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Effects of Cassava Effluent in Concrete Production

B.E. Adewumi, A.O. Familusi, A.A. Olatunji and B.O. Adegbenle

[1]Department of Civil Engineering, Federal Polytechnic Ede, Osun State, Nigeria
E-mail: ayomacfamilson@gmail.com; Tel: +2348069209798

Abstract- Water is needed to begin the hydration process by reacting with the cement to produce concrete. This study investigated the effect of cassava effluent on concrete. Four main tests were carried out; chemical composition test, slump test, compaction factor test and compressive strength test. Cassava effluent was taken to Nigerian Institute of Science Laboratory and Technology (NISLT) Ibadan and the following elements were analysed: Magnesium, Calcium, Iron, Cadmium, Zinc, Lead and Copper. Tests were carried out on concrete made with cassava effluent cured in cassava effluent (CEC), concrete made with cassava effluent cured in potable water (CPC), concrete made with potable water cured in potable water (PPC) and concrete made with potable water cured in cassava effluent (PCC) for 1:2:4 mix. The presence of heavy metals in cassava effluent rendered most of concrete made or cured with cassava effluent less effective. The results revealed that cassava effluent has no pronounced effect on concrete workability as concrete made with cassava effluent and potable water were on the same level of workability. PPC had the highest value of compressive strength at 28days (17.6N/mm^2) followed by PCC (14.7N/mm^2), followed by CPC (13.5N/mm^2) and CEC had the lowest comprehensive strength (11.4N/mm^2). There was considerable reduction in the values of compressive strength, slump and compaction factor of concrete made with cassava effluent and cured in cassava effluent. Quality of water used in mixing concrete has adverse effect on strength of concrete than that used in curing. Cassava effluent should not be used in mixing and curing of concrete.

Keywords: Cassava, Compressive Strength, Concrete, Effluent, Potable Water, Workability

1. INTRODUCTION

Concrete is a structural material that contains some simple elements but when mixed with water would form a rock like material. Concrete mix is comprised of coarse aggregates usually gravel, fine aggregates usually sand, cement, water, and any necessary additives**.** Water is one of the most important elements in concrete production. Water is needed to begin the hydration process by reacting with the cement to produce concrete. There has to be a sufficient amount of water available so that the reaction can take its full course but if too much water is added, this will in fact decrease the strength of the concrete. The water-cement ratio is an important concept because other than the recipe for the concrete mix, the amount of water used would also determine its final strength (Palmquist, 2003). In more details, if too little water were added, there would not be enough water available to finish the reaction, thus some of the cement would harden and bond with other dry cement shorting the hydration process.

On the other hand, if too much water was added while the cement is undergoing hydration the cement would be in a slurry solution, and the probability of cement bonding with aggregates would decrease. And as a result, when the hydration process is completed, the cement content would still be in a slurry solution and with no strength. The type of water that can be used to mix concrete must be potable which essentially has neither noticeable taste nor odour. Basically, water containing less than 2000 ppm of total dissolved solids can be used. Mixing water can cause problems by introducing impurities that have a detrimental effect on concrete quality. Although satisfactory strength development is of primary concern, impurities attained in the mix water many cause efflorescence. Water should be avoided if it contains large amount of dissolved solids or significant amounts of organic materials (Kuhi, 2002). The cassava starch/gari processing centres are generating huge quantities of wastewater to the extent of an average value of about 4,000 to 6,000 litres per tonne of starch/'gari' produced from the study areas under investigation. This wastewater contains very high concentration of cyanide; this will ultimately affect the quality of life where the processing centres are mostly located. Since majority of cassava-based starch/'gari' processing centres are small-scale or small clusters in nature, a simple and cost effective treatment system is essential to be developed (Afuye and Mogaji, 2015). T

The chemical composition of cassava effluent suggests its potential as a biofertilizer in terms of its potassium and magnesium content. Its use as a biofertilizer will provide an alternative to its wastage, transforming it into an organic supplement for crop cultivation (Adejumo and Olla, 2016). The experimental investigation presented by Adewuyi *et al* (2015) indicates that exposure of concrete structures to attacks from cassava effluent-contaminated soil certainly results in significant reorganization of the internal microstructure of concrete elements. However, it is highly proposed that cassava waste-water undergo proper treatment before discharge to rivers (UNN, 2016). The thrust of this study is to assess the effects of cassava effluent in concrete production.

