013). Clay Block is a solid unit of Building having standard size and weight. Its history traces back thousand years (almost 7500 BCE). The composition of clay used for block molding varies over a wide range. Usually, clays are composed mainly of silica (grains of sand), alumina, lime, iron, manganese, sulfur, and phosphates, with different proportions. Clay Blocks as building material have an average density of 125 pcf (Haseeb, Hassan, & Azam, 2017). One of the problems of Clay Blocks as it is conventionally used in Kano State today has poor strength properties, and problem of improper mixing ratio of the materials involved.

Mix ratio is the abundance of one component of a mixture relative to that of all other components. The quantitative relation between two amounts showing the number of times one value contains as against the other. The term can be referred to volume ratio, mole ratio or mass ratio. Two binary solutions of different compositions or even two pure components can be mixed with various mixing ratios by masses, moles, or volumes. The mass fraction of the resulting solution from mixing solutions is used to determine the volume content of the material used for construction purposes. This determines the setting time of the paste formed.

Setting time is when the paste formed when cement is mixed with water remains plastic for not a very long time to stiffen and sets. The setting process is subjectively divided into stages, time of initial setting and time of final setting, depending on the resistance to penetration by a probe. Before the time of initial setting, it is still possible to disturb the mixture for Block production and remix it (American International Journal, 2018).

Blocks are manufactured by grinding or crushing the clay in mills and mixing it with water to make it plastic. The plastic clay is then molded, textured, dried, and finally fired. Blocks are manufactured in different colors, such as dark red, dark brown, or dull brown,

depending on the fire temperature during manufacturing. The firing temperature for block manufacturing varies from 900°C to 1200°C (1650°F to 2200°F). A block can be composed of clay-bearing soil, sand, and lime, or concrete materials. Blocks are produced in numerous classes, types, materials, and sizes which vary with region and time period, and are produced in bulk quantities (Zhang, 2013). Blocks are laid in courses and numerous patterns known as bonds, collectively known as block work, and may be laid in various kinds of mortar to hold the blocks together to make a durable structure during building construction. Water absorption is an important characteristic in block as it should be exposed to wet conditions during construction as it is a means of providing shelter for individuals.

Water absorption is defined as a process by which materials absorb moisture into its body. Water absorption of a building materials refers to the amount of water absorbed by the composite material when immersed in water for a stipulated period of time (Omopariola, 2014). It is viewed that, water absorption is the ratio of the weight of water absorbed by a material to the weight of the dry material (Abah, Ndububa, & Ikpe, 2018). It is important to note that, all organic material will absorb moisture to some extent resulting in swelling, dissolving and leaching, lower resistance to heat, weathering and cracking. One major constituent proposed for Block Construction that absorbs water easily as additives is Locust Beans Pod known as Makuba or ParkiaBiglobosa botanically and is readily available as local Building Materials.

Raw Materials Research and Development Council of Nigeria (RMRDCN, 2017) stated that, available local building materials reveals that certain building materials deserve serious consideration as substitute for imported ones. Few of these materials includes: cement, lime stabilized bricks and blocks, sundried (Adobe) soil blocks, burnt clay bricks and blocks, cast in-situ walls, rice husk ash (RHA), mud and straw, lime, stonecrete blocks and Makuba, among others.

In view of the availability of locust bens tree; it's simple processing techniques and its strength properties. It is then, necessary to find a means of enhancing the strength properties of clay block using Makuba as a local additive in the production of clay blocks.

The importance of blocks and bricks as part of the local building materials that makes up the wall units in a building or construction work cannot be overemphasized. This is in line with the present quest for recycling Agricultural by-products such as locust bean pod for construction purposes. Considering the economic status of most building owners in the villages, it is not always easy for them to purchase cement for their usual building constructions and frequent renovations. The adoption of African locust bean pod (*Makuba*) as a partial substitute of cement would be eco-friendly for the common man. At the same time, the cost usually incurred on the cost of building constructions would drastically reduce (Jiao, Lloyd, & Wakes 2012).

