Assessment of Locust Bean Pod Extract for Foundry Core Making

Olatunde Ajani Oyelaran* and James Kehinde Abidoye
Department of Research and Development, Hydraulic Equipment Development Institute, Kano, Nigeria

Yau Yusuf Tudunwada
Department of Technology Business Development, Hydraulic Equipment Development Institute, Kano, Nigeria

* Corresponding author. E-mail: ajanioyelaran@gmail.com
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Abstract
This paper reports the experimental results on the use of locust bean pod extract as core binder in the foundry industry. Binders appropriate for foundry cores must not only hold the sand grains together, but must also be adequately resistant to high temperature, so as to avoid collapse before the metal solidifies, but after solidification and cooling, they must be able to collapse completely allowing easy removed from the casting. The Locust Bean Pod (*Parkia biglobosa*) is a waste material that is normally discarded after the seeds had been harvested. Results of the properties of cores produced with the locust bean pod extract as binder showed baking strength of 510 kN/m^2, green compression strength of 74 N/mm^2, bulk density of 1840 kg/m^3, green permeability of 100 perm unit, moisture content of 4.6%, mouldability index of 24 and 45% flowability. The results obtained showed that the locust bean pod extract could serve as an effective binder of high core strength for core making process.

Keywords: Binder, Compressive strength, Core, Locust bean pod extract, Permeability

1 Introduction

The locust bean pulp is a yellowish, gummy and sweet tasting edible pulp in which the bean seed is embedded. Gernmah *et al*., [1] wrote that the fruit pulp have moisture content of 8.41%, protein 6.56%, fat 1.80%, crude fibre 11.75%, ash 4.18% and carbohydrate of 67.30%. In the savanna region of West Africa, the pod extract is used in the rural areas during the construction of housesby mixing with the sand used. These houses have been found to be more durable under varying weather conditions. Its seed is used in making native sauce so call iru in Yoruba and dadawa in Hausa lauguages in West Africa. Hence this work sets to assess the locust bean pod extract for core making in foundry. The African locust bean (Parkia-biglobosa) has a wide distribution across the Sudan and Guinea Savanna and the ecological zones. The range extends from the western coast of Africa in Senegal across to Sudan. Depodding of the locust bean fruits are mostly done by hand by the processors, however, threshing machine used for cowpea could be used for removing the locust bean seeds coated with yellowish pulp from the pod. The yellowish pulp removed is then mixed with water to form a yellowish gummy paste.

Binders for core making could be organic and inorganic [2]. Some of the binders required heat (baking) to develop strength when used in making cores, while others develop strength without the application of heat (self-curing binder). Binders are developed to strengthen the cores, which are the most fragile part of a mold assembly. Clay binders are cheap and simple

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for core-making, but, they are seldom used because of their low bonding strength and poor permeability. Synthetic resins on the other hand have high strength and good moisture resistance but their high cost, non-recycling feature and high gas forming capacity restrict their widespread applications in foundry practice. Most of the known efficient binders cannot be sourced locally in most developing nations. Even when they are available they are expensive. Some of the binders require elaborate facilities before they are used. Core binders in the years to come might be different from those in use now. The motivating factor for this change will be environmental regulations, as binders will have to be more environmental friendly to meet the demands of lower air pollutant emission levels while maintaining the required properties of a good binder and meeting the productivity demands of a competitive global marketplace. Complex components cannot be produced without the use of cores. Cores are used to create holes in components and parts [3]. Sand cores are regularly in use, in foundry practice, to form complicated cavities in castings. They are being handled in a dry state during mould assembling, and often complex sand cores are also subjected to high stress due to hydrostatic pressure exerted by the molten metal during pouring. Cores, therefore, must be able to sustain the hydrostatic pressure of the liquid metal without change in geometric configuration or breakage. To achieve this the cores should possess sufficient strength in the dry state after baking or curing, they are also expected to break easily (collapsibility) during shake out in order to release all the sand out of the hidden cavities of solidified casting.

The objectives of this work are to provide the foundry industry with an alternative core binder and to add to the number of existing binders that are environmental friendly, affordable and easily accessible.

