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Production of Periwinkle Shell Reinforced Grindstone

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ABSTRACT: The study involves the use of periwinkle shell particles as reinforcement in the production of grindstone to meliorate its physical and mechanical properties. The assessment of the properties of the periwinkle shell reinforced concrete grindstone showed that reinforcement yielded several promising results. The compressive strength was higher for samples with lower water/cement ratio (7%) than those with higher water/cement ratio (10%). The introduction of concrete that contains periwinkle shells as fine aggregates resulted in the loss of smooth like appearance and reduction in weight. The loss of its smooth like nature introduces the rough nature which improved its functionality. The reinforced sample had the lowest hardness test and in hardness test the lower the number the higher the hardness. There was an increase in the density after absorption test was carried out on specimens. There was also reduction in production cost with periwinkle shells partial replacement of cement and gravel as fine aggregate. The composite was adequate for grindstone production since its sample has a compressive of 18.15Mpa and thus satisfied MOR requirements of 11.5 MPa for general purpose boards.

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A grindstone is a round sharpening stone used for grinding or sharpening of ferrous tools White (1962). It is a special rock formation from the Marshall sandstone. Grindstone is produced from a combination of cement, sand, aggregate and water, which are mixed in a particular proportion to get a particular strength. The cement and water react together chemically to form a paste, which binds the aggregate particles together White (1962). Periwinkle is any of small, often edible marine, especially of the genus littorina having thick, cone shaped and whorled shells (Orangun, 1974; Osayemwen, 1992). Periwinkles are widely distributed shore (littoral) snails, chiefly herbivorous, usually found on rocks, stones, or pilings between high- and low-tide marks; a few are found on mud flats, and some tropical forms are found on the prop roots or mangrove trees Periwinkles are the most known of "snail like" mollusks found on Cornish shores of Africa and western areas of Nigeria are part of these regions where they are found, harvested and processed, Olutoge *et al*., (2012). The edible part of periwinkle is used as meat while Periwinkle shell has remained one of man's useful raw materials in his creative art which he has to end successfully employed in the creation of accessories such as household dishes, cooking pots, cutleries, scoops, spatulas, fish lures, octopus lures, hooks and sinkers, tweezers, tongs and claspers, shovels plow, blades, hoes, scrappers etc. (Idris *et al*., 2011, 2012; Menandro, 2010; Osarenmwinda and Awaro, 2009). The inflationary trend in the Nigeria economy escalated the cost of abrasive materials to the extent that many of the conventional materials are no longer affordable for the manufacture of concrete grindstone (Balogun, 1986). The most expensive constituent is cement and in terms of quantity, the most demanding are fine and coarse aggregate. To this effect a search for locally available standard materials that would substitute these aggregate partially or wholly without compromising strength. The choice of

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the locally available materials for this purpose depends on three main factors; Strength, Availability and Economy. A possible alternative was found in periwinkle shells**,** this is because periwinkle shells possess some mechanical properties which undoubtedly eliminate the deficiencies associated with the concrete grindstone, such as: Lighter weight aggregate (as it has lower bulk density), Good bonding properties, Compressive strength and Good compatibility and availability (Falade, 1995; Bamidele 2002). The study aimed at evaluating the use of periwinkle shell particles as reinforcement in the production of grindstone to improve its physical and mechanical properties

MATERIALS AND METHOD

Sample Collection and preparation: The materials used for the preparation of the periwinkle shell reinforced concrete grindstone are grouped into two: Equipment's and Conventional materials. The following equipment's were used for the mixing of the aggregate: Mixing basin, Hand Trowel, Shovel, Tape, Rubber gloves, Groove cutters, Manual hand compactor and Weighing scale. Conventional materials are those materials that were used for mixing. They include: Aggregates (fine gravel) Cement, Water, periwinkle shell and Sharp sand. The proportioning of concrete grindstone mixture is a process by which one arrives at an economical and practical combination of concrete ingredients to produce quality concrete. Experimental and statistical approach was adopted in this project. Physical and mechanical properties of periwinkle shell reinforced grindstone was also determined and compared. The manufacturing process used in this project work is as follows: Preparation of the mixture, Mixture of the grindstone, Construction of mold, Casting of the mixture and Curing.