Statement of the Problem

Clay blocks are produced using a natural binder which will not give the product sufficient strength to withstand the presumed and expected loads to be exerted on the structure. The production of clay blocks considers, the rate of water absorption of Clay blocks and sufficient drying process within the shortest possible time to be put into use.

Clay Blocks produced in Nigeria nowadays are not of the quality expected in the construction industries and the growing population. The present block is produced without considering any standard ratio in the course of production in order to achieve the expectation of lasting and load carrying capacity. Moreover, the present block does not withstand the forces being exerted on them. The strength capacity of the blocks is not

sufficient enough to withstand the expected loads of any structure thereby leading to the rampant collapse of building structures.The setting time of the ordinary clay blocks could also be a factor that constitutes the need to find a lasting solution. The economic status, culture and environment made it possible to consider the costs of building construction using locust bean pod as a local additive to find out if it could enhance the strength properties of clay block and reduce the cost of Building materials such as cement.

The inability of the present Clay Blocks produced by local dwellers especially in Kano State to withstand the expected loads is a serious concern to this study. Considering the strength properties of Makuba, as a binding material in enhancing clay becomes imperative. The study determined the possibility ofreducing the cost of construction in the state considering the availability of Clay and Makuba in Kano State.

Purpose of the Study

The general purpose of this study is to enhance the strength of clay block for Building construction using Locust Beans Pod (Makuba) as local additive. Specifically, the study seeks to;

1. Determine the mix ratio of clay to locust beans pod powder and water suitable for the production of Clay Blocks.
2. Compare the setting times of Ordinary clay blocks and Makuba enhanced Clay Blocks.
3. Compare the compressive strength of Makuba enhanced Clay Blocks and Ordinary Clay Blocks.
4. Compare the water absorption properties of Makuba burnt, unburnt and Ordinary Clay Blocks.
5. Compare the binding capacity of Makuba enhanced clay block and Ordinary Clay Block with cement as a binding agent.

Research questions

The following research questions were answered by the study:

1. What are the different mix proportions of Locust Beans Pod, clay and water which will produce workable clay block?
2. What is the setting time for ordinary Clay Blocks and the enhanced Makuba Clay Blocks?
3. What is the Compressive Strength of the Makuba enhanced Clay Blocks compared to Ordinary Clay Blocks?
4. What is the rate of water absorption of burnt, unburnt Makuba enhanced and Ordinary Clay Blocks?
5. What is the binding capacity of Makuba enhanced Clay Blocks and Ordinary Clay Blocks with cement as a binding agent?

Hypotheses

The following hypotheses have been formulated to guide the study. The hypotheses will be tested at 0.5 level of significance.

1. Significance difference does not exist in the mix ratio of Locust Beans Pod, enhanced Clay Block and water to that of Ordinary Clay Blocks.
2. Significance difference does not exist in the water absorption ratio of the Ordinary Clay Blocks and that of enhanced Makuba Clay Blocks.
3. Significance difference does not exist on the binding capacity of ordinary clay blocks and that of the enhanced Makuba Clay Block.

Methodology

The research design adopted for the study is the Research and Development (R & D). According to Gall, Gall and Borg, (2007) explained research and development (R & D) (Putri, & Wardoyo,2017)as anindustry-based development model in which the findings of research are used to design new products and procedures, which then are systematically field tested, evaluated and refined until they meet specified criteria of effectiveness, quality or similar standards. Research and Development (R & D) design is suitable for this study in that, the study intends to develop

an enhanced clay block which will be used for building construction.

The study was carried out in Kura town, Kura local Government in Kano State which is located at the North Western Geopolitical Zone, Nigeria. Kura town is selected for this study based on the fact that, Locust beans trees are in abundance and most of the populace are farmers and there is availability of water around. Kura town is known by their irrigation farming which promotes high yield of locust beans trees all year round.