2 Materials and Methods

The sand used was obtained at the bank of River Challawa of Kumbotso area of Kano, Nigeria. The sand was washed to remove clay and other impurities. After it was appropriately dried, the sieve analysis was carried out on dry samples. Sieve shaker equipped with sieves of different meshes was then shaken continuously for a period of 15 minutes. After shaking, the sieves were taken apart and the sand left over on each of the sieves was carefully weighed and expressed as a percentage of the total mass (Table 1). Prior to mechanical testing the preparation of the core mixtures was made with one kilogram of the sand and 6% (based on the weight of the sand) locust bean pod extract collected from the premises of Bolanta DC Primary School in Masifa Area of Ogbomoso, Oyo State, Nigeria. The filtered extract which act as binder, the collected sand and water were mixed. After proper mixing, standard specimens were made from it using specimen rammer. Ramming was achieved by dropping a rammerof 50 g mass three times from a height of 50 mm [4] and the core specimen was ejected fromsleeve by a piston. After ejection, three samples were randomly selected for each evaluation.

The core baking was carried out in an electric fired oven capable of attaining a temperature of 1200°C and it accommodate the test specimen at a time so as to ensure a uniform and standard baking procedure [5]. The specimens were introduced into the furnace on a steel plate. The oven has an extraction system for removing the moisture produced during baking.

Gas permeability of a moulded sand is the ability of the sand mould to allow the passage of gaseous product from the mould cavity to the atmosphere. The permeability test was carried out on the standard sample specimen of 5 cm diameter × 5 cm height. The specimen, while still in the tube, was mounted on a permeability meter. The permeability meter employed the orifice method for rapid determination of sand permeability. Air at a constant pressure was applied to the standard sample specimen, immediately after the sample preparation and the drop in pressure was measured on the pressure gauge, which is calibrated directly in permeability numbers.

The determination of green compressive strength values was carried out using the universal sand testing machine. The tested specimen was mounted on a stripping post and a compressive load was gradually applied until fracture. The fracture load was automatically recorded on the attached scale [4]. For the mouldabilitytest, 50 g of the core mixture was taken and riddled in the mouldability tester for ten seconds and the droppings were collected, weighed and divided by two to get the mouldability.

Table 1: Sieve analysis of sand used for making of core

ASTM No.	Sieve Aperture (microns)	% weight retained	Multiplier	Product
14	1400	0.15	0	0.00
18	1000	0.36	10	3.60
25	710	2.16	16	34.56
35	500	4.21	22	92.62
45	355	22.98	30	689.40
60	250	38.76	44	1705.44
80	180	15.83	72	1139.76
120	125	10.46	100	1046.00
170	90	2.96	120	355.20
230	63	0.51	150	76.50
-230	- 63 Pan	0.17	200	34.00
Total 985177.08				

$$\text{A.F.S} = \frac{Totalproduct}{Total\ \%\ sandretained}$$

$$= \frac{5177.08}{98.55}$$

$$= 52.54\%$$

To test for the moisture content, a sample of the core mixture was introduced into the speedy moisture tester accompanied by two spoonful of absorbent chemical, the tester was shaken for a minute and the result was displayed on the dial of the instrument. The flowability was also tested using flowability meter attached to the specimen rammer. The baked compression strength was tested by baking the core specimen at various temperatures between 90 and 220°C and for a fixed time of two hours. Baked compressive strength values were determined as in the green compression strength test. The shear strength was obtained in the same way as compression strength by changing the holding devices so that the load was applied on the diametrically opposite halves of the two plane surfaces of the specimen. The point on the scale at which fracture occurs on the specimen is the shear strength of the sand mould. The standard cores were heated to various temperatures upto 800°C to determine its strength variation with temperature.

3 Results and Discussion

The results of the research are presented in Tables 1–4. Table 1, presents the sieve analysis of the sand used as base sand. Tables 2 and 3 give the results of the core properties of the locust bean pod water. The sieve analysis result (Table 1) of the sand used for making of the cores shows that it has a mean grain size of 52.54. This falls within the acceptable AFS range between 50 and 100 [6]. The sand also conforms to the AFS standard of five screen sand [7]. This makes the sand suitable for core making in providing the necessary green and baked strength values, adequate flowability, good mouldability and permeability.

