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Effect of Sisal Fibre on Partially Replaced Cement with Periwinkles Shell Ash (PSA) Concrete

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ABSTRACT: An investigation on the effect of sisal fiber on partially replaced cement with Periwinkle Shell Ash in Concrete was carried out. Sisal fiber of 40mm length which forms 1% of the mix by weight with Periwinkle shell Ash as a partial replacement for cement was used to cast the concrete. Compressive strength test was carried out using 0%, 5%, 10%, 15%, 20%, 25% and 30% of Periwinkle Shell Ash as partial replacements of cement at different curing ages of 7, 14, 21 and 28 days. A skewed result was observed showing a significant increase in the compressive strength recorded in 21 and 28 days of curing whose peaks are at 5% replacement of PSA in the fiber-reinforced-concrete after which, there was a continuous decline in compressive strength of concrete as the percentage of PSA increased. The peak compressive strength value of 28.8 N/mm^2 was obtained at 40mm sisal fiber and at 28 days curing age. This is followed by a compressive strength value of 26.15 N/mm^2 after 21days of curing, all gotten at 5% PSA replacement. This makes 5% the optimal and apparently an exclusive PSA content for Sisal fiber-reinforced-concrete.

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Periwinkle shell is a waste product generated from the consumption of a small greenish-blue marine snail (periwinkle), housed in a V-shaped spiral shell found in many coastal communities within Nigeria and worldwide. It is a very hard and brittle material. Snails called periwinkle are found in the lagoon sand mud flats of the Niger Delta between Calabar in the South-South and Badagry in the West of Nigeria. The people in this area consume the edible part as sea food and dispose the shell as a waste, though few people utilize the shell as coarse aggregate in concrete in areas where there are neither stones nor granite for purposes, such as paving of water logged areas. A large amount of the shells are still disposed as waste though it still constitutes problem in areas where they are yet to find its significant use with yet a large deposit having accumulated in many places over the years. Considerable efforts are being taken worldwide to improve on the strength and durability of concrete through the use of pozzolanic materials. The commonly used pozzolanas have been fly ash, silica fume, metakaolin, and blast furnace slag. In the continuous quest for more cost - effective and environmentally friendly materials, recently, there has been a growing interest in the use of agricultural wastes as pozzolanas. Some of the pozzolanas of agricultural origin include sawdust ash (Sumaila and Job 1999; Udoeyo and Dashibil 2002), rice husk ash (Zhang and Malhotra 1996), corn cob ash (Adesanya 2001; Adesanya and Raheem 2009b; Adesanya and Raheem 2009a), palm oil fuel ash (Tangchirapat et al. 2009) and periwinkle shell ash (Badmus*et al*., 2007; Dahunsi and Bamisaye 2002; Job *et al*., 2009; Koffi 2008).Periwinkle Shell Ash (PSA) is obtained by burning periwinkle shell which is the by-product of periwinkle which, in zoology is any small greenish marine snail from the class of gastropod, the largest of the seven classes in the phylummollusc (Okon 1987; Olorunoje and Olalusi 2003). They are herbivorous and found on rocks, stones or pilings between high and low tide marks; on mud-flats as well as on prop roots of mangrove trees and in fresh and salt water. Dance (1980) observed that ten (10) out of the eighty (80) species of periwinkle in the world are found in West Africa. The common periwinkle (*littorina littorea*) is one of the most abundant marine gastropods in the North Atlantic, but *tympanotonus fuscatus* is commonly found in the estuaries and mangrove swamp forest of the South-South region of Nigeria (Badmus *et al.,* 2007). Massive periwinkle harvesting has been reported from some communities in this region of Nigeria (Powell *et al.* 1985; Job 2008; Jamabo and Chinda 2010; Mmom and Arokoya 2010).Olutoge *et al*., 2013 observed that the compressive strength decreases as the percentage of