Instruments used for the collection of the sample are; shovel, wheel barrow, empty bag of cement, sack, Head Pan and Pick Axe. The wheel barrow will be used to transport the to the mixing area. The Head Pan will be used for conveying already mixed specimen for moulding. Sacks and shovel would be used for conveying clay from the areas of which it was dug. Pick Axe will be used for digging the soil to convenient depth where the appropriate clay sample will be found, while locust bean pod powder will be collected from Rantan and Butalawa villages of Kiru and Kura Local Governments respectively.

Recycling of agricultural by-products in concrete mixes such as block production is now identified as one of the meaningful ways to dispose some solid waste and transform them to wealth. Provision of Shelter is one of the basic needs of man and the means of possessing a building which has become a problem in this country especially among the teaming low-income earners. However, the need of alternative materials to be used to improve the strength of clay blocks have compelled researchers to intensify work on substitutes of cement with a view to investigating their usefulness wholly as construction material or partly as substitute for cement in construction. In the process of producing enhanced clay block, the researchers modified the process into six stages thus;

The pods were bagged and transported to a block production industry in Kura town (Manaja Blocks Industry, Kura) in Kura local Government, Kano State. The pods would be stored in a shady place for it to dry, for 14 days. The pods will then be grinded manually using peel and mortar which is hoped to last for five days. Women would be employed for this activity. After grinding, the result obtained from the manual grinding of the pods leading to the pod being powered would be called MAKUBA which will be use in the production of the Makuba enhanced clay blocks under study.

The following equipment were used in carrying out the experiment, sieve of size 0.850mm, wooden mould with internal dimension of 300mm long, 200mm thick and 100mm high would be considered to be an acceptable size,

For clay blocks to be produced, there are materials usually needed and mixed using a specified proportion. The materials are; Clay, Water and Makuba. Twenty clay blocks of size 150mm cube will be molded using different mix ratios of 7:8, 7:8:4 and 7:14:6 and their strengths will be determined at 28 days. Hand mixing will be used throughout the production and uniformity will be achieved by turning the mixture thoroughly six times.

A head pan full of 25kg dry powder (Makuba) will be mixed with already dug clay for the production of the enhanced Makuba clay block. Each of the following concentrations will be used in producing clay blocks for the purpose of this study. The following procedure will be used to obtain the required product (Enhanced Clay Block).

The materials for this study would be weigh batched because weigh batching is reliable, uniform and consistent quantity could be maintained. Weigh batching gives much more accurate results Darwin, Dolan & Nilson, (2016). According to Darwin,et al (2016), weigh batching is the correct method of measuring the material. The researcher

maintained the use of weigh system in batching, which facilitates accuracy, flexibility and simplicity. The use of empty sack was significant so as to maintain uniformity in the measurement. The clay samples after sieving with sieve No 2o (0.850mm) will be batched first, followed by locust bean pod powder (additive) at various mix ratios which will be added to clay sample. The materials were mixed thoroughly while still dry by turning with shovel until the homogenous mixture is obtained.

Water was added to the dry mix and mixed thoroughly to a uniform consistency for workability. Each of the specimen groups based on the different ratios will be worked-on, on separate days to avoid complication in the specimen identification. The mixture was poured into the lubricated wooden mould and will be compacted manually using a wooden tamping rod. A total of 200 samples of clay blocks were produced at different ratios for the experiment. Five samples each will be tested using three trial proportions for the different four different ratios to determine their strength, binding capacity, mix ratio and water absorption.

The blocks were air dried for 28 days in the open field because at 28 days the clay blocks would have been practically suitable for handling and safe for use in building construction. During the curing period of (28 days), the blocks were covered with grasses to avoid spontaneous drying that will cause shrinkage and leads to cracks.

The compressive strength tests of the cubes were performed using a mould of 50mm x 50mm x 50mm in accordance with ASTM C 109. The 1:2:4 mix ratios were adopted. The cubes will be cured for 7, 14, 21 and 28 days respectively. For each mix, 3 cubes will be crushed to obtain the average strength.

