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Atili Seed Shell as Partial Replacement of coarse Aggregate in No-fines Concrete

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Abstract:- This research assessed the suitability Atili seed shell as partial replacement of conventional coarse aggregates in no-fines concrete. Six mixes were prepared using design mix ratio of 6:1 (coarse aggregates/cement) and water-cement ratio of 0.4. Coarse aggregate was partially replaced with Atili seed shell at 0%, 10%, 20%, 30%, 40% and 50%. The workability of the mixes was assessed using compacting factor tests. 100x100x100mm concrete cubes and 100x100x500mm concrete beams were cast and tested for compressive strength and flexural strengths respectively at 7, 14 and 28 days. The water absorption of the mixes was also assessed. The results show that the workability of no fines concrete improves as the percentage replacement coarse aggregate with Atili seed shell increases. The compressive strengths of all the samples fall within acceptable range of compressive strength of no-fines concrete. The compressive strengths of samples with 10%, 20% and 30% replacements of coarse aggregate with Atili seed surpasses the minimum compressive strengths of 3.50 specified for load bearing walls in buildings. The flexural strengths of the samples at 0%, 10%, 20%, 30%, 40% and 50% replacement levels were 2.25N/mm^2, 2.09N/mm^2,1.67N/mm^2, 1.34N/mm^2, 1.09N/mm^2 and 0.92N/mm^2 respectively. The flexural strength of no fines concrete reduces with increase percentage replacement coarse aggregate with Atili seed shell. The percentage of water absorbed by the concrete reduced as the percentage replacement coarse aggregate with Atili seed shell increases. Up to 30% replacement of coarse aggregate with Atili seed shell can be adopted in no fines concrete for load bearing walls.

Keywords:- *No-Fines Concrete; Atili Seed Shell; Workability; Flexural Strength; Compressive Strength; Water Absorption.*

I. INTRODUCTION

No-fines concrete is a concrete consisting of cement, coarse aggregate and water [1]. No-fines concrete is sometimes referred to as pervious concrete, permeable concrete, porous concrete, zero-fines concrete, open-textured concrete, gap-graded concrete or enhanced-porosity concrete. The size of aggregates used in no-fines concrete mixing are normally range from the size passing through 20 mm and retained on 10 mm sieve [1].

The strength of No-fines concrete is dependent on the water cement ratio, aggregate cement ratio and unit weight of concrete. The water cement ratio for such concrete will vary between a narrow range of 0.4 to 0.5 [3]. The compressive strength of No-Fines concrete ranges between 1.4 N/mm^2 to about 14 N/mm^2 [3]. No-fines concrete is generally made with aggregate/binder ratio of 6:1 to 10:1. Coarse aggregates used are normally of size passing through 20 mm sieve and retained on 10 mm sieve [1]. Somehow no-fines concrete will not combine with steel reinforcement due to bonding issue unlike normal reinforced concrete. However, if the addition of steel reinforcement is necessary, protection to prevent corrosion of steel reinforcement have to apply [4].

No-fines concrete is employed as sustainable and eco-friendly means of construction. No-fine concrete allows a significant amount of storm water to seep into the ground, thereby recharging the groundwater and reducing the storm water runoff [1]. No-fines concrete is employed in pavements. No-Fines concrete has also been used in walls of houses due to its thermal insulation behavior [4]. No-fines concrete has advantages of having low density which when used to construct building can reduce the dead weight [5]. No-fines concrete relative density may be much lower if lightweight coarse aggregate is adopted in concrete mix [6].

Effort to produce affordable houses which will impose less environmental stresses and make construction sustainable has compelled research on the use of alternative materials. Such materials according to Osei and Jackson [7] should be locally available and can replace conventional ones used in construction. Furthermore, the materials should be cheap, readily available and contribute to stress reduction on the environment

Canarium schweinfurthii is a large forest tree with its crown reaching to the upper canopy of the forest, with a long clean, straight and cylindrical bole exceeding 50 m [8]. *Canarium schweinfurthii* produces a fruit locally called “Atili”. The fruit is commonly found in large quantity in Pankshin, Plateau State of Nigeria and is also produced in similar quantities in other states of the northern and south-eastern Nigeria. The plant produces its fruits in the rainy season (usually) between the months of April and September. The fruit is cooked and yields oil, sometimes used as a substitute for shear butter [9].

The fruit contains a very hard seed with shell which can be used as aggregate in concrete. Muhammad, Ibrahim and Kaura [10] found that crushed Atile seed shell can be used as partial replacement of fine aggregate in concrete. Yohanna, Bang, Zakka & Anigbogu [11] also found Atili seed shell

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suitable as partial replacement of coarse aggregate in concerte.

This study is aimed at assessing the suitability of Atili seed shell as partial replacement of conventional coarse aggregate in no-fines concrete.

