Experimental Study of the Structural Behaviour of Fibre Reinforced Concrete Using Cassava Strand (Central Vascular Fibre CVF) Waste

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ABSTRACT

The purpose of this experimental research is to know the structural behaviour of fibre reinforced concrete using cassava strand (Central Vascular Fibre CVF) waste. This project is been done by adding cassava strand (CVF) waste as fibre to concrete and this is to increase the toughness and tensile strength and improve the cracking deformation characteristics of the resultant composite material. The cassava strand (CVF) waste constitute a bye product of a predominantly tuber crop in Nigeria. These strand (CVF) wastes were air dried to remove or reduce the moisture content. Their aspect ratio were then calculated and they were mixed by volume proportion of 0% to 3.0% in concrete matrix (1:2:4) with varying water/cement ratio in order to have an acceptable workability. Slump and compacting factor tests were carried out on the wet concrete and compressive strength test on the hardened concrete after curing. Results showed that a wide range of high strength were achieved with compressive strength of 25.42N/mm2 and 19.42N/mm2 for 0.5% and 1.0% CVF addition respectively while the control is 21.75N/mm2 at 28day test. It is recommended that up to 1.0% CVF can be used for structural works while 1.5% and 2.0% be used for non-structural works like solid ground floors and light weight concrete.

Keywords: *Fine aggregates, coarse aggregates, cassava strand, concrete, workability, compressive strength*

1. INTRODUCTION

The range of materials in construction industries is very vast and it therefore becomes more complex if its study is to be compounded or lump together and treated in one single write up. Concrete generally, particularly those made with Portland cement as the binder has its tensile strength which is about one-tenth of its compressive strength and thus tends to be brittle. Conventionally, this low strength in tension is usually overcome by the introduction of reinforcement and by the addition of volume fraction of certain fibres. The inclusion of fibres also modifies the performance by improving its toughness of the composite. There are different types of fibres and the most common ones are artificial fibres such as steel, carbon, glass, polythene and natural fibres such as Silsa, Coconut heaves, cassava strand (CVF) and so on. It is therefore desirable within the scope of this project to concentrate on the structural materials like cassava strand waste fibre as construction materials so as to understand the structural behaviour of fibre reinforced concrete using cassava strand waste.



I. Cassava plant II. Cassava Tuber III. Cassava waste
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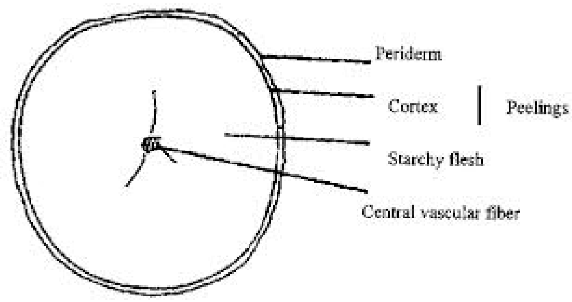
The cassava plant is among the first three carbohydrate food in the tropics coming after rice and maize and serve as a major source of daily food for millions of people living within this region [1,2]. The process of making cassava into staple food generates different kind of waste among which is the central vascular fibre CVF (cassava strand waste). Being a very staple food in Nigeria, it also generates a lot of waste, in which some are used for animal feed.



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The strand (CVF) is obtained as a by-product in the processing of cassava into Gari (a staple food found in West Africa). The cassava tubers are peeled, washed, grated, pressed, sieved (this is the point where the CVF are gotten), fried and finally sieved again. The CVF are removed as waste. [3]. These CVFs are what we used in this experimental study as fibre in concrete matrix.

2. LITERATURE REVIEW

The use of fibres in reinforcing construction materials date back to over 4000BC, when the Egyptians used straws to reinforce bricks as stated in Exodus 5:6 [4]. (The Holy Bible KJV). There is no information as to when fibres were first used to reinforce building materials but the fact that idea is ancient is undoubted. Evidences abound that fibres (asbestos, straws, horse hairs) were used in reinforcing clay pots, plasters and Portland cement mortars [5, 6, 7]. Adding straws and related products into mortars and building materials are consider as the first fibre-reinforced by researchers. [5] Patents were gotten from different part of the world for different types of fibre reinforced concrete with the fibre varying in sizes, diameter, physical and mechanical properties [6, 8, 9]

Various experimental and empirical researches have been carried out and published in various media over the years across the nations of the earth. In a published work on steel fibrous concrete beam-column connections, round; mild steel fibres with a length of 31.5mm and an aspect ratio of 100 were used at volume fraction of 0.6%. 0.8% and 1%. A total of 50 connections were tested in order to test the 3 main types of connections found in a multi-storey reinforced concrete structures. Twenty tee type, Ten cross type, and twenty knee type joints were tested. Static loading (to failure) or a slow cycle fatigue load was applied to the specimens. Results showed that steel fibre concrete reduced cracked width and spelling, and there was an increase in the load carrying capacity and improved ductility [10].