2. MATERIALS AND METHODS

The study was undertaken in the concrete laboratory at the Department of Building Technology, Federal Polytechnic Ede, Osun State Nigeria. The research involved two major steps. Firstly, preliminary investigation of some of the physical properties of constituents of concrete was carried out. Secondly the actual study of evaluating the quality of concrete produced using Potable and cassava effluent for mixing and curing.

2.1 Materials
The materials used in this research include cement (Dangote Ordinary Portland Cement), water (potable water and cassava effluent), cassava (cyanide), coarse aggregate and fine aggregate (river sand).

2.2 Methods
The various methods used in this research work are briefly discussed below:

2.2.1 Sample treatment
Cassava tuber was harvested from the farm with the woody ends of the roots chopped-off with sharp knife after purchase before subsequent processing. After the tuber has been peeled with knife in small and medium size mills, the general practice was to remove the skin and cortex and to process only the central part of the root. All dirts remaining on smooth surface of the core of the root was washed off and peeled roots were immersed in water for sometimes. Soaking of cassava root normally preceeds cooking. It provides a suitably larger medium for fermentation and allows greater extraction of soluble cyanide into the soaking water. The cassava was soaked in water for seven days. After seven days, water was separated from soaked cassava root using sieve in order to ensure that no particles of cassava was in its effluent.

2.2.2 Preliminary Tests
The fine aggregate and coarse aggregate were graded by passing through BS sieves in order to determine their grading curves while the Cassava effluent collected at seven days was taken to Nigerian Institute of Science Laboratory and Technology (NISLT) Ibadan in order to determine its constituent. The concrete mix used was 1:2:4.

2.2.3 Preparation of concrete cube
Concrete slab or pavement over which concrete is to be mixed was prepared and cleaned. Then, the required mass of fine aggregate to be used was measured and spread on the clean concrete slab according to the mix

proportion. The required mass of cement was measured and poured into the spread sand. This was then mixed thoroughly by the use of a hand shovel until a homogenous mix was attained. Coarse aggregate was also measured and poured into homogenous mix. The required volume of Potable water was then added instantaneously as mixing commences using a hand shovel, mixing continued until a homogeneous fresh concrete mix was attained. The mix was now collected in a head pan and transported to the point of placement. The fresh concrete was now placed into the mould already coated with engine oil using standard procedure (BS, 1986). The surface of the cubes formed was then finished using a hand trowel to acquire smooth surface. Permanent marker was used to label the cubes for the purpose of identification. The above procedures were repeated all over for concrete made with Cassava effluent. Sixty-four (64) cubes of size 150mm x 150mm x 150mm were casted, sixteen specimens of concrete made with cassava effluent cured in cassava effluent (CEC), concrete made with cassava effluent cured in potable water (CPC), concrete made with potable water cured in potable water (PPC) and concrete made with potable water cured in cassava effluent (PCC) were labelled CE, CP, PP and PC respectively. The samples were removed from the mould after 24 hours and cured inside curing tank for 7, 14, 21 and 28 days.

2.2.4 Compressive strength test

For the fact that compressive strength is the most important property of concrete that is used to assess the quality of concrete (Neville and Brooks, 2002). The cube samples were subjected to compressive strength test in accordance to the appropriate British Standards. At the end of 7, 14, 21 and 28 days, respectively of curing, the compressive test was carried out on each cube; four (4) cubes were used for each of the four types of concrete samples. This amounted to 16 cubes for each curing day. The crushing machine was used to determine the crushing load or failure load of the cube specimen. The machine applied load axially on the cube specimen at constant rate until a minimum load which corresponded to the ultimate compressive load was recorded as the failure load for that cube.