Water absorption test was conducted in accordance with BS 1881, part 122. The specimen was weighed and immersed in water. They will be brought out and reweighed at intervals of one day until saturation point is achieved. The Water absorption test was a measure of the ratio of difference in weight and the initial weight. The formula for calculating water absorption is:

$$\frac{M2 - M1}{M1}$$

Data were collected based on experimental research principles by observation and recording values. Specimens will be tested at different times and for different proportion of the additives for strength, binding capacity, mix ratio and water absorption. Readings foreach specimen will be recorded until the entire specimens subjected to 28days curing period are tested.

The conventional clay blocks used for building construction in Kano were tested first and strength, binding capacity, mix ratio and water absorption level in the products would be recorded. Subsequently, the clay blocks with the additives were also be tested of the same properties to see whether there will be any change in the strength and water absorption. The findings were based on known industrial standard; ASTM, C1825, C1601, C1314, and E84.

Result

The results were presented in tables in line with the research questions.

Table 1: Mix proportions of Locust Beans Pod, clay and water which will produce workable clay block

Mix proportion Procedure: This test was conducted in accordance with BS1377: 1990: Part 4.

Specimen	Material	Mix Ratio	Outcome
A	Clay and water	7:8	Broken clay block
B	Clay, water and Makuba	7:8:4	Stable clay block
C	Clay, water and Makuba	7:14:	Enhanced clay block

The summary of the results obtained from the tests conducted on the use of Makuba to determine its suitability to enhance the strength of clay blocks for building construction purposes is presented in table 1. The specimens were tested after 28 days of curing. Table 1 revealed the properties of the materials used for the production of clay block using Makuba to enhance the strength of clay block for building construction. As for ordinary block, the mix ratio is 7:8 indicating that, 7 head pan of clay and 8 bucket of water is sufficient for the production of ordinary clay block which is brittle in nature and can easily break (Sample A). On the other hand, the same amount of water and clay and addition of four head pan of Makuba as local additive in the ratio (7:8:4) was used in the production of clay block as (Sample B) which is stable for construction. Another batch was raised with a ratio of (7:14:6) indicating seven head pans of clay, fourteen bucket of water and six head pans of Makuba which gives an enhanced block termed as (Sample C).

Table 2: The setting time for ordinary Clay Blocks and the enhanced Makuba Clay Blocks

Specimen	Material	Mix Ratio	Settingtime	Outcome
A	Clay and water	7:8	21 days	Broken clay block
B	Clay, water and Makuba	7:8:4	16 days	Stable clay block
C	Clay, water and Makuba	7:14:6	14 days	Enhancedclay block

The different samples of blocks produced were monitored to determine how long each will be ready for construction. Sample (A) which is the ordinary clay block took 21 days for it to be set for construction. The second sample (B) was monitored and it took exactly 16 days this because of the presence of Makuba which facilitate the drying process. The last sample (C) set earlier than sample A and B, this is because the content of the additive added was higher than that of sample B and the setting time was 14 days only for it to be ready for construction.

Table 3: The Compressive Strength of Makuba enhanced Clay Blocks compared to Ordinary Clay Blocks

Specimen	Material	Mix Ratio	Compressive strength	Outcome
A	Clayand water	7:8	4.45N/m^2	Broken clay block
B	Clay, water and Makuba	7:8:4	6.35N/m^2	Stable clay block
C	Clay, water and Makuba	7:14:6	12.78N/m^2	Enhanced clay block

Result of compressive test of clay blocks and Makuba clay blocks.

The mix ratio applied was 7:8, 7:8:4 and 7:14:6 by volume of clay, based on the result at 28th day, the mean compressive strength test were 4.45Mpa, 6.35Mpa, and 12.78Mpa respectively, which are better than the mean compressive strength of the locally fired clay blocks which is 3N/mm2When tested in accordance with DKS 2802-1.Therefore, these results showed that the fired enhanced Clay Blocks performed excellently on the minimum mean compressive strength requirement based on the ES, ASTM and IS standards.But the ordinary clay blocks achieved above the minimum compressive strength requirements of IS standard.