Preparing the grinding wheel mixture begins with selecting precise quantities of abrasives, bond materials, and additives according to a specific formula. The cement used in this work is a type of Portland cement called, ordinary Portland cement (opc**)** which is grey in colour. Ordinary Portland cement was gotten from Dangote cement factory in Gboko, Benue State of Nigeria and was used as binding agent together with River Benue sharp sand and washed sundried fine gravel. The periwinkle shells used in this work was obtained from Watt market, Calabar Cross River Sate. The periwinkle shells are the remains after the shells were cooked and the edible part removed. Impurities such as soil and other dirt are removed from the (PWS) by thoroughly washing it. Hand-picking of further impurities was done before the project was carried out. The periwinkle shell was then sundried thoroughly for about 2 months before it was taken for grinding. The periwinkle shell was grounded at Michael Okpara University of agriculture Umudike with the help of periwinkle grinding machine to its fine aggregate as shown in fig.1 before use.

Fig 1: Grounded Periwinkle Shell

The periwinkle shell, sharp sand and fine aggregate used in this work went through sieve analysis before being used for the experiment**.** Sieve analysis is a procedure carried out to access the particle size distribution (gradation) of a material by allowing the material to pass through a series of sieves of progressively mesh size using the following equipment's. Mechanical shaker, Beam balance with weights, Necessary sieves and bottom, Necessary pails pans and containers, Brushes for cleaning pans and sieves. Procedures used in the sieve analysis include;

i) A good representative of sand, periwinkle shell and gravel was secured.

ii) The sample was reduced to the required size with a filler sieve.

iii) Samples were sundried before usage.

- The mesh of required sieves was set up in a mechanical shaker. The mesh of the sieve was arranged in decreasing order E.G Mesh size of 3.0mm, 2.5mm, 2.0mm, 1.9mm, 1.5mm, 1.4mm.
- The sample was Weighed and mass recorded (weight) to nearest 1 g (0.1 lb.).
- The sample was poured into the mesh of sieves and shake for a minimum of 7 minutes. Hand fitting of rock through a sieve was avoided.
- Each material was examined on the sieve for clay balls; if present, was hand-picked and discarded.
- The sample was passed from one level of mesh to the other.
- Finally the sieve with mesh size 1.40mm was used for the work as it tallies with the particle size of other aggregate.

The table 1 below shows the grading size of each material used in this work after a detailed sieve analysis was carried out on them

Table 1: Grading of aggregates

	Grade/Particle size(mm)							
Sample	A	B	C	D	E	F	G	H
Aggregate(fine gravel)	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Sand	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Periwinkle shell	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40

Table 2: Compositions of mixture

Specimen	Water (%)	Sand (%)	Cement (%)	Fine Aggregate (%)	Periwinkle Shell (%)
A.	8.34	7.63	36.69	32.45	14.89
B.	7.63	9.13	33.07	32.74	17.43
C.	7.00	7.00	45.00	31.00	10.00
D.	7.00	8.50	39.50	35.00	10.00
E.	8.50	10.0	30.00	35.00	16.51
F.	7.00	8.50	34.50	30.00	20.00
G.	7.00	10.0	43.00	30.00	10.00
H.	8.00	7.00	30.00	35.00	20.00

Production of reinforcement grindstone: The mixing was done by taking different Percentage (%) of the materials. The table 2 below gives a summary of the compositions for each specimen. Before mixing, protective measures were worn; hand gloves were worn, the basin was washed thoroughly, and the environment was made clean. Mixing of the grindstone was done mainly by hand with the aid of a hand trowel in the mixing basin. The cement and water was first mixed into a paste according to the design percentage before combining fine aggregate, sand and the periwinkle shell according to design specifications. The cement reacts with water and other ingredients to form a hard matrix that binds the materials together. Because from previous studies mixing of cement and water separately increases strength in the mixture. The whole constituents were mixed until an even paste was obtained. The mixture forms slurry that is easily poured and molded into shape. Example 8.34% of water and 36.69% of cement was first mixed before adding 7.63% of sand, 32.45% fine aggregate and 14.89% of periwinkle for a particular mixture Sample.

Small rectangular molds were constructed from clay material. The mold serves as housing for the mixed constituent so as to give it a definite shape and enhance smooth finishing. A measuring tape was used to get the dimension of the mold.

The thickness and length of the mold cavity is 35mm by 52mm while the outer is 37mm by 54mm. The mold was made air tight and sealed properly because of its slurry form it could pour out. Separate molds were constructed for specimen A to H.

