SECTION 2.

BUILDING AND ARCHITECTURE

FLEXURAL STRENGTH OF REINFORCED CONCRETE BEAM WITH LOCUST BEAN POD EXTRACT AS REPLACEMENT FOR WATER

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Abstract. Study on the flexural strength of reinforced concrete beam using locust bean pod extract (LBPE) as a replacement for water is presented. Chemical test of the extract and other preliminary tests on aggregates were carried as materials that were used. The chemical composition of LBPE shows that it is a good binder (pozzolana) and contains all major oxides found in Ordinary Portland cement (OPC): SiO_2 (49.993 %), Fe_2O_3 (6.342 %) and Al_2O_3 (18.966 %). Sixteen (16) beams specimens of size 0.15 m × 0.15 m × 0.6 m doubly reinforced with 12 mm diameter steel bars as major reinforcement and stirrups of 8 mm diameter evenly spaced were cast. Four beams were cast for each replacement of water with 0, 5, 10 and 15 % LBPE and cured for 28 days. Flexural test results show that the flexural strength from the average of the best three values for each replacement, was maximum (8.59 N/mm^2) at 10 % replacement of OPC with LBPE and higher than the control (8.11 N/mm^2)

at 0 % replacement. The LBPE concentration is seen to affect the flexural strength of reinforced concrete beams positively.

1. INTRODUCTION

As a result of increased in industrial and agricultural processes across the globe, there has been significant increase in industrial and agricultural wastes which most often have negative impact on the environment. Much research efforts in recent times are geared towards possible ways of recycling these wastes for re-use to keep the environment clean and safe. The locust bean tree (Figure 1) is being cultivated over a wide area within the African sub region which occurs in large quantity from the Atlantic coast in Senegal to Sudan, northern Uganda, and northern Nigeria [1]. Locust bean pod is a waste agricultural biomass (WAB) obtained from the fruit and it is the required waste for the production of locust bean pod extract (LBPE) [2; 3].

Locust Beans Pod Extract as a Replacement for Water in Concrete Production: The pods are usually measured and soaked with water (solvent) which has been identified as the best extractor at four days soaking period [4]. The pod solution obtained after the required soaking period is used in mixing the concrete cubes at the expense of the ordinary distilled water. This is carried out at different concentrations of the pod extract expressed in gram per litre.

Research on using the locust bean pod extract as a binder [1;2] in the production of mud blocks showed that locust bean pod extract can significantly increase the compressive strength of lateritic block by 78.57 % and that the higher the concentration of the pod extract, the greater the compressive strength of lateritic blocks.

However, in this work the aim is targeting the effect of locust bean pod extract (LBPE) as a replacement for water on the flexural strength of revibrated reinforced concrete beams. This shall be achieved through the following primary objectives:

1. Determination of oxides composition of the extract through chemical analysis;
2. Casting of sixteen (16) reinforced concrete beams at different concentration of the pod extracts (0, 0.05, 0.10 and 0.15 kg/l) and cure for 28 days only.
3. Determination of the flexural strength of all beam specimens by crushing.

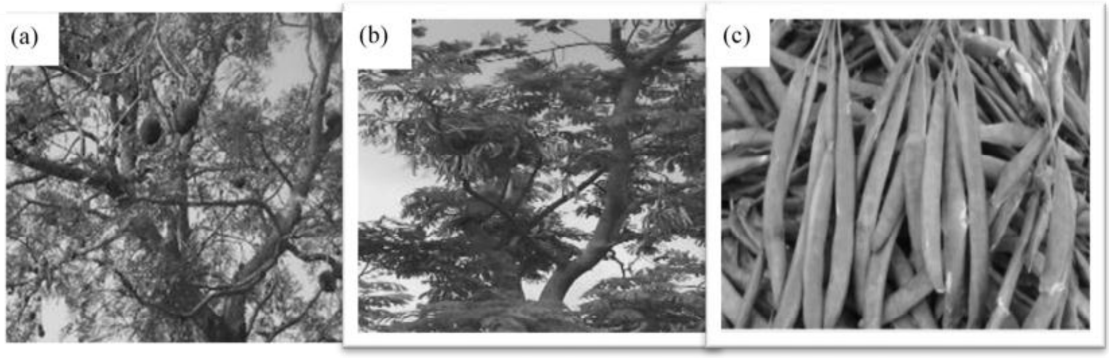

Figure 1. (a) Locust bean tree flowering to produce fruits, (b) Locust bean tree with maturing fruits, (c) Matured locust bean fruit