3. RESULTS AND ANALYSIS

The results of the chemical analysis of the constituent of cassava effluent, slump and compaction factor tests and compressive strength test are presented in Tables 1-5 respectively:

3.1 Sieve analysis

Sieve analysis of representative samples for the fine and coarse aggregates to be used in the concrete mix are governed by the British Standards and the sieves used were the standard BS sieves. Aggregate materials showed S-shaped curves with coefficient of curvature of 2.35 and uniformity coefficient of more than 4 indicating well graded materials (Kadayali and Lal, 2008; Garg, 2003).

3.2 Chemical analysis test

The following metals were analyzed, Calcium (Ca), Magnesium (Mg), Iron (Fe), Manganese (Mn), Copper (Cu), and Zinc (Zn) as shown in Table 1. The result revealed that fermented water contain heavy metals which make it not suitable for mixing and curing because these heavy metals have adverse effect on the workability and strength of concrete (Babu *et al*, 2007; Babu, 2009).

Table 1: The Percentage of Analysed Metals Present in Cassava Effluent

Metals	Percentages
Calcium	71.33
Magnesium	23.44
Lead	4.33
Iron	3.11
Copper	2.07
Manganese	0.64
Cadium	0.07
Zinc	0.09

3.3 Workability

Result of the slump test (Table 2) shows that all the various concretes have low degree of workability while the compaction factor test result (Table 3) revealed that PPC, PFC have high workability and FFC, FPC have low workability. Although, there is no significant difference in the slump value of concrete made with potable water and cassava fermented but their compaction factor value showed the difference. This implies that fermented water has negative influence on the workability of the concrete sample. Concrete having low degree of workability (as shown in Table 4) is suitable for roads, vibrated by power-operated or hand-operated machines. This concrete can also be used for mass concrete work in foundation without vibrations and lightly reinforced section with vibrations.

Table 2: Slump Test Result

Concrete Identification	Slump Value (mm)	Form of Slump	Remark
PPC	28.5	True Slump	Low Workability
CEC	27.5	True Slump	Low Workability
PCC	28.5	True Slump	Low Workability
CPC	27.5	True Slump	Low Workability

Table 3: Compaction Factor Test Result

Concrete Identification	**Compaction Factor Value**	**Remark**
PPC	0.95	High
CEC	0.85	Low
PCC	0.95	High
CPC	0.85	Low

Table 4: Interpretation of Compaction Factor Test Result as Described in British Road Note 4

Degree of Workability	Slump (mm)	Compaction Factor		Applications
		Small Apparatus	Large Apparatus	
Very low	0-25	0.78	0.80	Vibrated concrete in roads or other large sections.
Low	25-50	0.85	0.87	Mass Concrete foundations without Vibration. Simple reinforced sections with vibration.
Medium	50-100	0.92	0.935	Normal reinforced work without vibration and heavily reinforced sections with vibration.
High	100-180	0.95	0.96	Sections with congested reinforcement. Not normally suitable for vibration.

Source: Neville and Brooks (2002)

3.4 Compressive strength

Table 5 showed the result of compressive test carried out on each cube at 7, 14, 21 and 28 days, respectively of curing and from that result, it can be observed that, there is steady increase in strength with increase in days. However such increase varies. The rate of increase for the control cube is relatively higher than CEC, CPC, and PCC samples. From the compressive strength test result, it can be observed that there is narrow gap between the results of the control samples (PPC) and other samples. For example, the average compressive strength for the control sample is 17.50N/mm^2 while for CEC, it is 11.42N/mm^2, and this represented 35% difference. Compressive strength result of CEC at 28 days (11.42N/mm^2) is the least followed by that of CPC (13.47N/mm^2) and later by that of PCC (14.7N/mm^2), however PPC has the highest compressive strength value of 17.5N/mm^2 at 28 days. This showed that the quality of water used in mixing has adverse effect on strength than one used in curing. CEC having the least value, implies that fermented water makes concrete weaker thereby reducing its quality. Also the graph in the Figure 1 below illustrates the relationship between the compressive strength of both the control sample and other types of concrete investigated at 28 days of curing.