Periwinkle Shell Ash (PSA) increases and for each of percentage replacement the compressive strength increases as the curing age increases which is an indication that the crushing strength increases with curing age increase .Fiber-reinforced concrete (FRC) is a cement-based composite material reinforced with discrete, usually randomly distributed fiber material. Fiber material of various shapes and sizes produced from steel, synthetics, glass, and natural materials can be used. However, for most structural purposes, steel fibers are the most used of all fiber materials, whereas synthetic fibers (e.g. polypropylene and nylon) are mainly used to control the early cracking (plastic-shrinkage cracks) in slabs. Fiber reinforcement mainly enhances the post-cracking properties of concrete and leads to a more ductile material behavior. The increased ductility is due to the ability of the fibers to transfer tensile stresses across a cracked section, potentially leading to a reduction in crack widths. The extent of the crack width reduction depends on the amount of fibers added as well as their physical properties (e.g. surface roughness and chemical stability) and mechanical properties (e.g. tensile strength). Therefore, the focus of this research is to investigate the effect of Sisal fibre on partially replaced cement with periwinkles shell ash concrete.

MATERIALS AND METHODS

The major materials obtained as specimen for this research work include cement, sand, coarse aggregate, periwinkles shell, sisal fiber and water.

Ordinary Portland Cement (OPC): Ordinary Portland Cement (OPC) grade 42.5 conforming to BS 12 and relevant Nigeria Standard was sourced from local market at Panteka, Kaduna.

Coarse and Fine aggregate: Locally available river sand and crushed chippings of 20mm maximum aggregate size were used as fine aggregate and coarse aggregate respectively. They were sourced from a local supplier at Tunduwada, Kaduna.

Periwinkle shell: Periwinkle shells used for this research work were sourced from Yenagoa, Bayelsa State. They were washed clean and allowed to dry before poured into an open perforated pan where it is subjected to fire to be burn locally using firewood. Thereafter it was taken for grinding at Pantaka Market, Tudun Wada, Kaduna after which it was sieved using 200µm sieve.

Plate 1. Showing Periwinkle Shell used for the Experiment

The Sisal fiber used for the experiment was sourced from Panteka market Tudun Wada, Kaduna it was cut into 40mm length. The results of the properties of the Sisal fibre was adopted work carried out by Sani*et al*, 2017

Table 1. Properties of the sisal fibre (Sani *et al*, 2017)

Property	Quantity
Natural humidity, %	14.48
Average diameter, mm	0.13
Water absorption, %	340
Specific gravity	0.22
Tensile strength of 1 strand, N/mm^2	10.60
Tensile strength of 2 strand, N/mm^2	24.45
Tensile strength of 2 strand, N/mm^2	30.60
Elongation at break, mm	5.58
Colour	shiny white

Table 2 Chemical and physical properties of PSA (Olusola and Umoh, 2013)

Chemical composition											
Elemental oxide, %											
S_iO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	Mn_2O_3	P_2O_5	TiO_2	LOI
33.84	10.2	6.02	40.84	0.48	0.26	0.14	0.24	0	0.01	0.03	7.6
Physical properties											
PR on45µm sieve	AI with PC (% of control) 7 days			28 days	WC (% of control)			Soundness (mm)		MC (%)	SG
21	78.17			79.12	104			1		1.5	2.13

PR = Percentage retained; AI with PC= Activity index with Portland cement; WC = Water requirement; MC = Moisture content; SG = Specific Gravity

Proportioning and Mixing of Constituents: Water to be used for the fibre reinforced concrete was a portable drinking water from the Civil Engineering Department, Material/Structure Laboratory, Kaduna Polytechnic, Kaduna. The constituent material were hand-mixed at a mixed proportion of 1:2:3 by weight.

Moulds of size 100mmx100mmx100mm were prepared and a trial (control) mix was cast to determine the compressive strength the concrete. Crushed results after 7days, 14days, 21days and 28days of curing the cubes were obtained. Concrete Cubes were cast using the mould sat 5%, 10%, 15%, 20%, 25% and 30% replacement of cement with PSA was carried out.1% of sisal fibre by weight of solid concrete constituents was cut into 40mm constant length and used as reinforcement and curing was done at ambient temperature for 7days, 14days, 21days and 28days.

