CONCRETE ADMIXTURE AND SET RETARDER POTENTIAL OF PALM LIQUOR

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ABSTRACT
This paper presents the investigation of palm liquor produced from the abundant palm trees in the Niger Delta of Nigeria for its potential as a workability aid and set retarder admixture in tropical hot weather concreting, as a low cost product. The properties of palm liquor and its performance on concrete at two different water cement ratios were studied.
The results show that palm liquor increases concrete workability, improves compaction, reduces honey combing and retards the initial and final setting time of concrete.

INTRODUCTION

Palm trees are abundant in the riverine areas of the Niger Delta of Nigeria and represent the main source of lignocellulosic materials in the area. Lignin refers to a group of phenolic polymers that confer rigidity to the woody cell wall of plants. Its chemical and physical properties differ depending on the plant type and the extraction method (Mark and Gaylord 1968, Britt 1984 and Rance 1980), and can serve a lot of purposes as binder, dispersant and emulsifier (Baucher et al 2003, Wrobel et al 2007 and Pan 2008). Lignosulphonates have been shown to have the potential of workability aid for cement (American concrete Institute, ACI 1981, El shereef 1988), while alkali lignin may be extracted from palm or black liquor and sulphonated for the same purpose (Chang 1995, Kamoun et al 2003); but the sulphonation process is very expensive and difficult (Myreen 2001a, Myreen 2001b, El Shaal 2003, 2004, Guang et al 2004, Hassan and Nada 2003 and Bhattacharjee et at 2006). Kumar et al studied paper mill effluent as a workability aid for cement motars (Kumar et al 1995).

Although there are little or no reports of use of palm liquor as a workability aid for mortar and concrete, the use of black liquor show that alkali black liquor does not have any negative effect on concrete durability or steel corrosion (Ali 1999, Ali et al 1998, El Sayed et al 1998); and can be treated using microbial community (Yang et al 2008, 2010a , 2010b). Apart from the edibility of palm liquor in Nigeria, this research studies the possibility of utilizing palm liquor as a low cost concrete admixture which is of preferred economic advantage in the region to the importation of chemical admixtures with hard earned foreign exchange.

EXPERIMENTAL METHOD

Table 1 shows the water cement ratios adopted for the experimental study. Water cement ratio of 0.5 was selected to represent commonly used concrete in Nigeria, while the water cement ratio of 0.4 corresponds to higher strength concrete.

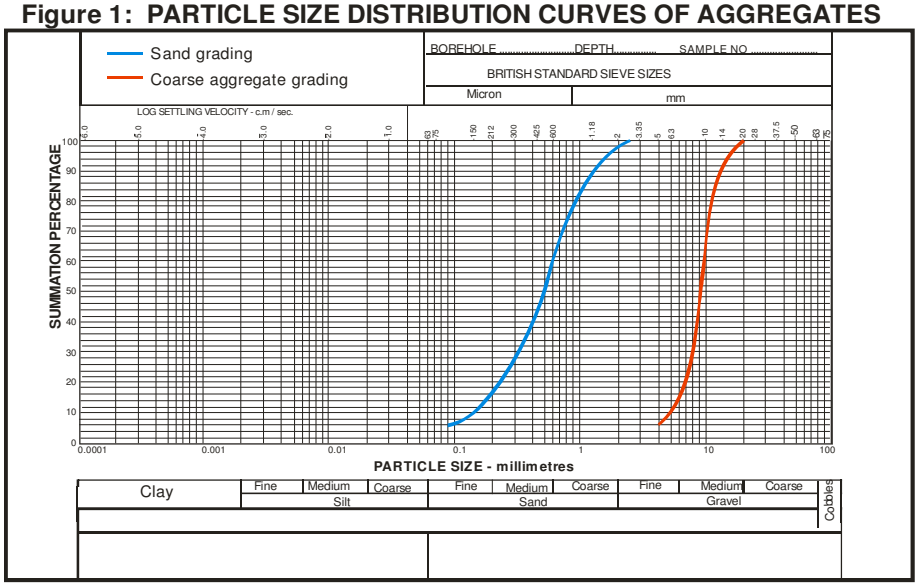
Table 1 concrete mixes.