2. MATERIALS AND METHOD

2.1. Materials and equipment

Materials needed for the research work include granite, sharp sand, ordinary Portland cement, locust bean pod, reinforcement (iron rod) and water, which are for the making of the reinforced concrete beam. Granite was collected from a construction site in Kpakungu, Bosso Local Government Minna, Niger State. It was dried and was handpicked. The sharp sand was collected from Bosso Local Government Minna, Niger State and then sieved to remove dirt. Portland cement was sourced in open market and water from a borehole in Federal University of Technology Minna, Niger State Nigeria.

The Locust bean pod used was obtained from Paso, in Gwagwalada area council of Abuja, F.C.T., Nigeria. It was then used for the leaching process to obtain the extract (LBPE). The LBP (Figure 4) waste is pounded into fibres (figure 2a) which is now placed in a required volume of water and soaked for four days and then filtered using sieve size of 0.425 mm to remove the fibres (figure 2b and 2c). The LBPE was subjected to laboratory chemical test to determine the chemical composition.

The mix ratio of 1:2:4 and water cement ratio of 0.52 was used. Altogether, sixteen beams were cast in all. Equipment includes wooden moulds (150mm x 150mm x 600mm), shovel, hand pan, hand trowel, tamping rod, hammer, weighing balance and flexural strength crushing machine.

2.2. Physical Properties tests of aggregates

The following tests were carried out on the aggregates used in order to determine their properties: specific gravity; sieve analysis; moisture content test; bulk density test; absorption test; porosity test; void ratio test; workability test all according to British Standard specifications [5; 6].

Figure 2. (a) Locust Beans Pod after grinding into fibers, (b) Sieving of extract, (c) Extract inside basin

2.3. Casting of Reinforced Concrete beams

Sixteen (16) reinforced concrete beams were cast using the extract (LBPE) and the needed proportion of aggregates. After 24 hours they were demoulded and transferred into the curing tank for the required age of 28 days in accordance to British Standard. After 28 days curing, the beam specimens were tested for flexure using flexural strength **(**Figure 5**)** according specifications [7].

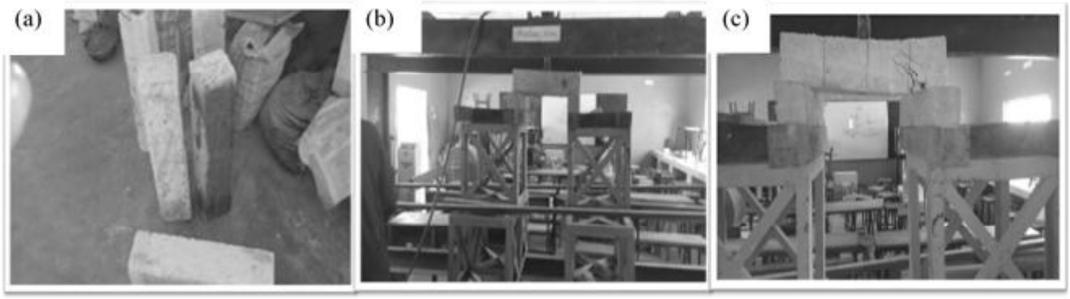

Figure 5. (a) Reinforced concrete beam after curing, (b) experimental setting of the beam for flexural test, (c) failure mode reinforced concrete beam

3. DISCUSSION OF RESULTS

3.1. Results

The results of chemical test for oxides of the LBPE, sieve analysis, moisture content, specific gravity, bulk density, percent porosity, void ratio, compaction factor test of aggregates, slump test and flexural strength test after 28 days curing are represented in Tables 1, 2, 3 and Figures 4 and 4 respectively.

Table 1.

Chemical composition of locust bean pod extract

Element	Concentration%
Na_2O	**4.411 %**
MgO	**8.432 %**
Al_2O_3	**18.966 %**
SiO_2	**49.993 %**
P_2O_5	**4.542 %**
K_2O	**14.974 %**
CaO	**3.294 %**
TiO_2	**0.686 %**
Fe_2O_3	**6.342 %**

Table 2.

