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PRELIMINARY INVESTIGATION IN THE USE OF LOCUST BEAN POD EXTRACT AS BINDER FOR PRODUCTION OF LATERITE BLOCKS FOR BUILDINGS

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ABSTRACT

This paper presents the investigatory result on the use of locust bean pod extract as binder for the production of laterite blocks for buildings. The Locust Bean Pod is a waste material that is normally discarded after the seeds have been harvested. Twenty blocks of size 150 x 150 x 150mm were produced using locust bean pod extract as binder in concentrations of 0, 0.04, 0.06, 0.08 and 0.10kg/l respectively. The blocks without locust bean pod extract were used as control. The whole blocks were cured under atmospheric condition in the laboratory and their compressive strengths were determined. It was found that locust bean pod extract can siginificantly increase the compressive strength of laterite blocks by 78.57% and that the higher the concentration of the locust bean pod extract, the greater the compressive strength of the Laterite blocks.

Key words: Binder, Compressive strength, Laterite blocks, Locust bean pod extract,

INTRODUCTION

In developing countries the increasing cost of building materials such as blocks, cement, concrete and the availability of Laterite soil have led to the need for utilizing the lateritic soil in the construction industry. Housing is one of the most important needs of human beings and as such the demand for it is always on the increase. Laterite exists in most parts of this country and a good proportioned mix of laterite and cement as binder proved to be suitable for buildings. They are used all over the world, particularly rural areas in most developing countries like Ghana and Nigeria. Laterite blocks are sometimes mixed with shrubs, pod of locust bean and other local materials to improve the strength and binding quality of the walls of buildings.

The process of solvent extraction may be used either for the production of a concentrated solution of a valuable solid material or to remove an insoluble solid such as pigment from a soluble material with which it was contaminated. In northern part of Nigerian, the seeds of locust bean are used for food seasoning and it is popularly known as Dawadawa while the Yorubas call it iru. The fruit is also sweet and can be consumed directly by people while the pod is used in making gums in the industries (Campbell-Patt, 1980). According to Alabi, Akinsulire and Sanyaolu, (2005), seeds of Parkia biglobosa were found to be rich in lipid, protein, carbohydrate, soluble sugars and ascorbic acid. The oil has very high saponification value and hence would be useful in soap industry. Aliero, 2004 reported that the seeds contain 54% fat and 30% protein in addition to vitamins and minerals such as Calcium, Potassiun and Phosphorus. The pods and roots are used as sponges and as strings for musical instruments. The trees serve as wind break and provide shade (Okunlola, Adebayo and Orimogunje, 2011). Tee, Oguche and Ikyaagba, 2009 reported that locust bean trees and ironwood trees contribute significantly to nutritional wellbeing of the people of North-Central Nigeria and that their monthly net incomes from products of these trees compared favourably with the national minimum wages of N7500 (USD59 equivalent). Many of them were living above the national minimum wage.

The African locust bean tree, “Parkia biglobosa” is a perenial tree legume, belonging to the sub-family Mimosodeae and family leguminosae (Campbell-Patt, 1980). Parkia biglobosa is an important multipurpose tree from the savannah zone of West Africa. The plant increases soil fertility, grows to about 15m in height and has dark, evergreen, pinnate leaves. It’s fruit is a brown, leathery pod of about 10 to 30cm long and contains gummy pulp of an agreeable sweet taste, in which lies a number of seeds. The pods are edible and are often used for livestock feed. It has been reported that the bark of the plant can be used in the treatment of toothache, leprosy, eye sores, fever, hypertension as well as wound, ulcer and snake bite. The seeds are used extensively as seasoning and also nutritious additives to soups and stews as well as good source of essential amino acids (Hassan and Umar, 2005). The fruit pulp analyzed showed moisture content of 8.41%, protein 6.56%, fat 1.80%, crude fibre 11.75%, ash 4.18% and carbohydrate of 67.30% (Gernmah et al, 2007)

The locust bean seed produced by the parkia tree is embedded in a yellowish, sweet tasting edible pulp. The pods, containing locust bean seeds, resemble that of a soyabean pod that starts out as a bright green and turns dry and deep brown as it matures on the tree. In the middle belt and Northern states of Nigeria, the pod is used in the rural areas in the construction industry. The pods are collected and soaked in water for at least four days. The extract is now used to mould mud blocks for building purposes. At other times, the pods are spread over mud walls and as soon as rain begins to fall on the pods, the leachate percolates down the wall. On further investigation, the natives have ample evidence to show that buildings made of locust bean pod extracts are not attacked by termites in termite infested areas in contrast to those built without the pod extracts. These buildings and fence walls have been found by the natives to withstand over a long period of time under varying weather condintions such as rains, wind and heat. Hence this work sets out to study the Civil Engineering properties and applications of these observations made by the natives.