Water cement ratio	0.4, 0.5
Cement content (kg)	500
Fine/coarse aggregate ratio	0.5
Palm liquor/water ratio (vol.2)	0,5,15,25,35

Initial test was to determine the initial and final setting time of the cement, after mixing the cement with water and palm liquor.

Relative density, bulk density and water absorption of the fine and coarse aggregates were determined according to BS 1377 (1990). The result of the sieve analysis is shown in fig. 1.

Figure 1: PARTICLE SIZE DISTRIBUTION CURVES OF AGGREGATES



Ordinary Portland cement was used for the investigation. Tests on the cement such as fineness, setting time and compressive strength were determined according to BS 1881-116: 1983.

The workability of the fresh concrete was determined by slump test, using standard slump cone of height 300mm, bottom diameter of 200mm and a top diameter of 100mm; and according to BSEN 12350-2: 2009.

Standard calibrated cube crushing machine was used to crush 150mm x 150mm x150mm hardened concrete cubes to failure, in order to determine its compressive strength, defined by:

$P = F/A$

where F is the failure load and A is the cross sectional area of the specimen whereas, the splitting tensile strength was determined by using the same crushing machine to crush a concrete cylinder specimen of 50mm diameter and 300mm height, and defined by:

Splitting tensile strength = $2F/\pi dL$

Where F is the failure load, L is the cylinder length and d is the diameter of the cylinder.

Safety and durability of structures are usually influenced by aggressive chemicals such as sulphates and chlorides; which are expressed as percentages of the cement content. The sulphate content should not exceed 4% of the cement weight used.

Palm liquor was, not produced by any industrial process, they are commonly produced in Nigeria by local tappers in a traditional way. Characterization of the palm liquor was performed by determining the relevant parameter such as pH, Specific gravity, total solids content, chloride content, sulphate content, chemical

oxygen demand (COD), Biological oxygen demand (BOD), sugar content and carbohydrate content. Table 2, summarizes the analysis of palm liquor produced from three locations: Port Harcourt, Bori and Ikuru Town.

Since the properties from the palm liquor from the three locations are similar, it is only the palm liqour from Ikuru town that was selected for the study as a representative sample.

Table 2- Analysis of palm liquor produced from Port Harcourt, Bori and Ikuru town.

S/No	Property	Port Harcourt	Bori	Ikuru Town
1.	PH	9.8	11.5	11.7
2.	Specific gravity at 15^0C	1.15	1.27	1.26
3.	Total solid content (g/L)	264.1	270.3	271.5
4.	Sulphate content (mg/L)	4852	5629	5670
5.	Chloride content (mg/L)	3340	3455	3560
6.	Sugar content (g/L)	67.9	68.1	68.0
7.	Hydrolysable Carbohydrate Content (g/L)	73.8	82.9	83.4
8.	C O D (mg/L)	196.200	200.400	198.500
9.	B O D (mg/L)	42.900	43,900	41,900

RESULT AND DISCUSSIONS

Fresh concentrated palm liquor was obtained from the three locations above. By the following day, fermentation had started. So, formaldehyde was added to the fresh samples to stop further fermentation. This confirms the slight decrease in pH value of the palm liquor with increased age as shown in Table 3. The liquor was then added as a partial replacement for mixing water, such that the total liquid, water, palm liquor and cement content are invariant and similar to the control mix of water cement ratio, w/c =0.4 and w/c =0.5. The minimum acceptable slump to ensure proper workability and compaction of concrete on site is assumed to be 70mm. the effect of the addition of palm liquor on concrete slump is shown in fig 2.

