Effects of Powdered Fruit Pods of Acacia Tree on the Performance Characteristics of Soil Renders

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***Abstract*— This paper is an experimental investigation into the effect of powdered fruit pods of acacia tree (PFPAT) on the performance properties of fine reddish-brown (FRB) and fine light-brown (FLB) soil renders with the view to establishing an appropriate proportion of PFPAT required for effective performance. PFPAT is known in Hausa Language as *gabaruwa* while FRB soil and FLB soil are known as *jarkasa* and *jangargari* respectively. Studies carried out on liquid limit, plastic limit, plasticity index, shrinkage limit, drying shrinkage, and moisture absorption of FRB and FLB soil renders with PFPAT as an additive shows that it can effectively be used as admixture for the renders because it improved the above mentioned properties of the soil renders, and for better results, 10% of PFPAT by weight of the soil is recommended for addition.

***Keywords*— Acacia Tree, Effects, Performance Characteristics, Powdered Pods, Soil Renders.**

I. INTRODUCTION

Studies by Reference [1] show that in most rural parts of Northern Nigeria, majority of residential houses are built with mud and the walls and domed-shaped roofs are usually rendered seasonally with suitable mud renders mixed with suitable admixtures to improve performance. Some of these local admixtures are *katsi* (dye reside), *makuba* (powdered locust bean pods), *gabaruwa* (powdered fruit pods of acacia tree), etc.

Katsi has been tested to be a suitable rendering admixture in mud rendering for area with 500mm to 1250mm rainfall per annum and for effective performance , 20% to 30% *katsi* by weight of soil had been recommended for incorporation into renders containing at least 60% fine-ground soil particles [1].

Reference [2] also found that *makuba* is a suitable rendering admixture in mud renders for areas with 500mm to 1250mm rainfall per annum and for effective performance, 20% *makuba* by weight of soil had been recommended for incorporation into mud renders containing inorganic clay of low plasticity and up to 75% fine- ground soil particles while 25% *makuba* is recommended for mud renders containing inorganic clay of low plasticity and up to 57% fine- ground soil particles.

Historical buildings most of which stand as monuments today, such as *Masallacin Jumma'a* (Friday Mosque in Zaria City – Nigeria; *Gidan Benimister*; the British Council Library; *Gidan dan Hausa; Gidan Rumfa* and *Gidan Murphy* all in Kano City - Nigeria, have external wall surfaces rendered with *makuba*-mud render. *Katsi*-mud render has also been used to render the external wall surfaces of some historical buildings such as *Gidan Makama* in Kano Municipal, and the Emir of Daura's Palace in Katsina State all in Nigeria [1], [2].

This paper is an experimental investigation into the effect of powdered fruit pods of acacia tree on the performance properties of soil renders with the view to establishing an appropriate proportion required for effective performance.

II. MATERIALS AND EXPERIMENTAL PROCEDURES

The materials used in this investigation are powdered fruit pods of acacia tree (PFPAT) as a local rendering admixture; fine reddish-brown (FRB) soil and fine light-brown (FLB) soil.

A. Fine Reddish-Brown and Fine Light-Brown Soils as Mud Renders

The soils were obtained from *Rimin Gata* Village along Watari River close to Bayero University New Campus, Kano – Nigeria. The Properties of the original soils were determined by laboratory tests performed in accordance with British Standards [3] and are as shown in Table 1 and the soil composition for the two soil renders is as summarized in Table 2.

TABLE 1 PROPERTY OF ORIGINAL SOIL RENDERS

Test	Results	
	FRB Soil Render	FLB Soil Render
Natural M.C. (%)	4.96	4.02
LL (%)	21.00	20.40
PL (%)	11.67	12.69
PI (%)	9.33	7.71
SL (%)	4.68	4.86
LS (%)	2.50	5.07
M.A (%)	27.12	23.23

TABLE 2 SUMMARY OF SOIL COMPOSITION

	Types of Soil Render	FRB Soil Render	FLB Soil Render
Sand Composition	Fine	65	60
	Medium	12	16
	Coarse	13	11
Gravel Composition	Fine	2	3
	Medium	-	-
	Coarse	-	-

From the preliminary tests carried out, FRB soil had liquid and plastic limits of 21% and 11.67% respectively, specific gravity of 2.91 and a natural moisture content of 4.96% while FLB soil had liquid and plastic limits of 20.40% and 12.69% respectively, a specific gravity of 2.96 and a natural moisture content of 4.02%. Both soils were classified into CL- group in accordance with the unified Classification system using the plasticity or A-chart as inorganic clay of low plasticity.