Physical properties of aggregates

Test	Fine aggregate	Coarse aggregate
Moisture Content, %	**3.60**	**0.4**
Specific Gravity	**2.54**	**2.62**
Bulk Density	**0.9**	**0.89**

Table 3.

Flexural Strength of Non Revibrated Beam Using Locust Bean Pod Extract

Concentration	Sample	Volume (mm^3)	Area (mm^2)	Weight (kg)	Density (kg/m^3)	Flexural strength (N/mm^2)	Average strength (N/mm^2)
0%	N_1	13500000	90000	36.10	2674.07	8.10	8.11
	N_2	13500000	90000	35.40	2622.22	8.10	
	N_3	13500000	90000	35.70	2644.44	8.13	
0.05 %	N_1	13500000	90000	35.20	2607.41	8.20	8.17
	N_2	13500000	90000	36.10	2674.10	8.10	
	N_4	13500000	90000	34.90	2585.19	8.21	
0.10 %	N_1	13500000	90000	35.20	2607.41	8.53	8.59
	N_3	13500000	90000	34.50	2555.56	8.61	
	N_4	13500000	90000	35.25	2611.11	8.64	
0.15 %	N_1	13500000	90000	35.50	2629.63	8.32	8.37
	N_2	13500000	90000	35.30	2614.81	8.40	
	N_4	13500000	90000	35.40	2622.22	8.40	