Table 4: The rate of water absorption of burnt, unburnt Makuba enhanced and Ordinary Clay Blocks

Specimen	Material	Mix Ratio	Rate of water absorption, $\frac{M2 - M1}{M1}$	Outcome
A	Clay and water	7:8	3.184-2.890/2.890=2.184	Broken clay block
B	Clay, water andMakuba	7:8:4	3.172-2.854/2.854=2.172	Stable clay block
C	Clay, water and Makuba	7:14:6	3.162-2.928/2.928=2.162	Enhanced clay block

Table 4 shows that the rate of water absorption of the clay block made with the local additive was higher considering the weights of the products before and after immersion into the water. The samples were weighted before immersed into the water which gives 2.890, 2.854 and 2.928 as their weight for the ordinary clay block, unburnt clay block and burnt clay block respectively before immersed into the water while after immersion the weight change to 3.184, 3.172 and 3.162 respectively. All values are in kilogram (kg). Therefore, the water absorption ratio of phase (C) of the samples was found to be more efficient and stand a chance of being a better material for building construction going by the result of the study depending on the density of the blocks using the standard formula of: Density= Mass/Volume.

Test was performed to determine the liquid and plastic limits, and the plasticity indicator of the clay sample. With progressive addition in percentage of Makuba content in the clay, the liquid limit and plastic limit progressively increase and plasticity indicator decreases. This increase can be seen for each of liquid limit and plastic limit as well as decrease in plasticity indicator in appendix…., respectively. This increase in liquid and plastic limits with increases in Makuba content is due to the moisture absorption properties of Makuba.

Discussion of findings

Based on the study conducted, from the results obtained the following findings were realised:

The mix ratio of 7:14:4 was found suitable for the production of enhanced Makuba clay block for building construction purposes. This is in line with the findings of Adamu, Jimoh and Kolo, (2023) who found tha locust bean pod can ehance the strength characteristics of clay block.The setting time of sample (c) with the highest content of the additive was found to have set for construction within fourteen days of production unlike the other two samples.Sample (C) which was produced using the additive and undergo firing treatment has the highest compressive strength going by the international standard of 2.73Mpa.

The rate of water absorption based on the analysis indicated that, the burnt clay enhanced clay blocks absorbed less water compared to the other two samples.The binding capacity of ordinary clay block with cement as binding agent was more efficient compared to that of Makuba enhanced clay block. This corroborates the findings of Aguwa and Okafor (2012) who reported that though the binding strength of cement is better but when used in moderation, Locust bean pod can serve as a partial replacement for cement.

Conclusion

Locust Beans Pod (Makuba) can economically and effectively be used in the production of clay blocks for building construction purposes with some percentage reduction in the quantity of cement. The percentage reduction in quantity of cement can be up to 25% without reducing the compressive strength of the blocks to unsatisfactory level. Hence, the cost of sandcrete blocks can be reduced significantly by partially reducing the quantity of cement and mixing with locust bean pod powder. This will lead to reduction in construction cost of houses in Nigeria. This will also create employment to the rural dwellers where locust been trees are grown and as well improve their economic status.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Ideally, a major initiative to enhance the use of Makuba as building material could be mass planting of locust beans tree wherever they can take root and thrive.
2. That various government agencies should engage in the use of Locust beans pod powder rather than campaigning to developers.
3. That every state should establish cottage building industries to improve the supply, and that more researches should be engaged on for more discoveries of varieties of Locust Beans Pod Trees.
4. Farmers should be encouraged to farm locust bean tree to a certain level for it to be in abundance for building construction purposes.
5. Advocacy on the use of agricultural by-product and recycled waste as building material as partial replacement of cement for construction.
6. Ministry of education, Curriculum developers should design a program on using Makuba in conducting practical trainings in our schools.

7. Unemployed youth should be encouraged to go into farming of locust beans tree to reduce over dependence on government on provision of jobs opportunities.

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