B. Powdered Fruit Pods of Acacia Trees

PFPAT is gotten from the dark- grey fruit pods of the acacia tree which grows commonly and abundantly in Hausa land in Northern Nigeria and harvested during the dry season. The pods are dried, and then pounded into powder using a mortar and pestle or on the ground; the resulting powdered is then used as an admixture in local renders.

C. Experimental Procedures

Laboratory tests were conducted on the CL-group soils with 0, 10, 15, 20, 25, and 30 percent of PFPAT by weight of the soil. The tests conducted were Atterberg limits, grain size analysis, specific gravity, drying shrinkage and moisture absorption. The first four tests were performed in accordance with British Standard Specification [3] and the test for moisture absorption was performed in accordance with specification in the Handbook by Norton [4].

In the absorption test, each sample (100mm cube) was weighed and then dried out until no further weight reduction was recorded. Then the simples were exposed to constant saturation for seven days, and weighed again. The absorption is the increase in weight of the wet sample as a percentage of the dry weight. The results were averaged from five samples.
In preparing the sample, powdered fruit pods of acacia tree and the soils were properly mixed dry in a metal tray manually and some amount of water approximating to the appropriate liquid limit was added and then mixed to a plastic consistence and used for the various tests.

III. RESULTS AND DISCUSSION

The results of Atterberg limit tests on the CL- group soils (used as renders) with various percentages of PFPAT are shown in Table 3 of appendix I.

The variation of liquid limits, plastic Limit, plasticity index and shrinkage limit with increase in PFPAT contents for FRB soil and FLB soil are presented in figure 1 and figure 2 respectively (plotted using table 3).

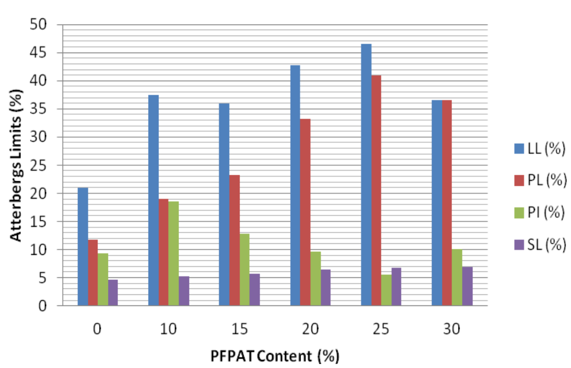

Figure 1 Variation of liguid limit, plastic limit, plasticity index and shrinkage limit with increase in PFPAT content for FRB soil render

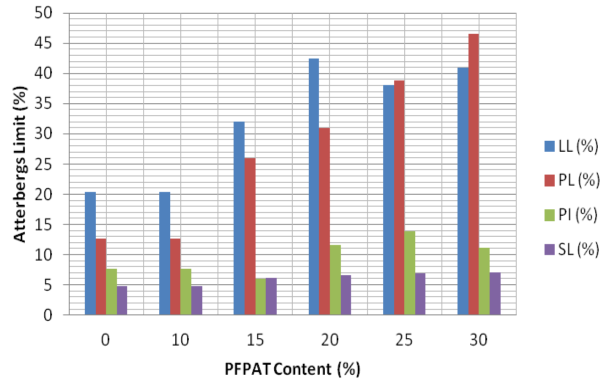

Figure 2 Variation of liquid limit, plastic limit, plasticity index and shrinkage limit with increase in PFPAT content for FLB soil render

From figure 1, it could be seen that liquid limit, plastic limit and shrinkage limit for FRB soil render increase with increase in PFPAT contents, while plasticity index increase with increase in PFPAT contents up to 10% and then begins to decrease down to 25%. Similar trends were followed for liquid limit, plastic limit and shrinkage of FLB soil render except for the plasticity index which decreased down to 10% of PFPAT contents and begins to increase as from 15% to 25% before decreasing again (see figure 2). The trends exhibited above show that PFPAT can be used to increase the liquid limit, plastic limit, shrinkage limit and plasticity index of FRB and FLB soil renders but for better plasticity, PFPAT contents should not be more than 10%.

The effect of PFPAT on the drying shrinkage of FRB and FLB soil renders are shown in table 4 of appendix I while the variation of PFPAT with drying shrinkage of FRB and FLB soil renders are presented in figure 3.