RESULTS AND DISCUSSION

Fine aggregate: The particle size distribution analysis shown in table 3 and in figure 1 shows the fine aggregate is well graded and free from silt.

Table 3. Particle size distribution of fine aggregate

S/N	Sieve Size	Percentage Retained (%)	Percentage Passing (%)
1	4.76mm	2.9	97.1
2	2.4mm	8.3	88.8
3	1.18mm	15.2	73.6
4	600μm	13.4	60.2
5	300μm	49	11.2
6	150μm	9.8	1.4
7	Pan	1.2	0.2

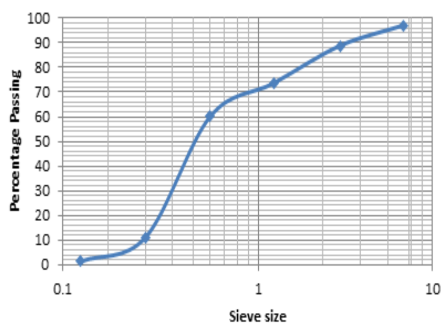

Fig 1 Particle size distribution of fine aggregate

Coarse aggregate: The Coarse aggregate has a specific gravity of 2.73, aggregate impact value of 8%, flakiness and elongation index of 1.6% and 0.02% respectively. All these properties agreed with BS 812 Part 101 1984.The sieve analysis report is shown in table 4 below. It is well graded coarse aggregate as the highest percentages of the aggregate were retained on sieve size 12.7mm and 19.05mm.

Table 4 Particle size distribution of normal coarse aggregate

S/N	Sieve Size	Percentage Retained (%)	Percentage Passing (%)
1	38.1mm	0	100
2	19.05mm	45	55
3	12.7mm	52.67	2.33
4	9.5mm	2.33	0.00
5	6.35mm	0.00	0.00
6	4.76mm	0.00	0.00
9	3.55mm	0.00	0.00
10	Pan	0.00	0.00

Workability: The slump test was used to find the consistency of the fresh concrete at 0.5 water/cement ratio for the plain concrete and 0.65 for the PSA/fiber-reinforced concrete. The slump result is as shown in figure 2. The slump value decreases with the increase in the percentage addition of periwinkle shell ash.

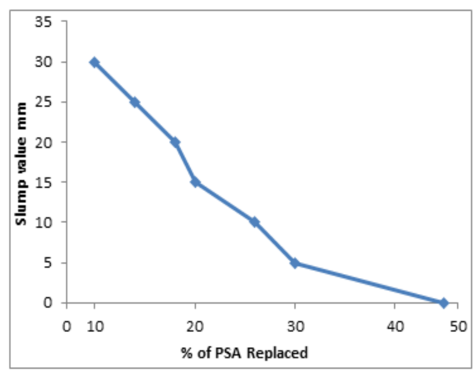

Fig 2 Slump value of Concrete with varied %PSA Replaced

*Concrete Properties/Mix***:** Trial control mix of 1:2:3 for concrete grade 25N/mm^2 and w/c ratio of 0.55 was used. The result of the concrete properties is shown in table 5. The compressive strength test results with 0% PSA shows a consistence increase in strength from 17.15N/mm^2 to 24.41N/mm^2.

Table 5. Compressive strength of 0% PSA replacement

Sample	Age of Testing	Slump Value(mm)	Weight of Cubes (Kg)	Density of Cubes (kg/m^3)	Crushing Load (Kg)	Average Crushing Strength (f_{cu})(N/mm^2)
1a	7 days	45	2.37	2370	161.9	17.15
1b		::	2.39	2390	169.5	
1c		::	2.37	2370	183.0	
2a	14 days	45	2.40	2400	205.8	20.82
2b	::	::	2.35	2350	220.7	
2c	::	::	2.35	2350	198.2	
3a	21 days	45	2.40	2400	235.8	23.93
3b	::	::	2.40	2400	234.9	
3c	::	::	2.50	2500	248.6	
4a	28 days	45	2.47	2470	218.4	24.41
4b	::	::	2.47	2470	250.6	
4c	..	..	2.49	2490	263.2	

Periwinkle Shell Ash Concrete: It was observed that the inclusion of Sisal fiber in the concrete increases the compressive strength of concrete, the highest value of compressive strength was 28.8N/mm^2 at 5% replacement and a cut length of 40mm Sisal fiber.