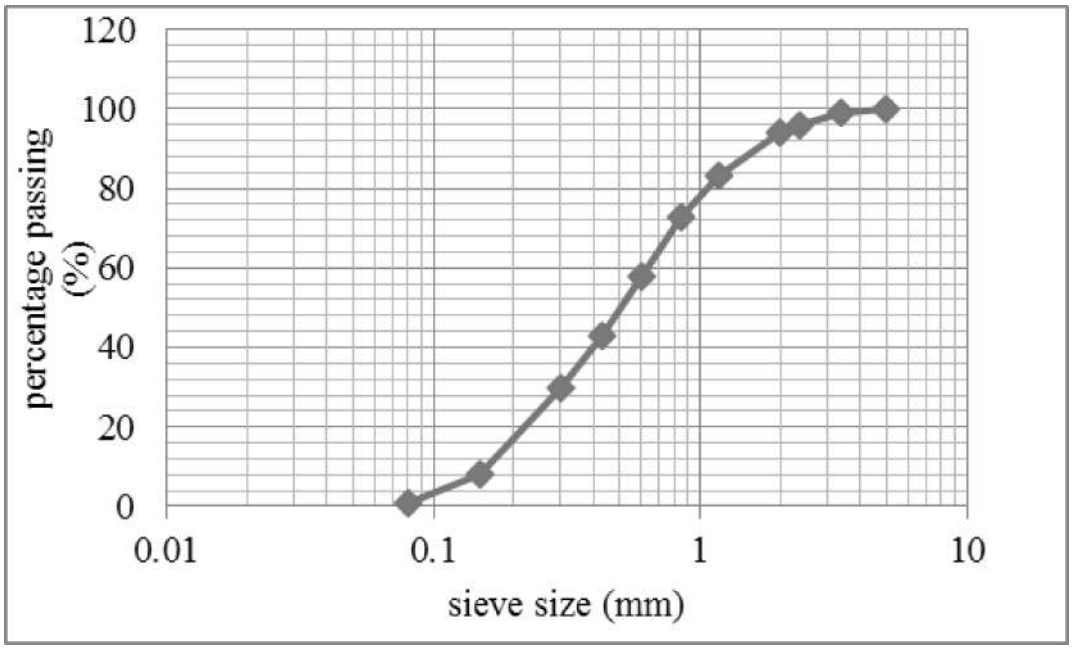

Figure 3. Particle size distribution curve of fine aggregate

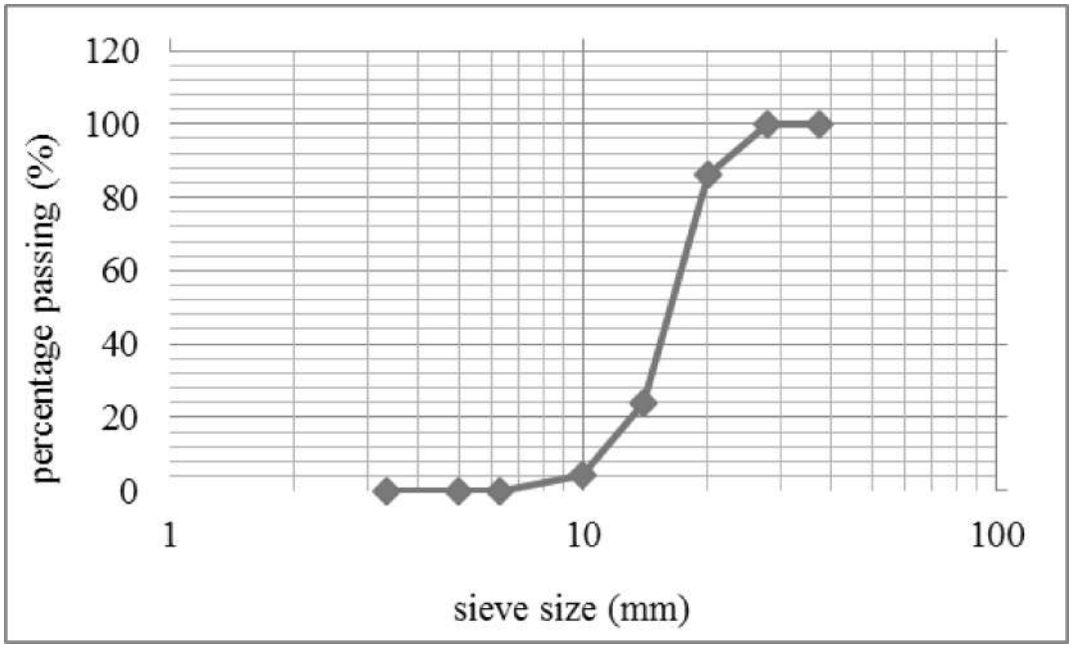

Figure 4. Particle Size Distribution Curve of Coarse Aggregate

3.2. Discussion of Result

As shown in Table 1, the summation of the oxides:SiO_2, AL_2O_3, Fe_2O_3 = 49.993+18.966+6.342= 75.301 %, which places the LBPE in class C pozzolana [8] which is above 70 %. It is a good pozzolana.

The particle size distributions in Figures 3 and 4 place the fine aggregate as finely graded sand and coarse, while other physical properties as presented in Table 2, are within specifications by standards.

The average flexural strength values of the beams in Table 3, were taken from the best three (3) flexural strength values for each replacements of water with 0, 5, 10 and 15 % of LBPE are 8.11 N/mm^2, 8.17 N/mm^2, 8.59 N/mm^2 and 8.37 N/mm^2 respectively. It shows that the flexural strength of reinforced concrete beam increases as percentage of LBPE is increasing from 0 to 10 % and started decreasing as the percentage further increases from 10 to 15 % and upwards. This decreased in flexural strength may be as a result of weakening of the bond between cement and other constituent due to excess LBPE with excess Silico oxide (SiO_2).

4. CONCLUSIONS AND RECOMMENDATIONS

Having carried out the test on flexural strength of reinforced concrete beam using locust bean pod extract as a replacement for water, the following conclusions were made:

1. Chemical analysis of locust bean pod extract (LBPE) used showed that it is a pozzolana with major constituents' oxides which include: SiO_2, AL_2O_3, Fe_2O_3 and some other minor oxides placing it under class C pozzolanic material [8].
2. The maximum flexural strength (8.59 N/mm^2) of the reinforced concrete beam was achieved with 10% locust bean pod extract as a replacement of water which is in agreement with the results obtained from [2] and [3].
3. The flexural strength started decreasing when 15 % of locust bean pod extract was used as a replacement for water. This decreased in flexural strength may be as a result of weakens of the bond between cement and other constituent due to excess locust bean pod extract (LBPE).
4. To obtain best result, 0.10kg/l of LBPE can be used to replace water to obtain optimal result.

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IMPROVED COMPRESSIVE STRENGTH OF CONCRETE WITH SAW DUST ASH AS PARTIAL REPLACEMENT FOR CEMENT USING RE-VIBRATION

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