Table 3: Effect of age on the palm liquor

Location	Property	0.25 month	3 months	6 months
Port Harcourt	Specific gravity at 15% temperature pH	1.039	1.037	1.033
	Total solid content (g/l)	7.15	6.59	6.51
	Sugar content (g/l)	89.6	86.3	76.9
	Hydrolysable carbohydrates (g/l)	25.34	15.16	12.95
	COD	29.89	27.92	14.23
	BOD	149.200	115.000	100.600
		37.900	27.900	24.900
Bori	Specific gravity at 15% temperature pH	1.042	1.040	1.037
	Total solid content	7.21	6.63	6.58
	Sugar content	92.9	90.5	78.4
	Hydrolysable carbohydrates (g/l)	28.33	16.24	13.32
	COD	32.78	30.89	16.37
	BOD	151.200	117.000	102.600
		39.900	29.900	26.900

Ikuru Town	Specific gravity at 15% temperature pH	1.041	1.038	1.035
	Total solid content	7.19	6.61	6.56
	Sugar content	91.8	89.3	77.3
	Hydrolysable carbohydrates (g/l)	27.94	15.42	13.16
	COD	31.51	26.05	15.22
	BOD	150.200	116.00	101.600
		38.900	28.900	25.900

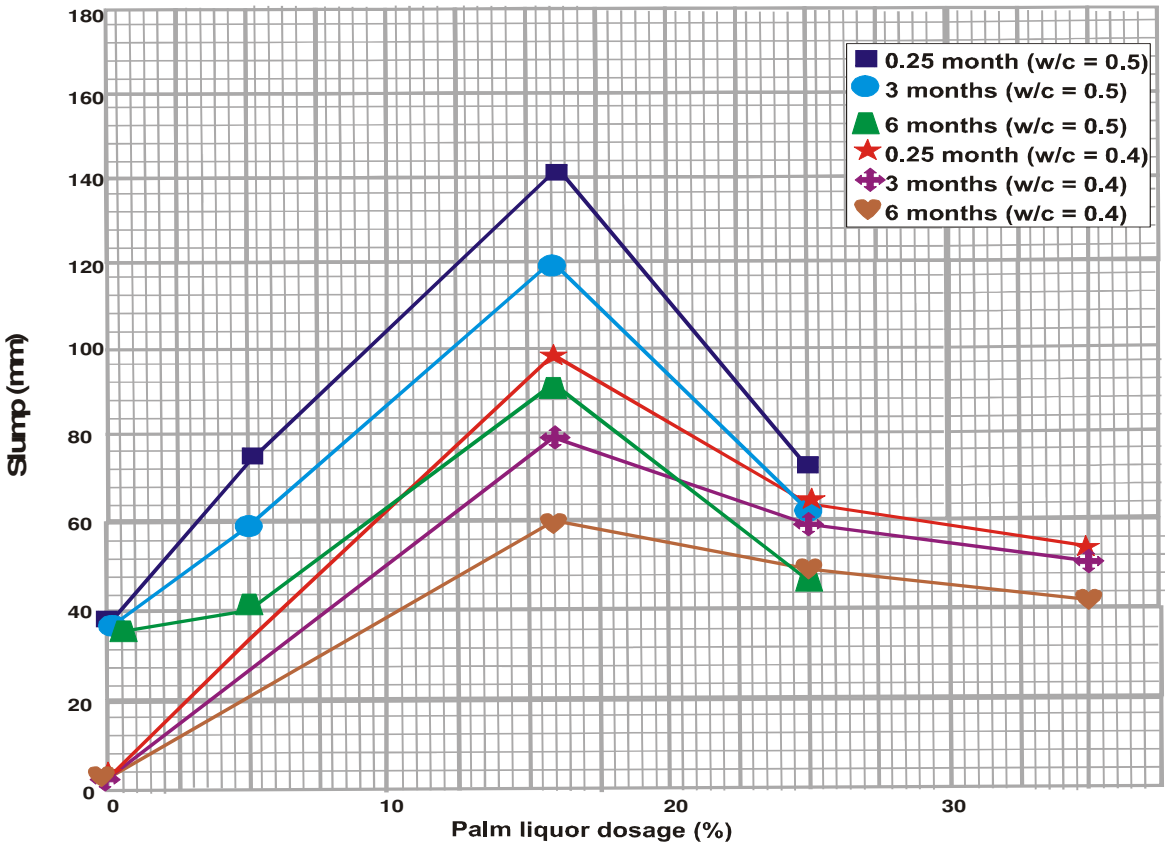


Figure 2 - Effect of palm liquor on concrete slump.