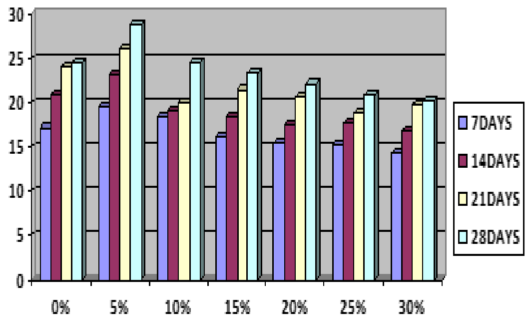

Fig 3 Compressive Strength with percentages of Replacement at different curing days

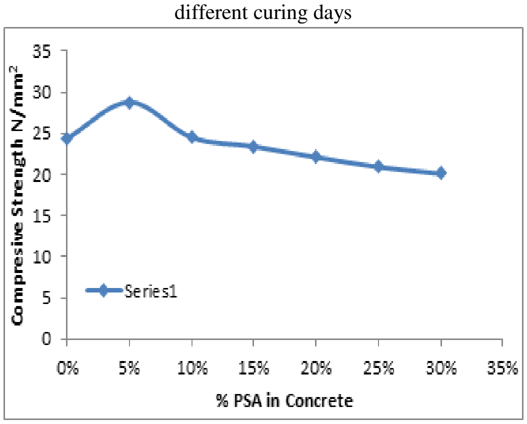

Fig 4.28 Days Curing with Varied Percentage of PSA

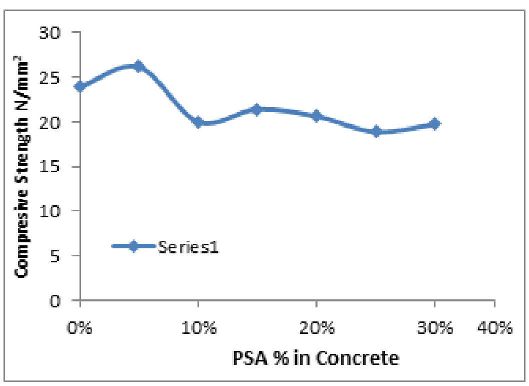

Fig 5. 21 Day Curing with Varied Percentage of PSA

It can be observed that the inclusion of periwinkle shell ash and sisal fiber in a concrete increases the compressive strength of concrete and the highest value of compressive strength was obtained at 5% replacement of PSA in a sisal fiber-reinforced-concrete. Significant increase in the compressive strength is recorded in 21 and 28 days of curing whose peaks are at 5% replacement in fiber-reinforced-concrete. This invariably shows that 5% PSA replacement is the optimal PSA content since it gives the maximum compressive strength with the concrete cured at 28days. Also, for 10% PSA replacement and at a curing age of 28 days, there is an observed increase in compressive strength which is as good as a 0% PSA replacement at 28 days of curing. From this study, it can therefore be deduced that 5% PSA replacement can be regarded not only as the optimal PSA content but also as an exclusive PSA content in that, the use of PSA can be narrowed down to the 5% partial replacement content or not to be used at all, that is, 0%. This is because between 10 and 30% of PSA, no compressive strengths obtained reaches that gotten at 0%.

Conclusion: The results of the study Sisal fibre can be used as reinforcement to increase the compressive strength of a concrete.The compressive strength obtained decreases as the percentages of replacement increases after 5% PSA.The compressive strength of concrete at 15% replacement and at 28 days curing, however, satisfies BS 4550 Part 3 section 3.4 requirements.The use of Sisal fiber at 1 %by weight of the entire concrete mass and of 40mm length can be considered an optimal percentage for concrete in view of the highest compressive strength obtained at 28 days curing and is hereby recommended as adequate.

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