The African locust bean (Parkia-biglobosa) has a wide distribution ranging across the Sudan and Guinea Savanna and the ecological zones. The range extends from the western coast of Africa in Senegal across to Sudan. It is found in nineteen African countries: Senegal, Gambia, Guinea Bissau, Guinea, Sierra Leone, Mali, Cote De Voir, Burkina Faso, Ghana, Togo, Benin, Niger, Nigeria, Cameroon, Chad, Central Africa, Republic, Zaire, Sudan and Uganda. In Nigeria, it is predominantly found in the northern part of the country.

Locust bean pod apart from being food is medicinal in relief of diarrhea. The bark is boiled to make tea for treatment of wounds and fever. Several authors have reported on its medicinal uses and treatments. Concentrated locust bean pod extract is used to impart water resiliency to floors, walls and ceramics pot. The tannins present in the husk act to bind the soil by their polymeric nature and render the surface impervious to water, sealant to pot and creates a dark, mottled surface. The pod ash is used for soap making and for dying the traditional indigo clothes.

In the textile industry, locust bean are either used alone or in combination with starch and synthetics as a seasoning agent for cotton and other natural fibers. It is also used as a print-paste thickener in both roller and screen printing to help provide greater purity and uniformity of shades and deeper penetration of dyes. Other minor uses include incorporation in oil-drilling fluids and some pharmaceutical and cosmetics applications. The wood ash is used in soap making, and indigo dying (Campbell-Plath 1980).

Locust bean pod has a pH of 6 implying weak organic acid with a density of l0.97kg/m^3 with a dark brown colour. It has the following chemical composition the bark contains 12 - 14% of tannin while the husk contains 27- 44% of tannin. Also Campbel-Platt (1980) reported that Locust bean pod contains 60% carbohydrates and 10-20% of which is sucrose, with 29mg of vitamin C per 100g of Locust bean pod. The pulp is a beneficial food source in the middle of the dry season with initial early colour white, turning to bright yellow as the pod matures.

Therefore the aim of this work is to find out if the addition of locust bean pod extract to laterite as binder for production of laterite blocks can improve the compressive strength. Addition of cement as binder in the production of laterite blocks has been established to have significant increase in the compressive strength of the blocks (Aguwa, 2010). The objectives of the study include; carrying out extraction of active ingredients in locust bean pod, production of laterite blocks using the locust bean pod extract as binder and carrying out compressive strength test on laterite blocks produced.

MATERIALS AND METHODS

Laterite: The Laterite used was collected from an existing borrow pit at a depth of about 1.5 to 2.5 m in Minna, Nigeria (Latitude 9^o 37'N and Longitude 6^o 33'E), using method of disturbed sampling. A study of the geological and soil maps of Nigeria after Akintola (1982) and Areola (1982) respectively shows that the samples taken belong to the group of ferruginous tropical soils derived from acid igneous and metamorphic rocks. The index properties of the natural soil are summarized in Table 1.

Locust bean pod: Locust bean pod samples were collected within Gidan Kwano campus of Federal University of Technology, Minna, Nigeria.

Water: Tap water free from contaminants either dissolved or in suspension (BS 3148, 1980) was collected from Civil Engineering Laboratory, Federal University of Technology, Minna, Nigeria and used for leaching process of the locust bean pod as well as for moulding the laterite blocks.

Laboratory tests

Laboratory tests carried out on the laterite, which included determination of natural moisture content, particle size distribution, Atterberg's limits, specific gravity and compaction, were in accordance with BS 1377, (1990).

Leaching process in the production of binding material from Locust bean pod

The process of leaching was employed in the extraction of a soluble constituent from the pod by means of a solvent. The method used for the extraction is determined by the proportion of soluble constituent present, its distribution throughout the solid and the nature of the solid and the particle size. Generally, leaching process is divided into three major parts; the change of phase of the solute as it dissolves in the solvent, the diffusion through the solvent in the pores of the solid to the outside of the particle and the transfer of the solute from the solution in contact with the particles to the main bulk of the solution. The smaller the particle sizes the greater the interfacial area between the solid and liquid, and therefore the higher the rate of transfer of materials and the smaller is the distance the solute must diffuse within the solid as already indicated. In most cases, the solubility of the material which is being extracted will increase with increase in temperature and this will also increase the rate of extraction. The liquid chosen should be a good selective solvent and its viscosity should be sufficiently low for it to circulate freely and in this case water was used. Generally, a relatively pure solvent will be used initially, but as the extraction proceeds the concentration of the solute in the solvent increases and the rate of extraction will progressively decrease first, because the concentration gradient will be reduced and because the solution will become more viscous. Agitation of the solvent is important because this increases the eddy diffusion and therefore the transfer rate from the surface of the particles to the bulk of the solution.