Figure 2 shows that the slump for the control mix with w/c = 0.4 was much lower than that at w/c = 0.5. Infact, slump was almost zero for control mix with w/c = 0.4. This means that the concrete was not adequately mixed and compacted because of the low water content ratio; which in turn has reduced the slump and subsequently reduced the compressive strength of the hardened concrete. But on addition of the palm liquor, the slump increased to a peak value at about 16% palm liquor replacement, and decreased slightly thereafter at which peak value, honey combing is reduced and the compressive strength is increased (fig 3). Further increase in the palm liquor replacement beyond this optimum value of 16% decreased the slump and the compressive strength. Similar behavior was observed for the w/c ratio = 0.5.
Fig 2 and 3 also show the effect of aging of the palm liquor on the concrete slump and compressive strength respectively. It clearly shows that slump and compressive strength decreased with age. Therefore safe limits to ensure acceptable values for slump and compressive strength have to be set.

Fig 4 shows the same trend of effect of palm liquor on the concrete tensile strength, and having the same optimum values of 16% palm liquor replacement. In general, fig 3 and 4 shows considerable increase in the compressive and tensile strength compared to the control mix.

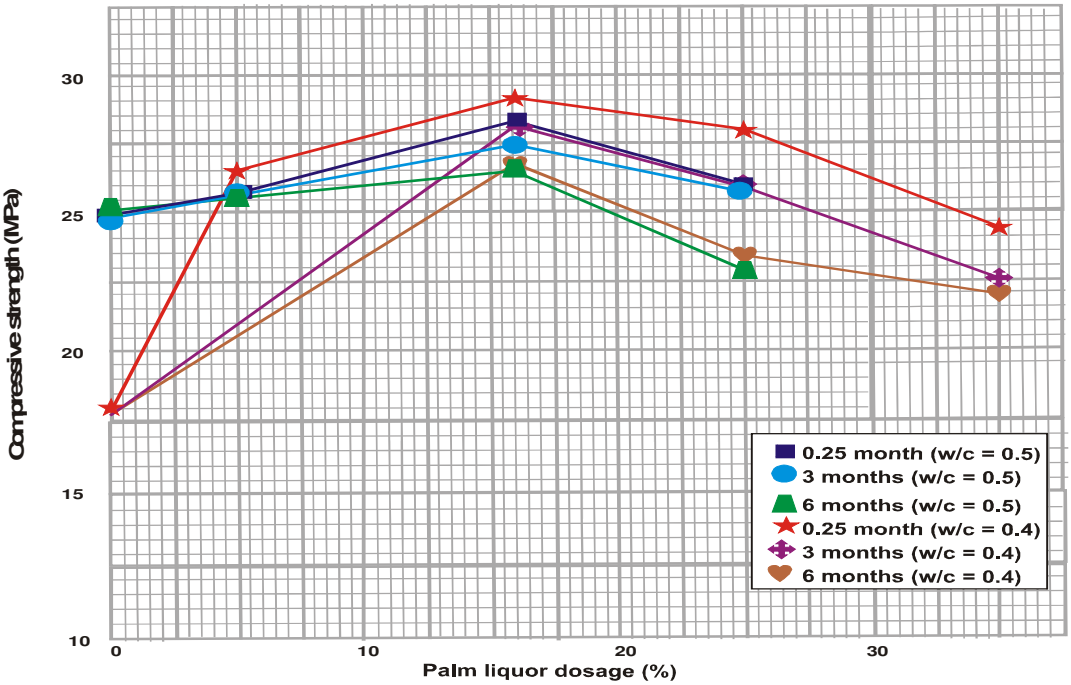


Figure 3 - Effect of aging of palm liquor on concrete compressive strength

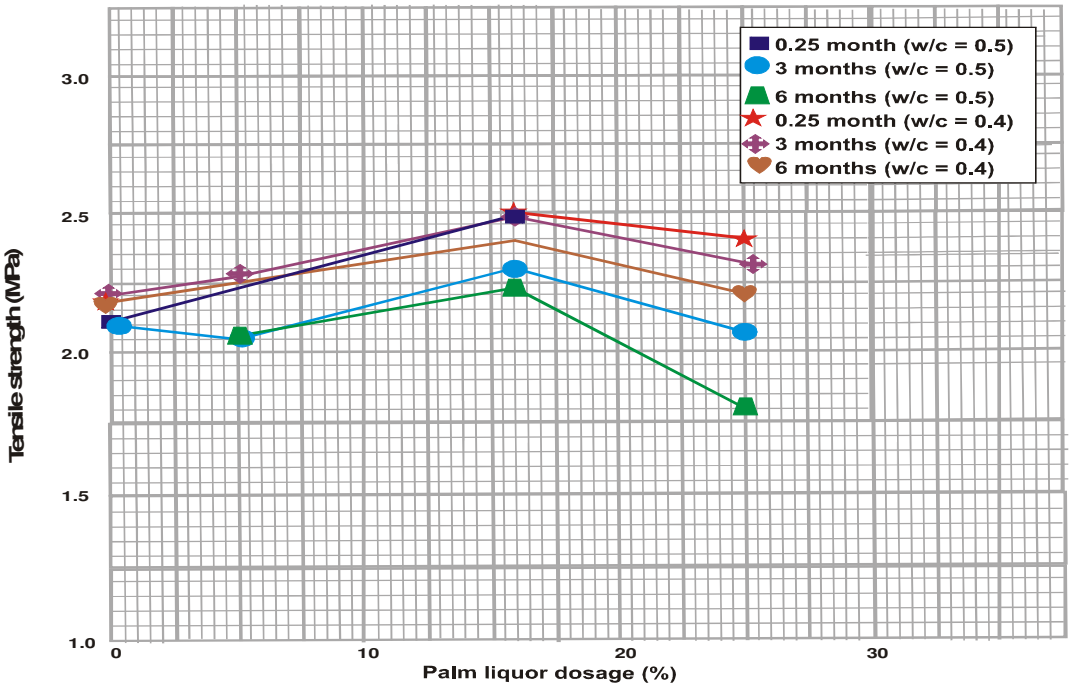


Figure 4 - Effect of palm liquor on concrete tensile strength

Soluble chlorine and sulphate ions were determined from the hardened concrete. This chlorine ions causes corrosion to reinforcement, while the sulphate ion is harmful to concrete and causes cracking. The maximum allowable chlorine ion is between 0.3% and 0.15%, while sulphate ion is 4%. Table 4 shows that use of the palm liquor as a replacement for mixing water does not adversely affect concrete durability.