Casting sand should have good flowability to pack well during moulding to produce good surface finish [8]. The shape of the sand used is semi-circular to sub-angular this might be responsible for the good flowability of 45%. From Table 2 it can be seen that the bulk density obtained is 1840 kg/m^3, which is relatively high, hence reduced porosity. The green compressive strength obtained was 78 kN/m^2. From the results obtained it is clear that the cores have adequate strength values. This is relatively higher than the value of 10 kN/m^2 specification for green compression strength [7]. Permeability is defined by the AFS as the physical property of molded sand that which allows the gases to pass through it. A permeability of 100 perm unit was recorded, this is above the 80 perm units AFS minimum requirement [9]. The mouldability index recorded was 25, this is an indication how mouldable the core mixtures were. A moisture content of 4.6% was recorded, this is within the AFS specification of between 4–7% moisture content for core mixture to be baked.

High baking strength is necessary to avoid core erosion during pouring of hot metal into the mould [9]. Table 4 shows the effect of baking temperature on the compressive strength of the locust bean waste water bonded cores. From this figure, it is seen that maximum baked compressive strength was obtained, when baking was carried out at 200°C for two hours. This means that optimum baked compressive strength values will not be realized when these cores are baked outside this specification. The maximum compressive strength values achieved from this result was 510 N/mm^2. These baked strength values are within the standard value required for non-ferrous and iron castings. Table 4 also reveals that maximum shear strength of 475 kN/m^2 was attained when baking was carried out at 200°C. Below and above these values of temperature, both baked compressive and baked shear strength falls. At temperatures above 700°C the baked strengths dropped drastically to 56.37 N/m^2. At 800°C the baked compressive strength was 40.92 N/m^2. Throughout the baking temperature there was not significant colour change and the cores still maintained their shapes. The collapsibility was also excellent, since particles flowed freely just by moving a finger on the core [10].

Table 2: Results of properties of core produced (mean and standard deviation of three replicate samples)

Properties	Values
Bulk density	1840 ± 10.4 kg/m^3
Green comp. strength	78 ± 7.7 KN/m^2
Green permeability	100 perm unit
Moisture content	4.6 ± 0.3%
Mouldability index	24.0
Flowability	45%

Table 3: Result of variation of baked compressive strength with baking temperature between 100 and 220°C (mean and standard deviation of five replicate samples)

Baking temperature (°C)	Baked compressive strength (KN/m^2)
100	245 ± 12
120	289 ± 9
140	343 ± 17
160	387 ± 15
180	421 ± 20
200	510 ± 18
220	434 ± 14

Table 4: Result of variation of baked compressive and shear strength with baking temperature between 200 and 800°C

Baked temperature (°C)	Baked compressive strength (KN/m^2)	Baked shear strength (KN/m^2)
200	510 ± 18	475 ± 16
300	475 ± 16	422 ± 12
400	388 ± 12	377 ± 11
500	367 ± 12	322 ± 9
600	318 ± 14	213 ± 13
700	56 ± 1	-
80041 ± 2-		

4 Conclusions

The research into the properties of locust bean pod extract for use as core binder in foundry shows that it can be used as a binder for core making, because of its high baking strength of 510 N/m^2. Its high strength reduces incidence of erosion during molten metal pouring, it alsoposses good collapsibility and permeability. The Research proved that locust bean pulp extract has most requirement of a good foundry

Pod extract can be used in core making asbinder. The locust bean extract is readily available in large quantities in most West African countries. The greater bulk of the extracts are washed into the river and streams killing fishes. In fact, they present disposal problems. Large piles of waste and residues left in the field to decompose also provide excellent breeding grounds for reptiles, rats and insects. Hence the used of locust bean extract in the foundry as a binder will go a long way in creating economic activities thereby reducing unemployment and at the same time solving the problems of environmental degradation caused by its disposal.

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