Production of Laterite blocks

The laterite blocks of size 150mm x 150mm x 150mm were moulded using the locust bean pod extract as water for mixing. Twenty blocks were produced manually with pod extract in concentrations of 0.04, 0.06, 0.08 and 0.10kg/l. Also twenty laterite blocks of the same size but mixed with ordinary water as control were produced. Uniformity and consistency were achieved during mixing and the compaction was carried out using 2.5kg standard rammer falling from a height of 30cm in accordance with BS 1377, (1990). The freshly produced laterite blocks prepared with and without pod extract were cured in the laboratory under atmospheric condition with all the windows opened to allow proper circulation of air for 7, 14, 21 and 28 days respectively.

Compressive Strength test

Compressive strength test was carried out on the laterite blocks at the curing ages of 7, 14, 21 and 28 days respectively, in accordance with BS 1881 Part 116, (1983) using a Seidner compression machine. Five blocks for each level of concentration and the control were crushed in a particular age of curing and the average compressive strength was calculated for each.

Care was taken to ensure that the blocks were not disturbed during curing and the extrusion was cautiously carried out to ensure that there was no breakage. Also extra care was taken to ensure that the critical dimensions of the blocks were not disfigured, to maintain constant surface area of the blocks in contact with the compressive machine (Aguwa, 2009). During crushing, proper care was also taken to ensure that the blocks were perfectly positioned and aligned with the axis of the thrust of the compression machine to guarantee uniform loading of the blocks (Neville, 2000).

RESULTS AND DISCUSSION

The geotechnical index properties of the natural laterite used are summarized in Table 1 while Figures 1 and 2 show the particle size distribution of laterite and locust bean pod respectively. The index properties determined are typical of true laterite as a confirmation. Figure 3 is the result of the compaction test on the laterite and normal compaction curve was obtained indicating the maximum dry density and the optimum moisture content.

Table 1: Properties of the natural laterite

Characteristics	**Description**
Natural moisture content (%)	3.2
Percentage of gravel (%)	53
Percentage of sand (%)	15
Percentage of silt (%)	17
Percentage of clay	15
Liquid limit (%)	38
Plastic limit (%)	24
Plasticity index (%)	22
Linear shrinkage (%)	10
Maximum dry density (Mg/m^3)	1.87
Optimum moisture content (%)	12.5
Specific gravity	2.68
Condition of sample	Air-dried
Color	Brownish red
Group Index	17