II. MATERIALS AND METHODS

Ordinary Portland cement, coarse aggregates (granite), Atili seed shell and water were the materials used in this study. Dangote (3X) brand of ordinary Portland cement (OPC) manufactured by Dangote Cement Company was used in this study. The cement conforms to [12]. Machine-crushed coarse aggregates of max diameter between 10mm to 20mm procured from a private Quarry in Jos, Plateau State, Nigeria were used in this study. The specific gravity of the conventional coarse aggregate was found to be 2.57. The bulk density of the conventional coarse aggregates was found to be 1428.19kg/m^3.

The atili seed shells used in this research were obtained from Jiblik village in Pankshin Local Government Area of Plateau State, Nigeria. They were stockpiled, washed and sun-dried. Since the sizes of the seed shell ranged from 10mm to 20mm which was almost the same size as that of the coarse aggregates (gravel), they were used without crushing. The bulk density of the Atili seed was 721.14kg/m^3 while the specific gravity was 1.21.

The water used in this study was obtained from taps in concrete laboratory of Department of Building, University of Jos. The water is fit for drinking.

The aggregate/binder ratio of 6:1 was adopted for the production of the no-fines concrete at a water-cement ratio of 0.40. Coarse aggregate was replaced with Atili seed shell at 0%, 10%, 20%, 30%, 40% and 50%. Batching by absolute volume was adopted.

The concrete mixing was done manually. Since there is no sand (fine aggregate), the quantity of coarse aggregate was first measured and poured on the floor followed by a percentage of the atili seed shell and then the cement quantity was measured and spread on the aggregates. The materials were mixed using shovel. The required quantity of water was measured and added to the mix and then mixed altogether until a uniform mix of coarse aggregates, Atili seed shell, cement and water was obtained.

The workability of the mixes was tested through compacting factor test since no-fines concrete is said to have self compacting properties. The slump and VEBE tests are not good for testing no-fines concrete due to the low cohesion between the aggregate particles [13]. The compaction factor tests were also conducted on each concrete mix in accordance with the provisions of [14]. The wet concrete was then cast into cubes, cylinders and beams. After setting for 24 hours, the specimens were demoulded and cured in water for 7, 14 and 28 days.

The compressive strength and flexural strength of the concrete specimens were determined in accordance with the provisions of [15] and [16] respectively. Water absorption tests were conducted on each mix in accordance with [17].

III. RESULTS AND DISCUSION

A. Compacting Factor Test Results

The results of the compacting factor tests are presented in Table 1.

It was observed that the increment in percentage replacement of coarse aggregates with atili seed shell increased the compacting factor of no-fines concrete. This implies that replacement of coarse aggregates with Atili seed shell improves the workability of no-fines concrete.

The compacting factor values at 0%, 10%, 20%, 30%, 40% and 50% replacements of coarse aggregate with atili seed shell were 0.81, 0.85, 0.88, 0.90, 0.93 and 0.96 respectively. It showed that the concrete becomes more workable with the introduction of a lightweight material.

Table 1: Compacting Factor Test Result

Percentage Replacement	W/C ratio (kg)	Weight of uncompacted concrete (kg)	Weight of fully compacted concrete (kg)	Compaction factor A/B
0% (Control)	1.89	13.07	15.97	0.81
10%	1.89	12.82	15.01	0.85
20%	1.89	12.44	14.03	0.88
30%	1.89	11.72	13.09	0.90
40%	1.89	11.42	12.28	0.93
50%	1.89	10.78	11.23	0.96

B. Compressive Strength Test Results

The compressive strengths of the no-fines concrete samples after hydration periods of 7, 14, and 28days are presented in Figure 2. The results showed an increase in the average compressive strengths as curing duration increases and decreases in compressive strengths as percentage replacement coarse aggregate with Atili seed shell increases. At the 28th days, the compressive strengths of the samples at 0%, 10%, 20%, 30%, 40% and 50% replacements of coarse aggregate with Atili seed shells were 5.75, 5.17, 5.00, 4.17, 3.00 and 2.33 respectively. The compressive strengths of all the samples fall within acceptable range of compressive strengths of no-fines concrete. The compressive strengths of samples with 10%, 20% and 30% replacements of coarse aggregate with Atili seed surpasses the minimum compressive strengths of 3.50 specified for load bearing

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walls by [18]. Therefore conventional coarse aggregates can be partially replaced with up to 30% Atili seed shell for load bearing walls.