Table 4: Chlorine and Sulphate ion contents (28 days concrete)

Concrete mixes	Chlorine ion as % of cement by weight	Sulphate ion as % of cement by weight
w/c = 0.4 - 15% replacement	0.129	2.650
w/c = 0.5 - 5% replacement	0.120	2.139
w/c = 0.5 - 15% replacement	0.145	3.214
w/c = 0.5 - 25% replacement	0.158	3.310

Fresh palm liquor is very sweet because of its high sugar content. Table 5 shows the initial and final setting time of cement paste containing various doses of palm liquor. it is clear from the table that for all doses of added palm liquor, the initial setting time was greater than the minimum (75 min) allowable, and the final setting time was less than the maximum allowable.

Table 5: Effect of palm liquor on setting time of cement paste

Dosage of palm liquor (%)	Initial setting time		Final setting time	
	h	min	h	min
0	1	20	2	30
10	1	50	3	45
20	2	25	4	50
30	2	49	6	38

CONCLUSION

Palm liquor from the abundant palm trees in the Niger Delta of Nigeria is considered to be a low cost admixture to increase the workability and retard setting of concrete. The results obtained show that palm liquor improved compaction and honey combing and increases the workability of concrete with maximum performance at 16.0% water replacement by palm liquor. It also acts as a set retarder because of its high sugar content. There is general gain in tensile and compressive strength, for water cement ratio of 0.4 and 0.5 at 16% palm liquor replacement of water. Chemical analysis of hardened concrete shows that the palm liquor of early age is safe to be used for reinforced concrete, provided its dosage in concrete is not more than 16% palm liquor replacement of water.

It is finally concluded that palm liquor as a partial replacement of mixing water improved workability, tensile and compressive strength and setting time without adverse effect on concrete durability.

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