Source: From tests on the natural Laterite used

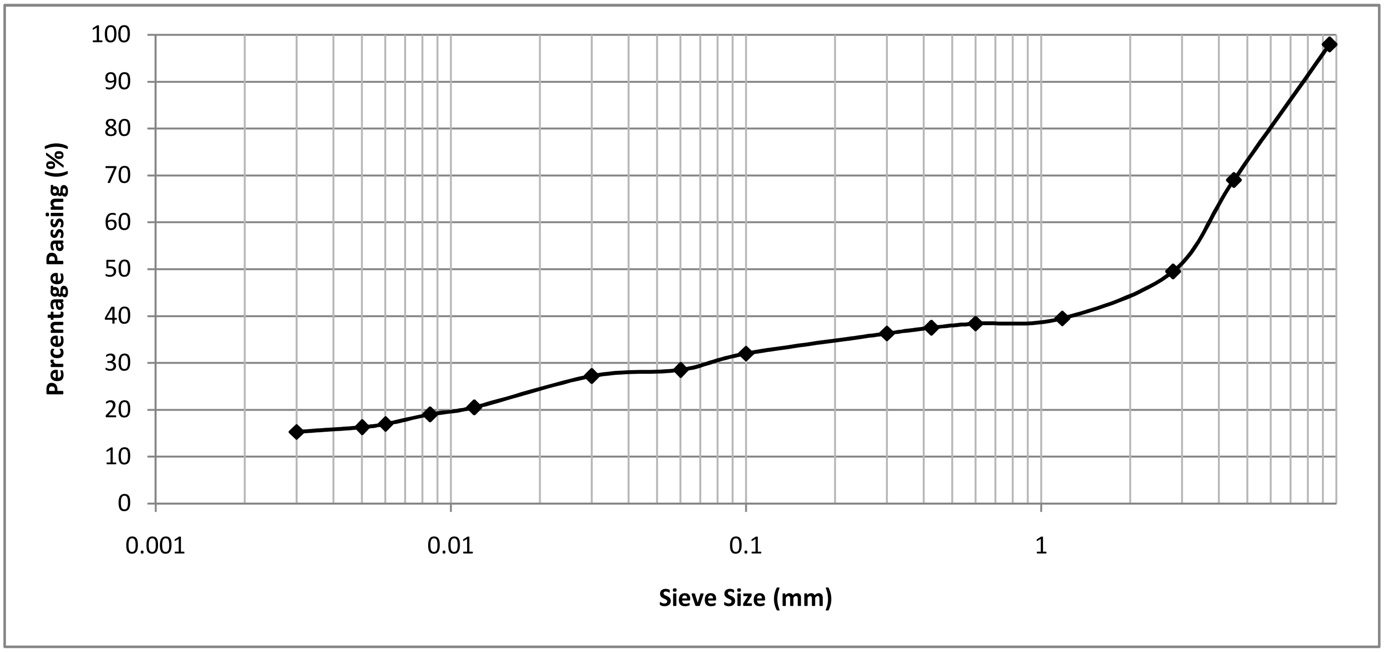

Figure 1: Particle size distribution for Laterite used in the experiment

Figure 2: Particle size distribution for Locust bean pod used in the experiment

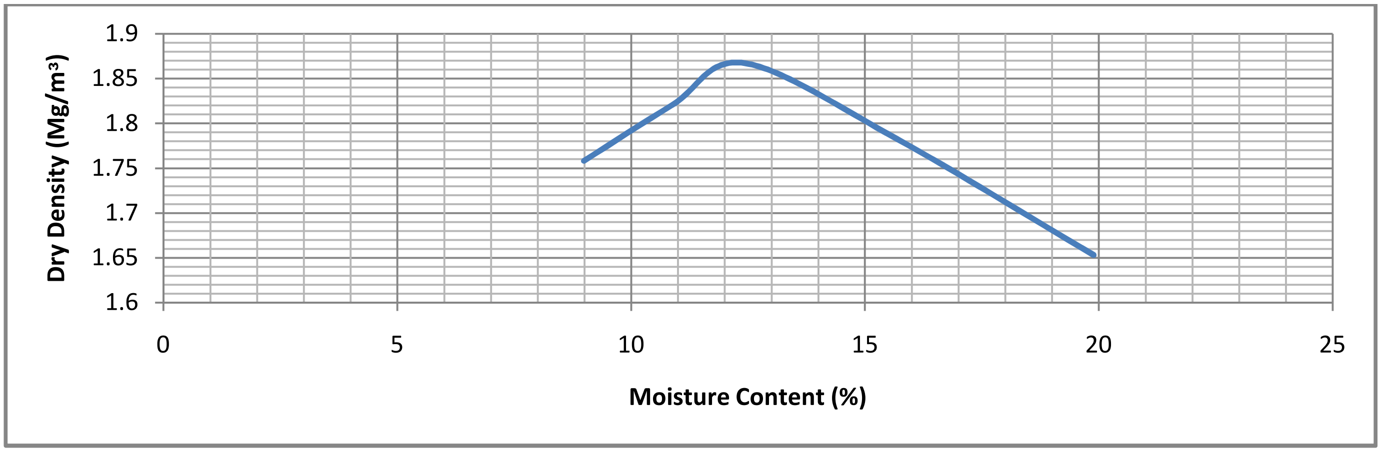

Figure 3: Dry density – Moisture content relation for the Laterite used.