Studies on the effectiveness of ductile fibre reinforced cementicious composites (DFRCC) in hindering the corrosion of steel in reinforced concrete beams with 1.5 % and 1.0 % PVA steel fibre content used in a DFRCC and a layer of DFRCC was placed around the main longitudinal reinforcement. The researchers reported that corrosion– induced damage in reinforced concrete beams was prevented effectively using DFRCC material by the FGC concept and increase the load carrying capacity of the beam and reduced deflection capacities. They also obtained that there is higher resistance against corrosion and cracking of the FGC beams have compared with conventional reinforced concrete [11].

In a typical examination of the effect of replacing fine aggregate with grounded plastic on the slump of concrete, a decrease of 25% of the original slump was recorded with 20% replacement,[12, 13]. Also in 2007, a study of the model use of granulated plastic pet bottles waste as a partial replacement for fine aggregate was undertaken. The pet bottles were cleaned, shredded and grinded into particles passing through sieve mesh up to 10mm and were used to replace sand between 2% and 100%. It was discovered that substituting sand at a level below 50% by volume whose upper granular limit equals 5mm, gives appreciable strength values that is good for light weight concrete [14]. In different researches spanning over three years, it was reported that the continuous addition of granulated plastic into concrete mix will lead to a decrease in the strength. A replacement of 20% causes the compressive strength to drop sharply by 72% of the strength of the control specimen [15, 11, 13].

Several research activities are underway to study and further develop SFRC. The practical applications of this new construction material are very limited. It is essential that this concrete type should not be simply viewed as an alternative to ordinary reinforced concrete. The steel fibres should be regarded as complementary to the mix. They significantly reduce the occurrence of plastic shrinkage cracking and may help minimize the effects of thermal cracking. The use of SFRC is naturally directed towards structural elements that would otherwise present cracking phenomena. There are also specific industrial applications that benefit from the use of SFRC, such as foundries and nuclear installations. It has been confirmed that SFRC exposed to strong temperature variations maintains strength, even at very high temperatures.

3. METHODOLOGY

The materials used for the experiment are as follows: Central Vascular Fibre (CVF) sourced locally from cassava processing farm waste dump site. Fine and coarse aggregates which are free from any impurity were used. Ordinary Portland Cement (OPC) was the main binder. The CVF wastes were hand selected and extracted into long strands which were then cut into required sizes for the use in this research work. Also too, the fine and coarse aggregates were subjected to sieve analysis, weighing 200g of each sample, allowing it to pass through standard set of sieve. The retained aggregate on each sieve was weighed. The percentage retained was calculated.

The concrete matrix (1:2:4) was used and the weight batching method was adopted for the mix. The CVF were introduced by percentage volume fraction of total mix from 0% to 3%. Having gotten a variety of mix portions, a water cement ratio of 0.6 was used for up to 1.5% CVF addition and a water/cement ratio of 0.7 for the rest for good workable concrete. These were determined by the slump test which was carried out according to British Standard [14]. This obviously shows that an increase in the addition of Oil Palm Fibre leads to an increase in the amount of water required for a workable concrete. The slump, compaction factor and V.B Constito meter tests were carried out to determine the workability of the concrete mix. The concrete was then placed in the 150mm cube mould and compacted. The cube samples were then removed from the mould after 24hours and cured in the curing tank for a period of 7, 14 and 28 days. At the end of each period, the samples were tested under loading using the compression testing machine.

4. RESULTS

The results of all the tests carried out are stated below:

4.1 Slump Test

This determines the workability of all the mixes used in this experimental work.

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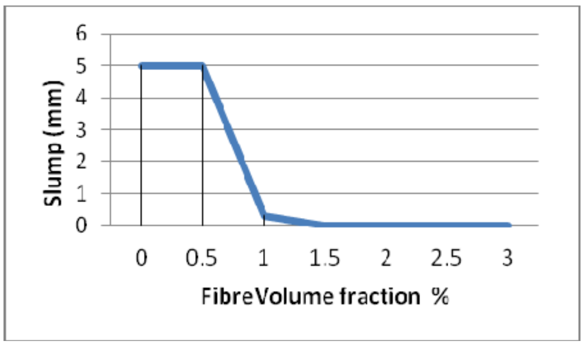
Table 1: Slump Test

S/N	Volume Fraction of Fibre %	Water-Cement ratio	Slump (mm)
1	0.0	0.6	5.0
2	0.5	0.6	5.0
3	1.0	0.6	0.3
4	1.5	0.7	0.0
5	2.0	0.7	0.0
6	2.5	0.7	0.0
7	3.0	0.7	0.0



Graph 1: Slump test (mm)

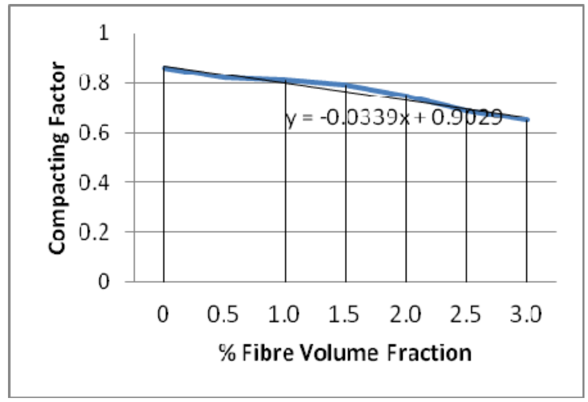
As seen above, there was true slump for the control (0%) fibre and 0.5% fibre fraction volume at 0.6 w/c ratio while to have workable mix and because the CVF reduces the workability of the concrete matrix from 1.5% and above fibre volume fraction, thus the w/c has to be increase for other concrete mixes.