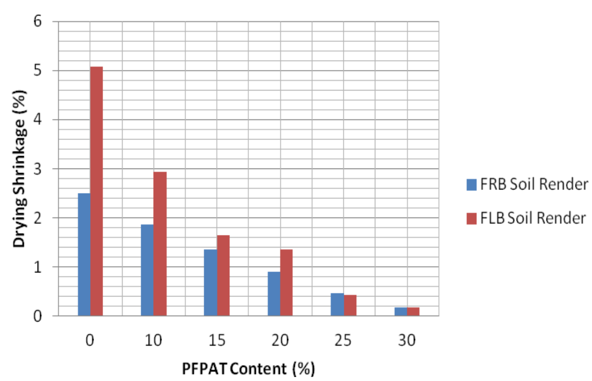

Figure 3 Variation of drying shrinkage of FRB and FLB soil renders with increase in PFPAT contents

For both soil renders, the drying shrinkage decreases with increase in PFPAT contents. This result shows that PFPAT can be used to reduce the drying shrinkage of both FRB and FLB renders.

Table 5 in appendix I shows the effect of PFPAT on the moisture absorption of both FRB and FLB renders while figure 4 illustrates the variation of PFPAT with moisture absorption of FRB and FLB renders.

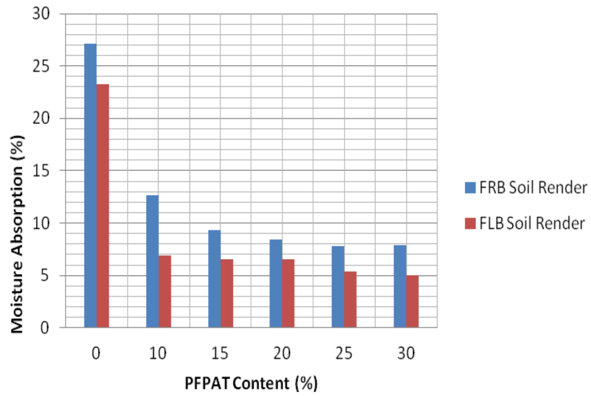

Figure 4 Variation of moisture absorption of FRB and FLB soil renders with increase in PFPAT contents

For both soil renders, moisture absorption decrease sharply from 0% to 10% PFPAT contents and then gradually and almost remaining constant with further increase in PFPAT contents. The decrease in moisture absorption of the renders with the addition of PFPAT is indicative of the fact that PFPAT can help in reducing permeability of the renders.

IV. CONCLUSION AND RECOMMENDATION

Based on the tests carried out on fine reddish-brown and light-brown soil renders with powdered fruit pods of acacia tree as an additive, it has been established that powdered fruit of acacia tree can effectively be used as an admixture for the renders and for better results, 10% of powdered fruit pods of acacia tree is recommended for addition.

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[3] British Standards 1975. *Methods for Testing Soils for Civil Engineering Purposes*. B.S. 1377, British Standards Institution, London

[4] Norton, J. 1986. "*Building with Earth (a Handbook)*", Intermediate Technology Development Group Limited, United Kingdom.

Appendix I: Tables

TABLE 3 EFFECTS OF PFPAT ON ATTERBERGS LIMIT OF FRB AND FLB SOIL RENDERS

Soil Renders	PFPAT (%)	LL (%)	PL (%)	PI (%)	SL (%)
FRB	0	21.00	11.67	9.33	4.68
	10	37.50	18.96	18.54	5.22
	15	36.00	23.22	12.78	5.75
	20	42.80	33.18	9.62	6.50
	25	46.50	40.98	5.52	6.79
	30	36.60	36.49	10.11	6.97
FLB	0	20.40	12.69	7.71	4.86
	10	20.40	12.69	7.71	4.86
	15	32.00	26.03	5.97	6.22
	20	42.50	30.89	11.61	6.54
	25	38.00	38.80	13.90	6.83
	30	41.00	46.57	11.07	7.00

TABLE 4 EFFECTS OF PFPAT ON DRYING SHRINKAGE OF FRB AND FLB SOIL RENDERS

Soil Renders	PFPAT (%)	Drying Shrinkage (%)
FRB	0	27.12
	10	12.64
	15	9.29
	20	8.44
	25	7.76
	30	7.87
FLB	0	23.23
	10	6.93
	15	6.51
	20	6.53
	25	5.39
	30	5.01

TABLE 5 EFFECTS OF PFPAT ON MOISTURE ABSORPTION OF FRB AND FLB SOIL RENDERS

Soil Renders	PFPAT (%)	Moisture Absorption (%)
FRB	0	27.12
	10	12.64
	15	9.29
	20	8.44
	25	7.76
	30	7.87
FLB	0	23.23
	10	6.93
	15	6.51
	20	6.53
	25	5.39
	30	5.01