Table 5: Compressive Strength Test Result for Concrete Cubes Made With Potable Water and Cassava Effluent

Concrete Identification	Cube Labels	Compressive Strength (N/mm^2) For Various Curing Ages			
		7 Days	14 Days	21Days	28 Days
PPC	PP	10.47	14.27	17.11	17.50
CEC	CE	7.78	8.85	10.60	11.42
PCC	PC	7.96	11.11	12.78	14.70
CPC	CP	8.55	9.69	12.74	13.47

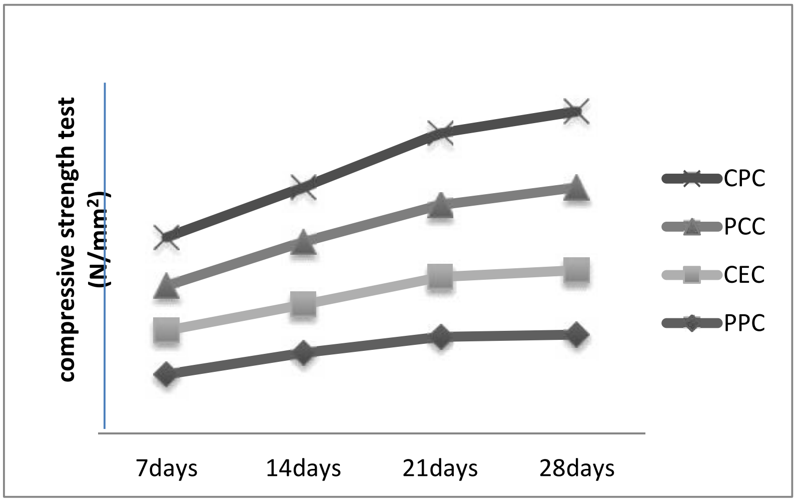

Fig. 1: Compressive Strength Test for PPC, CEC, PCC and CPC

3.5 Percentage water absorption

Table 6 shows that the water absorption for CPC and PCC is more that of PPC and CEC. This implies that the same quality of water used for mixing must be used for curing.

Table 6: Percentage water absorption values for various STA percentage replacement

Concrete Identification	Cube Labels	% Water Absorption Value for Various Curing Ages			
		7 Days	14 Days	21Days	28 Days
PPC	PP	2.3	2.5	4.5	5.0
CEC	CE	4.0	5.6	6.5	7.0
PCC	PC	3.1	4.0	7.7	8.4
CPC	CP	3.5	5.0	8.1	9.0

4. CONCLUSION

The following conclusion can be drawn based on the results obtained from an investigation on the effect of cassava effluent on properties of concrete. The results showed that concrete made with potable water cured in potable water has the highest values of compressive strength, slump and compaction factor. Likewise, there was considerable reduction in the values of compressive strength, slump and compaction factor of concrete made with cassava effluent cured in cassava effluent. And finally, the percentage reduction in concrete strength showed that concrete made with cassava effluent cured in cassava effluent has the highest percentage reduction, followed by concrete made with cassava effluent cured in potable water while concrete made with potable water cured in cassava effluent has the lowest percentage reduction of concrete strength. In a nutshell, it obvious that fermented cassava water is not suitable for mixing or curing

of concrete. Because of the presence of heavy metals like Ca, Mg, Mn, Pb and Fe, present in cassava effluent, these metals contain salt that makes cassava effluent not suitable for concrete production and affects the hydration of cement which can eventually lead to concrete deterioration (Babu *et al*, 2007; Babu *et al* 2009). It is a known fact that quality and quantity of water used in mixing and curing of concrete has an adverse effect on properties of concrete.
Moreover, the following are hereby recommended based on the results from the study. First, soaked cassava should not be spread on cement floor, deck and pavement to eradicate the probable source of heavy metals in its effluent. Likewise, the same quality of water used for mixing must be used for curing in order to produce concrete of sufficient quality while the effect of soaked cassava on the strength of an existing concrete floor should be checked in the subsequent research using schmit hammer. On a final note, further research should be carried out on the effect of cassava effluent on concrete properties in laboratory where degree of fermentation can be accurately controlled.

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