Effect of Locust Bean Pod Extract (Lbpe) as a Replacement for Water on the Compressive Strength of Concrete

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Abstract: This study investigates the effect of locust bean pod extract as replacement for normal mixing water on the compressive strength of concrete using water-cement ratio of 0.5 and a concrete mixing ratio of 1:2:4. The laboratory test conducted, consists of casting of sixty (60) cubes specimen 150mm x 150mm x 150mm and cured for 7 and 28days. The cubes were tested with their average compressive strength obtained from the best 4-cubes at each concentration. The result shows that the pod extract increases the strength of concrete by attaining maximum compressive strength of 37.59N/mm2 at 0.05kg/lt greater than the control which has 31.65N/mm2 at 0kg/lt. Chemical analysis of the extract revealed that the sum total of the combination of chemical compounds (SiO2 + Al2O3 + Fe2O3) was 50%. This shows that the locust bean pod extract is pozzolanic in nature and can be used to replace water up to 0.15kg/lt for good concrete performance that is better than the control.

Keywords: Locust bean pod extract, concrete, partial replacement

1. INTRODUCTION

As a result of increased industrial and agricultural activities 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 utilizing these wastes to keep the environment friendly to human habitation.

Locust bean pod which is a Waste Agricultural Biomass (WAB) and obtained from the fruit of the African locust bean tree (ParkiaBiglobosa) which is the material resource required for production of Locust Bean

Plate I: Closed up view of Locust bean fruit

Pod extract (LBPE). The harvested fruits (Plate I) are ripped open while the yellowish pulp and seeds are removed from the pods; the empty pods are the needed raw material (Plate II). The pods make up 39% by weight of the fruits (Adama and Jimoh, 2011).

Plate II: Locust bean pod grinded into fibers

Pozzolanic Admixtures: Pozzolanic materials are siliceous or siliceous and aluminous materials which in themselves possess little or no cementitious value, but will, in finely divided form and in the presence of moisture chemically react with calcium oxide liberated on hydration, at ordinary temperature, to form compounds, possessing cementious properties (Shetty, 2006). Some of the pozzolanic agro wastes ashes include: Rice Husk which is highly pozzolanic and suitable for use in lime, pozzolanic mixes and for Portland cement replacement; Sugar cane bark which is highly recommended for use in the production of lightweight concrete as its density decreases with increasing quantity of ash replacement (Daneji, 2014); Sawdust which in ash form has been used as partial replacement of cement in concrete production (Raheem at el.,2012).

1.1 History and general structure of locust bean pod extract (LBPE)

The African locust bean tree, "Parkiabiglobosa" is a perennial tree legume, belonging to the sub-family Mimosodeae and family leguminosae (Campbell-Patt, 1980). Parkiabiglobosais an important multipurpose tree from the savannah zone of West Africa.

The seeds are used extensively as seasoning and also good source of essential amino acids (Hassan and Umar, 2005). The African locust bean (Parkia-biglobosa) has a wide distribution of plantation ranging across the Sudan and Guinea Savanna and the ecological zones. It is found in nineteen African countries: Senegal, Gambia, Guinea Bissau, Niger, Nigeria, among others. In Nigeria, it is predominantly found in the northern part of the country.

1.2 Locust Beans Pod Extract as Replacement for Water in Concrete Production

The pods are usually measured and soaked with a solvent (water) which has been identified as the best extractor (Abagale, Twumasi and Awudza, 2013) for a number of days. The number of soaking days that gives maximum strength in the production of mud blocks using the extract is 4 days (Kareem, 2010). 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 concentration of the pod extract obtained which is usually expressed in kilogram per litre (kg/l).

Fewer researches have been conducted than necessary in using the locust bean pod extract as a binder (Aguwa, 2012; Adama and Jimoh, 2011, Adama, 2010) where it is discovered that the locust bean pod extract as a binder in the production of mud blocks, 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. These works focused on the production of mud and sandcrete blocks (Aguwa and Okafor, 2012), chemical stabilization in road construction (Adama, 2010) and as a pozzolana (Adama and Jimoh, 2011, Ndububa and Uloko, 2015) only. In this study however, the use of the locust bean pod extract will be directed on the production of concrete cubes by varying the concentrations partially replacing water to see possibilities of it improving concrete strength in general. The objectives of this study therefore include the following;

1. To determine the physical properties of the aggregates through preliminary test.
2. To determine the oxides composition of the extract (chemical analysis).
3. Casting of 60 concrete cubes at different concentration of the pod extracts (0, 0.05, 0.10, 0.15, 0.20 and 0.25kg/l) and curing for 7 and 28 days only.
4. To determine the compressive strength of concrete at varied concentrations by crushing of cubes.
5. To determine the optimum Locust Bean Pod Extract Replacement level.