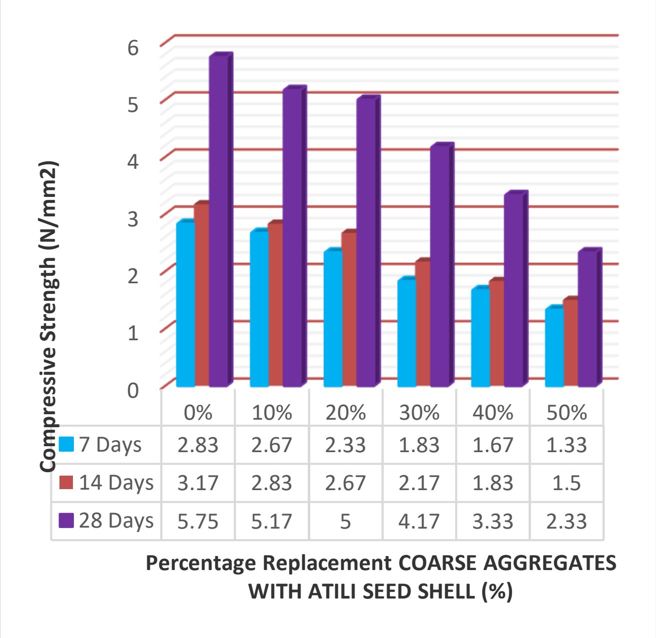

Fig 2. Result of Compressive Strength Test (N/mm^2)

C. *Flexural Strength Test Results*

The flexural strengths of the no-fines concrete specimens at hydration period of 7, 14, and 28days are presented in Figure 3. The flexural strengths increases with increase in curing duration and decreases with increase in percentage replacement of coarse aggregate with Atili seed shell. At the 28th days, the flexural strengths of the samples at 0%, 10%, 20%, 30%, 40% and 50% replacement levels were 2.25N/mm^2, 2.09N/mm^2,1.67N/mm^2, 1.34N/mm^2, 1.09N/mm^2 and 0.92N/mm^2 respectively.

The flexural strengths of specimens containing 40% and 50% atili seed shell were quite low that no readings were recorded by the testing machine at the curing age of 7 days. The results also showed a decrease in the average flexural strength as the percentage replacement coarse aggregate with Atili seed shell increases. The results show a similar pattern to that of the compressive strength.

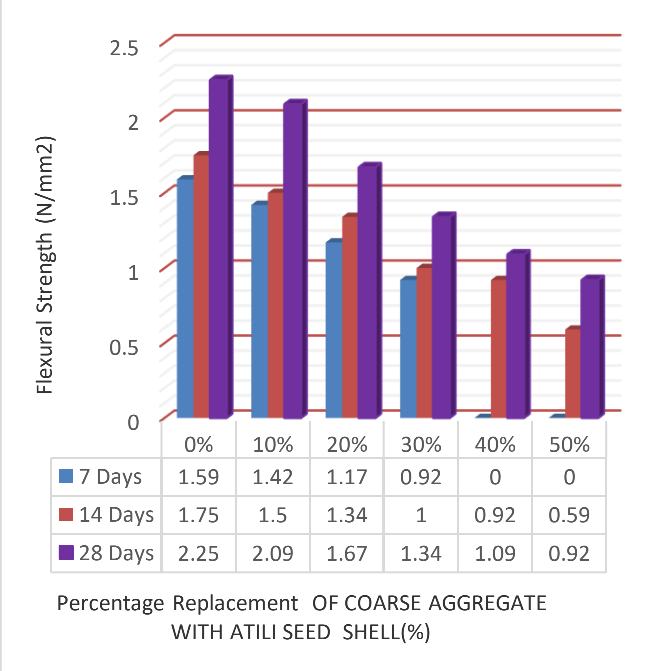

Fig 3. Result of Flexural Strength Test (N/mm^2)

D. *Water Absorption Test Results*

The results of water absorption tests are presented in Table 2. The results showed that with every increase in the percentage replacement of gravel with Atili seed shell, there was a decrease in the amount of water absorbed by the concrete. The water absorption of the no-fine concrete samples after curing for 28 days at 0%, 10%, 20%, 30%, 40% and 50% replacements of coarse aggregate with Atili seed shell were 10.40%, 7.20%, 6.41%, 5.94%, 4.81% and 2.44% respectively. At 0% replacement level, the concrete absorbed the highest percentage of water while the water absorption reduced progressively as the percentage of Atili seed shell increases. This development is due to the fact that Atili seed shell has a smooth, hard and less porous surface compared to the conventional course aggregate.