After the mold was constructed the next step carried out was casting the mixture. Before the mixture was cast a releasing agent called In and Out releasing Agent was applied in the mold cavity**.** Before usage it was diluted with water. Mixing is done by hand; it is not shacked or agitated, as it could be foamy. How you dilute in and out is dependent on the concrete aggregate mixture and the form material that is been casted into. The entire mold cavity was cleaned to make it free from dust and well coated with the releasing agent. After applying the releasing agent on the mold, the mixture was poured from the mixing basin into the mold and then vibrated (shacked) as necessary to remove air bubbles. Failure in removing air bubbles leads to surface voids or bug holes.

The grindstone was kept moist during curing in order to achieve optimal strength and durability. Curing was done at normal temperature. Depending on the level of curing, the cubes were removed at the end of 28 days from the day of casting and dried at room temperature for 2 hours before testing. Care was taken to avoid freezing or overheating due to the exothermic setting of cement. Improper curing could cause reduced strength, scaling, poor abrasion resistance and cracking. After curing the next step was finishing. Finishing involves smoothing and polishing the samples with brush to give it a smooth appearance. After which samples were labeled A to H as shown in fig. 2.

Fig 2: Prepared periwinkle shell reinforced grindstone

*Assessment of the properties of reinforced grindstone***:** The following properties were evaluated: Compressive strength, Tensile strength, and hardness and Water absorption. Compressive strength or compression strength is the capacity of a material or structure to withstand loads tending to reduce size as opposed tensile strength which withstands loads tending to elongate. This is the resistance of a material breaking under compression. Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures according to Beredugo (1990) as shown in equation (1).

$$Compressive\ strenght = \frac{f}{a} \qquad (1)$$

The compressive strength test was carried out in the mechanical laboratory situated at Proda, Enugu. The test was carried out with an automated compressive tester. The specimen was first placed on the plate. The specimen was aligned centrally on the base plate of the machine. From the top the handle was rotated in the clockwise direction so that it touches the top surface of the specimen. When the top and lower plate firmly holds the specimen load was applied gradually without shock till the specimen failed. The procedure was repeated for all samples. Readings were recorded from specimen A-H. Ultimate tensile strength (UTS), often shortened to tensile strength (TS), ultimate strength is the stress at which a force applied causes the material to lengthen then break. Ultimate tensile strength is measured by the maximum stress that a material can withstand while being stretched or pulled before breaking. For an axially load material the breaking strength in tension is given in equation (2) (Azam *et al.,* 2009)

$$s = \frac{p}{a} \tag{2}$$

Where: *S* = breaking strength; *P* = force that can cause it to break; *A*= cross-sectional area.

The hardness test carried out in this project is Rockwell hardness test. The test was done with an automated hardness tester. The specimen was first placed on the anvil the test axis was within 2-degrees of perpendicular to ensure precise loading; there was no deflection of the test sample during the loading application from conditions such as dirt under the test specimen or on the elevating screw.

The wheel was rotated in clockwise direction moving the load towards the indenter. At the point where the indenter holds the specimen firmly, the start button is pressed. Readings are taken from the dial face and then recorded. This procedure was repeated for specimen A to specimen H. the hardness number was determined from equation (3) and (4) (Salau 1990).

$$HBW = \frac{Test\ force}{Surface\ area\ of\ indentation} \tag{3}$$

$$HBW = 0.102\frac{2P}{\pi D(D - \sqrt{D^2 - d^2})} \tag{4}$$

Where, p, d, D represent the load, diameter of indentation and diameter of indentor respectively

Durability Test: This was determined according to ASTM procedure (ASTM D96-06). Rectangular specimens were cut from each sample and weighed to the nearest 0.001g. The samples were immersed in water for 24 hours at room temperature. Excess water on sample surface was removed before reweighing. The percentage increase in mass during immersion was calculated to the nearest 0.01% using the following equation (Idris *et al*., 2012):
A*RWR* (%) = Weight after 24 hrs – initial weight.

$initial\ weig$ht x 100

$$K = \frac{Q}{A}\left(\frac{thickness\ of\ material}{\Delta T}\right) \tag{5}$$

Where K = Thermal conductivity

$$Q = KA\frac{dt}{ds} \tag{6}$$

Where Q = Theoretical heat input

RESULTS AND DISCUSSION

Wear rate test and heat conduction test values of various samples were determined as shown in tables 3 and 4 and the various results from each table shows that sample C has the minimum wear rate, of 0.012mm/min, 0.022mm/min and 0.036mm/min for contact force/pressure of 5KN, 10KN and 15KN respectively at 2500rev/min.