2. METHODOLOGY

2.1 Materials

The materials used for this research work are; Dangote Portland cement of sound quality, Fine aggregates which were obtained from Rafin Shanu in Ungwan Kuka Chachanga Local Government Area of Niger state, Coarse aggregate collected from Kutah in Minna Niger state. The Locust bean pod used was obtained from Kusam Kagarko Local Government Area of Kaduna State. Tap water free from contaminant either dissolve or suspension (BS 3148, 1980) was collected from Civil Engineering Laboratory, Federal University of Technology Minna Niger State, Nigeria and used for leaching process of the bean pod as well as mixing the concrete cubes. The chemical composition of the locust bean pod extract test was conducted in chemistry department laboratory, Ahmadu Bello University Zaria using Oxford instrument.

The physical properties and strength of the aggregate were determined by conducting several tests, such as aggregate impact value (AIV), aggregate crushing value (ACV) , specific gravity and water absorption, bulk density and void ratio, moisture content, sieve analysis as well as compressive strength test at the ages of 7days and 28 days. The extraction process employed is the leaching process which is employed in the extraction of soluble constituent from pod by means of solvent. The solvent used in this case is water which is usually considered as the best solvent for leaching as it has sufficiently low viscosity which enables free circulation.

2.2 Leaching Procedure for Locust Bean Pod Extract

The pods were transferred into a container with a specific amount of water (solvent) to give the design concentration (solution). The resulting mixture was the filter using a sieve size of 0.425mm.

Concrete mixing, slump test and compaction factor tests precedes casting of concrete cubes. The mould were placed on a rigid horizontal surface and filled with concrete in such a way as to remove entrapped air as possible and to produce full compaction of the concrete with neither excessive segregation nor laitance. The concrete was placed in the mould in layers and compacted using compacting bar. Each layer of approximately 50mm deep was subjected to 25 blows of the standard compacting bar (16mm).The test cubes were prepared in accordance to BS 1881 part 108: 1983.

The cubes were submerged immediately in the curing tank for the required curing age of 7 and 28days which are the ages to be considered for the purpose of this study. The curing of cubes was carried out in accordance to BS 1881 part 111 (1983).

Compressive strength test was carried out on the concrete cubes at curing age of 7 and 28 days respectively, in accordance to BS 1881: part 116: (1983) using Seidner compression machine and the result is presented on Tables 2, 3 and Figure 3.

3. RESULTS AND DISCUSSIONS

3.1 Results

The results of the laboratory work carried out on chemical composition of pod extract, moisture content, specific gravity, bulk density, percentage porosity, void ratio and sieve analysis of aggregates, compaction factor test and compressive strength after 7 and 28 days of curing period are represented in Tables: 1, 4 and Figures 1, 2 and 3 respectively.

Table 1: Chemical Composition of Locust Bean Pod Extract

Element	Concentration
Na_2O	0.0000 Wt %
MgO	0.0000 Wt %
Al_2O_3	0.0000 Wt %
SiO_2	45.2203 Wt %
P_2O_5	0.0000 Wt %
K_2O	33.5274 Wt %
CaO	14.8564 Wt %
TiO_2	1.9126 Wt %
Fe_2O_3	4.4833 Wt %