Table 2: Result of Water Absorption Test in Percentage

Mix samples	**Wet weight in (kg)**	**Dry weight in (kg)**	**Water absorption in (%)**
Control mix (0%)	2.650	2.401	10.40
10 %	1.930	1.801	7.20
20 %	1.710	1.607	6.41
30 %	1.480	1.397	5.94
40 %	1.351	1.289	4.81
50%	1.257	1.227	2.44

IV. SUMMARY OF FINDINGS

From the results of the tests carried out, it can be summarized that;

- The workability of no fines concrete improves as the percentage replacement coarse aggregate with Atili seed shell increases.
- The compressive strength of no fines concrete reduces with increase percentage replacement coarse aggregate with Atili seed shell. However, compressive strength of the no fines concrete at up to 50% replacement of coarse aggregate with atili seed ash fall within acceptable limits for no fines concrete. Specimens with up to 30% replacement of coarse aggregate with Atili seed ash can be used as walling material in load bearing walls.
- The flexural strength of no fines concrete reduces with increase in percentage replacement of coarse aggregate with Atili seed shell.
- The percentage of water absorbed by no-fines concrete reduces as the percentage replacement coarse aggregate with Atili seed shell increases.

V. CONCLUSION

The increase in the percentages replacement of the conventional aggregates with Atili seed shell resulted to reduction in compressive strength, flexural strength and water absorption of no fines concrete. The workability of no fines concrete improves as the percentage replacement coarse aggregate with Atili seed shell increases. Up to 30% replacement of coarse aggregate with Atili seed shell can be adopted in no fines concrete for load bearing walls.

REFERENCES

[1]. Alam, A. & Naz, S. (2015). Experimental Study on Properties of No-fine Concrete. *International Journal of Informative & Futuristic Research*, 2(10), 3687-3694.

[2]. Ushane, K.S., Kumar, K.J.P. & Kavitha, C. (2014). Investigation of No-Fines Concrete in Building Blocks. *International Journal of Structural and Civil Engineering Research*, 3(4), 170-177.

[3]. Pateriya, A.S. & Chandurkar, A.R. (2018). No-Fines Concrete with Coir Fibre. *Journal of Innovative Science and Research Technology*, 3(8), 556-558.

[4]. Tittarelli, F., Mobili, A, Giosuè, C. and Ruello, M.L. (2013). Sustainable and Durable No-fines Concrete for Vertical Applications. *International Journal of Chemical, Environmental & Biological Sciences (IJCEBS)*, 1(5), 2320–4087.

[5]. Zaetang, Y., Wongsa, A., Sata, V. & Chindaprasirt, P. (2013). Use of lightweight aggregates in pervious concrete. *Construction and Building Materials*, 48, 585-591.

[6]. Prathyusha, K. & Rao, S.K.V. (2016). *Strength and Permeability Properties of No-Fines, Light Weight Concrete*. *An Experimental Study*, 3(4),

[7]. Osei, D.Y., &Jackson, E.N. (2012). Experimental Study on Palm Kernel Shells as Coarse Aggregates in Concrete. *International Journal of Scientific & Engineering Research, 3*(8), 1-6.

[8]. Ngbolua, K., Moke, L.E., Lumande, J.K. & Mpiana, P.T, (2015). Canarium schweinfurthii Engl. (Burseraceae): An Updated Review and Future Direction for Sickle Cell Disease. *Journal of Advancement in Medical and Life Sciences*, 3(3), 1-5.

[9]. Agu, H. O., Ukonze, J. A., &Uchola, N. O. (2008). Quality Characteristics of Crude and Refined Atilli Oils, *Pakistan Journal of Nutrition 7 (1): 27-30.*

[10]. Muhammad, U.I., Ibrahim, A.U. & Kaura, M.K. (2021). Effect of partial replacement of sand with African Elemi (canarium schweinfurthii) in concrete. *Direct Research Journal of Public Health and Environmental Technology*, 6, 52-61.

[11]. Yohanna, H.S, Bang, P.D, Zakka, P.W & Anigbogu, N.A. (2019). Optimization of partial replacement of concrete coarse aggregate with crushed canarium schweinfurthii (atili) seed shell. *International Journal of Scientific and Research Publications*, 9(3), 507-516.

[12]. British Standards Institution, BS EN 196-3. “Methods of Testing Cement: Determination of Setting Times and Soundness”. London, England, 2016.

[13]. Mageswari, M., Karthikeyan, M.P., Pavithran, S., Rajkumar, M., & Govindarajan, R. (2016). High strength permeable pavement using no fines concrete. *SSRG International Journal of Civil Engineering*, 3(3), 53-57.

[14]. British Standards Institution, BS 1881 Part 103:1993. “Method for Determination of Compacting Factor,” 1993.

[15]. British Standards Institution, BS EN 12390-3. “Testing Hardened Concrete. Compressive strength of test specimens”. 2019; 1-24.

[16]. British Standards Institution, BS EN 12390-5. Testing Hardened Concrete. Flexural Strength of Test Specimens”. 2019; 1-14.

[17]. American Society for Testing and Materials, C1585. “Standard Test Method for Measurement of Rate of Water Absorption in Hydraulic Cement Concrete”. ASTM International, 2016.