Result of the hardness test in table 5 showed that sample C with composition 7.00% water, 7.00% sand, 45.00% cement, 31.00% fine aggregate and10.00% periwinkle shell had the lowest hardness test when compared to the control sample made. The control sample had the highest hardness number. In hardness test the lower the number the higher the hardness, increase in the value shows less hardness while decrease in the hardness number shows high hardness.

Table 3: Result of contact force per pressure at different revolution per min.

Sample	Contact force/pressure of 5KN at 2500 Rev/Min (Wear rate)	10KN Contact/Pressure at 2500 Rev/Min	15KN Contact/Pressure at 2500 Rev/Min
A	0.025mm/min	0.033mm/min	0.045mm/min
B	0.023mm/min	0.031mm/min	0.043mm/min
C	0.012mm/min	0.022mm/min	0.036mm/min
D	0.013mm/min	0.023mm/min	0.033mm/min
E	0.024mm/min	0.032mm/min	0.044mm/min
F	0.026mm/min	0.035mm/min	0.046mm/min
G	0.025mm/min	0.034mm/min	0.045mm/min
H	0.024mm/min	0.036mm/min	0.043mm/min

Table 4: Table for Temperature Values

Sample A	Input Q 20 watt	T_1	T_2	T_3	T_4	T_5	T_6
		66 C°	64 C°	62.4 C°	55.0 C°	54.6 C°	54.2 C°
Sample B	Input Q 20 watt	65C°	67C°	63C°	55C°	59C°	66C°
Sample C	Power Input Q 20 Watt	68 C°	66 C°	64.2 C°	54 C°	33.4 C°	52.5 C°
Sample D	20 Watt	70 C°	68 C°	66 C°	54.1 C°	56.2 C°	55.9 C°
Sample E	20 Watt	66C°	68C°	64C°	56	60	67
Sample F	20 Watt	73.2 C°	71 C°	70.0 C°	62.1 C°	61.4	61.1
Sample G	20 Watt	79 C°	77.1 C°	75.3 C°	65.7 C°	64.7 C°	64.2 C°
Sample H	20Watt	83.2 C°	81.4 C°	78.8 C°	70.6 C°	69.6 C°	69.1 C°

Table 5: Results of hardness, Compressive Strength and Tensile Strength test carried out on samples

S/N	Sample	Hardness Test (Hrn)	Compressive Strength (Mpa)	Tensile Strength (Mpa)
1	Control	12	12	8
2	A	10	15.88	10.2
3	B	9.9	15.33	10.23
4	C	8	18.15	12.50
5	D	11	15.19	8.02
6	E	8.5	8.5	6.0
7	F	10.5	13.94	8.5
8	G	9	9.37	9.22
9	H	9.5	14.14	7.0

Result of the compressive strength in table 5 showed that sample C with composition 7.00% water, 7.00% sand, 45.00% cement, 31.00% fine aggregate and10.00% periwinkle shell had the highest compressive strength when compared with the control sample made. Increase in the value shows increase in compressive strength. The tensile strength result in table 5 showed that sample C with composition 7.00% water, 7.00% sand, 45.00% cement, 31.00% fine aggregate and10.00% periwinkle shell had the highest tensile strength when compared to the control sample made. Increase in the value shows increase in compressive strength.Result of water absorption of the composites is shown in the table 6. All the values obtained from the samples were higher than the unmodified sample (control). It can be observed that water absorption increased with increase in all samples after immersing them in water, with the least values obtained at sample G. Results showed that there is percentage increase in water absorption in sample C. As a result, water molecules could more easily penetrate.

Table 6: Water Absorption Test Result

Sample No.	Dry weight **(**kg**)** W1	Weight Of Specimen After Immersion (Kg) W2	water absorption (%)
Control	0.36	0.39	0.03
A	0.4	0.5	0.1
B	0.38	0.49	0.11
C	0.42	0.55	0.13
D	0.39	0.49	0.10
E	0.392	0.48	0.088
F	0.399	0.5	0.101
G	0.37	0.46	0.09
H	0.385	0.47	0.085

Conclusion: The use of periwinkle shell particles as reinforcement in concrete matrix brings about improvement in the physical and mechanical properties of the concrete. The assessment of the properties of the periwinkle shell reinforced concrete grindstone showed that reinforcement yielded several promising results.

This reinforced grindstone is recommended for uses both domestically and industrially just like other existing technologies. It can be used for grinding, filing and sharpening. Rough nature of the grindstone increase due to introduction of periwinkle shell gives it better efficiency.

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