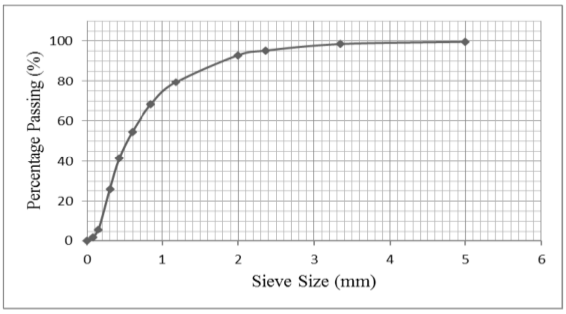

Figure 1: Particle size distribution of fine aggregate

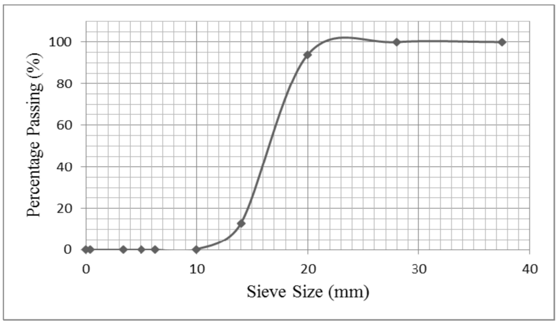

Figure 2: Particle size distribution of coarse aggregate

TABLE 2. COMPRESSIVE STRENGTH FOR 7 DAYS (CONTROL)

Concentrations (kg/lt)	Sample	Volume of cube (m^3)	Area of cube (mm^2)	Weight of specimen (kg)	Density (kg/m^3)	Crushing load (kN)	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
0	1	0.003375	22500	8.68	2571.85	740	32.89	31.67
	2	0.003375	22500	8.65	2562.96	690	30.67	
	3	0.003375	22500	8.86	2625.19	690	30.67	
	4	0.003375	22500	8.61	2551.11	730	32.44	
0.05	1	0.003375	22500	8.69	2574.81	750	33.33	33.44
	2	0.003375	22500	8.77	2598.52	700	31.11	
	3	0.003375	22500	8.58	2542.22	840	37.33	
	4	0.003375	22500	8.62	2554.07	720	32.00	
0.10	1	0.003375	22500	7.93	2349.63	790	35.11	34.80
	2	0.003375	22500	8.50	2518.52	770	34.22	
	3	0.003375	22500	8.49	2515.56	770	34.22	
	4	0.003375	22500	8.56	2536.30	800	35.65	
0.15	1	0.003375	22500	8.32	2465.19	830	36.89	34.11
	2	0.003375	22500	8.33	2468.15	810	36.00	
	3	0.003375	22500	7.96	2358.52	630	28.00	
	4	0.003375	22500	8.47	2509.63	800	35.56	
0.20	1	0.003375	22500	8.21	2432.59	610	27.11	24.84
	2	0.003375	22500	7.95	2355.56	426	18.93	
	3	0.003375	22500	8.29	2456.30	660	29.33	
	4	0.003375	22500	8.31	2462.22	540	24.00	
0.25	1	0.003375	22500	7.43	2201.4	320	14.22	18.96
	2	0.003375	22500	8.18	2423.70	500	22.22	
	3	0.003375	22500	7.89	2337.78	470	20.89	
	4	0.003375	22500	8.18	2423.70	416	18.49	

TABLE 2. COMPRESSIVE STRENGTH FOR 28 DAYS CURING

Concentrations (kg/lt)	Sample	Volume of cube (m^3)	Area of cube (mm^2)	Weight of specimen (kg)	Density (kg/m^3)	Crushing load (kN)	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
0	1	0.003375	22500	8.68	2571.85	810	36.00	33.89
	2	0.003375	22500	8.92	2642.96	860	38.22	
	3	0.003375	22500	8.76	2595.56	710	31.56	
	4	0.003375	22500	8.95	2651.85	670	29.78	
0.05	1	0.003375	22500	8.63	2557.04	1010	44.89	38.99
	2	0.003375	22500	8.46	2506.67	865	38.40	
	3	0.003375	22500	8.50	2518.52	805	35.78	
	4	0.003375	22500	8.76	2595.56	830	36.89	
0.10	1	0.003375	22500	8.44	2500.74	810	36.00	38.89
	2	0.003375	22500	8.14	2411.85	860	38.22	
	3	0.003375	22500	8.37	2480.00	850	37.78	
	4	0.003375	22500	8.33	2468.15	980	43.56	
0.15	1	0.003375	22500	8.10	2400.00	750	33.33	35.44
	2	0.003375	22500	8.38	2482.96	900	40.00	
	3	0.003375	22500	8.38	2482.96	735	32.67	
	4	0.003375	22500	8.06	2388.15	805	35.78	
0.20	1	0.003375	22500	7.94	2352.59	590	26.22	27.89
	2	0.003375	22500	7.79	2308.15	590	26.22	
	3	0.003375	22500	8.41	2491.85	710	31.56	
	4	0.003375	22500	7.96	2358.52	620	27.56	
0.25	1	0.003375	22500	7.98	2364.44	510	22.67	23.89
	2	0.003375	22500	8.25	2444.44	570	25.33	
	3	0.003375	22500	7.88	2334.81	530	23.56	
	4	0.003375	22500	7.96	2358.52	540	24.00	