4.2 Compacting factor Test

The compacting factor test is to determine the consistency of a freshly mixed concrete. It is another way of testing the workability of the concrete. The table below shows the results of the compacting factor test carried out on the concrete samples

Table 2: Compacting Factor Tests Results

S/N	Volume Fraction of Fibre %	Compacting Factor Test (mm)
1	0.0	0.86
2	0.5	0.82
3	1.0	0.81
4	1.5	0.79
5	2.0	0.75
6	2.5	0.69
7	3.0	0.65



Graph 2: Compacting Factor Test

The above result shows the compacting factor values for the concrete samples. The value decreases as the fibre increases due to the filling up of voids by the CVF

4.3 Compressive Strength

The compressive strength for 7, 14 and 28 days are given below:

Table 3: Compressive Strength

S/N	w/c	% Fibre Volume Fraction	Compressive Strength (N/mm2)		
			7day	14day	28day
1	0.6	0.0	16.91	18.67	21.75
2	0.6	0.5	22.00	22.50	25.42
3	0.6	1.0	8.70	15.17	19.42
4	0.7	1.5	5.00	5.30	11.12
5	0.7	2.0	6.70	4.08	2.50
6	0.7	2.5	5.08	3.92	4.50
7	0.7	3.0	5.50	3.30	3.55

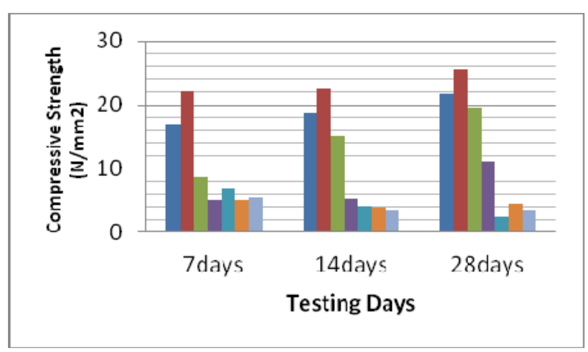


Fig 1: Compressive Strength (N/mm^2)

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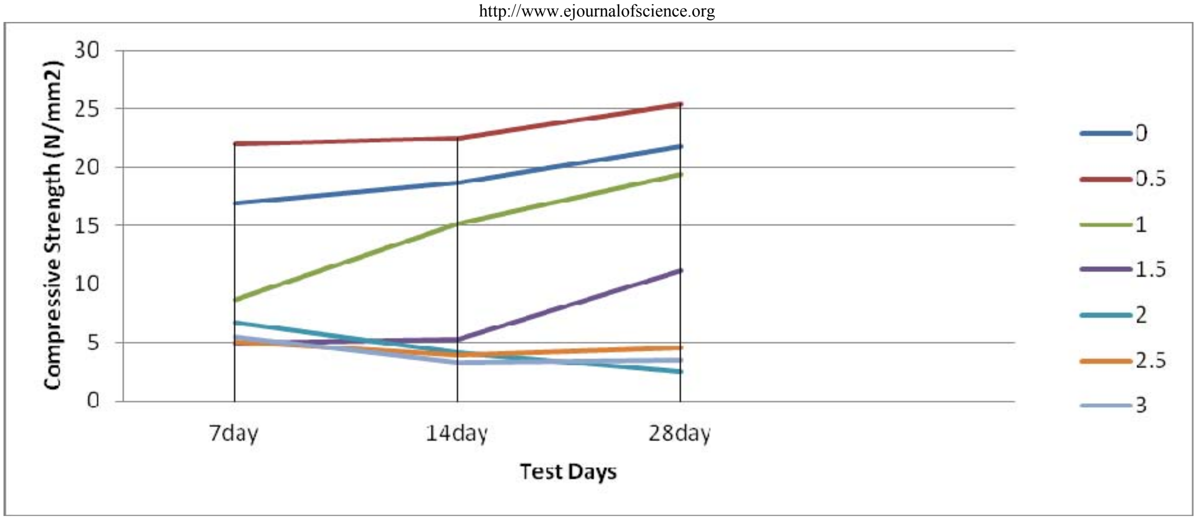

Graph 3: Compressive Strength (N/mm2)

As can be seen, the addition of fibre of 0.5% CVF, it performs better than plain concrete in compression.

5. CONCLUSION

The use of central vascular fibre CVF (cassava strand waste as fibre in FRC, particularly in our locality, where the waste is causing a nuisance, is encouraged of up to 1% addition and could be used for floors and light weight concrete. Further work shall be done on the flexural properties.

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