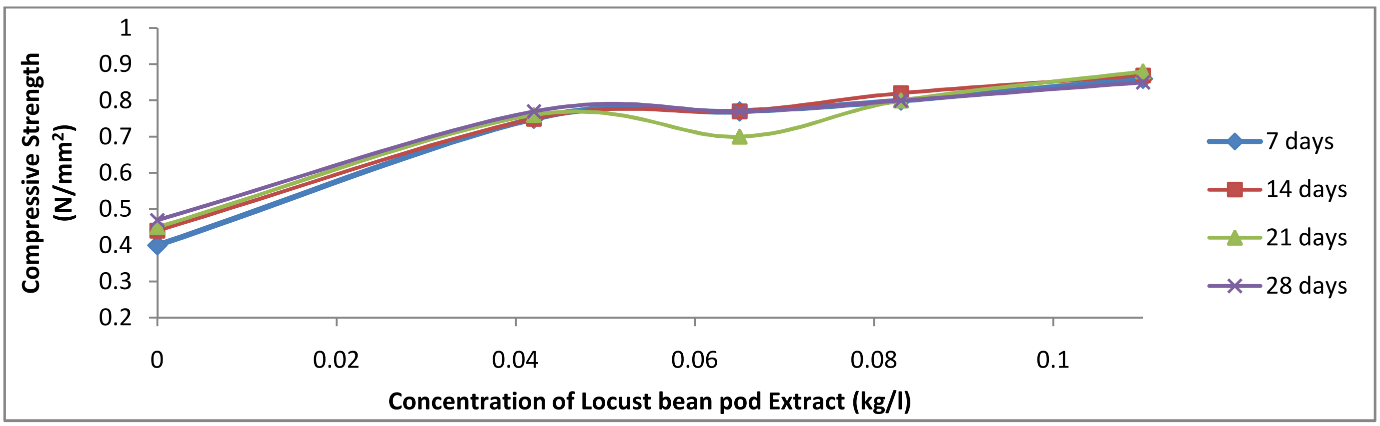

Figure 4: Relationship between Compressive Strength and Concentration of locust bean pod extract for Laterite blocks at various curing ages

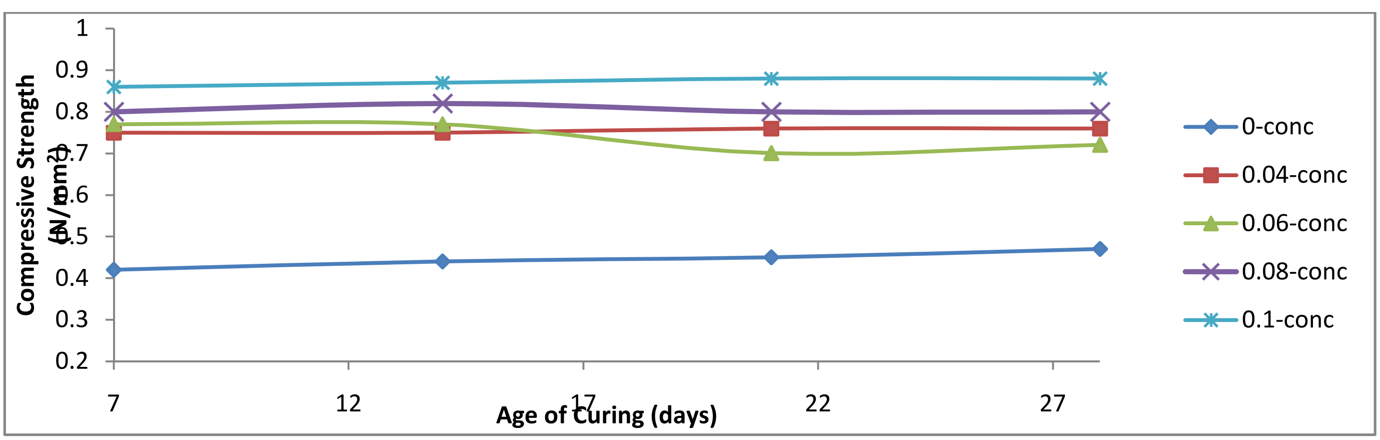

Figure 5: Relationship between Compressive Strength and Age of curing for Laterite blocks moulded with different concentrations of locust bean pod extract.

Compressive Strength

The effect of locust bean pod extract on the compressive strength of laterite blocks is shown in Figure 4. The locust bean pod extract has positive effect of increasing the compressive strength of Laterite blocks and the higher the concentration of the locust bean pod extract, the greater the compressive strength of the Laterite blocks.

Figure 5 shows the relationship between the compressive strengths of the Laterite blocks and age of curing for various concentrations of locust bean pod extract. There is no significant increase in the compressive strength with increase in age of curing of the Laterite blocks for the five different conentrations of locust bean pod extract used in production of the blocks. This is an indication that seven days are adequate for complete development of stength for Laterite blocks.

CONCLUSIONS

Preliminary laboratory tests carried out showed that the soil used is lateritic in nature. Locust bean pod extract as a binder in the production of Laterite blocks has the positive effect of increasing the compressive strength by 78.57%. The higher the concentration of the locust bean pod extract the greater the compressive strength of the Laterite blocks. However, the effect of age of curing of the Laterite blocks on the compressive strength is insiginificant; hence there is no need for longer days of curing.

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