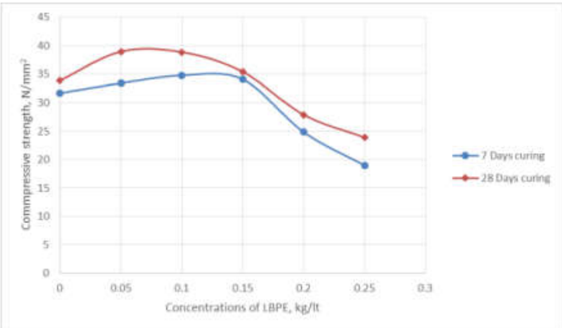

Figure 3: Variation of compressive strength with LBPE concentrations.

3.2 Discussions

The specific gravity was found to be 2.61 for fine aggregate and 2.64 for coarse aggregate which are within the range of 2.5 and 3.0 standard. The bulk densities of the materials were found to be 1362.57kg/m3 for uncompacted and 1653.07kg/m3 for compacted fine aggregate. While that of coarse aggregate was found to be 1492.06kg/m3 for uncompacted and 1634.92kg/m3 for compacted. The void ratio of the aggregate was found to be 0.56 with percentage porosity of 91%. The moisture content of sand was found to be 3.6% and that of coarse aggregate was found to be 0.4%. The water absorption of fine sand was found to be 1.12% while that of coarse aggregate was found to be 0.65%.

From the chemical analysis conducted (Table 1), it was found that the locust bean pod extract is a class C pozzolanic material with SiO3+Al2O3+Fe2O3 value of 50% which is the minimum standard for class C pozzolans (ASTM C618-92a, 1994).

The compressive strength of concrete in figure 3 increases from the control value 0kg/lt through 0.10kg/lt and decreases with minimum compressive strength obtain at 0.25kg/lt for 7 days curing age. Also, the compressive strength increases from the control value (0kg/lt) through 0.05kg/lt and continually decreases with minimum compressive strength obtain at 0.25kg/lt for 28days curing age.

The compressive strength of the control for 7days and 28days curing age are 31.67N/mm2 and 33.89N/mm2 respectively. While the maximum compressive strength for 7days curing was found to be 34.80N/mm2 at 0.10kg/lt, while that of 28days curing age was found to be 38.99N/mm2 at 0.05kg/lt, giving a maximum percentage increase of 10% and 15% for 7days and 28days curing ages respectively. It is generally visible that the addition of locust bean pod extracts (LBDE) up to 0.15kg/lt has improved the compressive strength of concrete. This is due to the percentage concentration of silicate oxide (SiO2 – 45.22%) that would react with every lime produced by the hydration of cement used. But when the lime is used up from cement at that level and there is excess of silicate oxide from the LBPE, it could result into weakening of the concrete.

4. CONCLUSIONS

Based on the study carried out on the compressive strength of concrete using locust bean pod extract (LBPE) as replacement for water, the following conclusions can be drawn:

1. The locust bean pod extract used is a class C pozzolanic material as SiO2, Al2O2 and Fe2O3 content summed up to 50% which is the

minimum for class C pozzolans (ASTM specification C618-92a, 1994);

2. The maximum compressive strength is 38.99N/mm2 at concentration level 0.05kg/lt of 28 days curing age which is the optimum concentration replacing water;

3. As the concentration level increases, the compressive strength decreases considerably to a value 23.89N/mm2 at 0.25kg/lt concentration and at 28 days curing days. This is due to the percentage concentration of silicate oxide (SiO2 – 45.22%) which is responsible for strength, would react with every lime produced by the hydration process of cement used. And when this lime is exhausted at that level, silicate oxide in excess from the LBPE would tend to weaken the concrete bonding.

Since the replacement of water with locust bean pod extract at 0.05kg/lt and 0.10kg/lt concentrations is seen to give higher compressive strength at the age of 7days and 28days, it is hereby recommended that the pod extract at 0.05kg/lt, 0.10kg/lt and 0.15kg/lt concentrations can be used to produce improved compressive strength concrete.

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