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Compressive Strength Characteristics of Pawpaw Leaf Ash and Bamboo Leaf Ash Blended Cement Concrete

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ABSTRACT: The study determined the physical properties of pawpaw leaf ash and bamboo leaf ash blended cement concrete, the effect of curing age on compressive strength characteristics of pawpaw leaf ash and bamboo leaf ash blended cement concrete, and the effect of percentage replacement of cement with pawpaw leaf ash and bamboo leaf ash blended cement concrete on compressive strength. 100 ×100×100 mm cubes specimens were cast, and the concrete compressive strengths were determined at 7, 14, 21 and 28 days of curing. The control sample, with 0% BLA and PLA replacement, exhibited the highest strength at 28 days but the lowest at 7 days. The sample with 5% BLA and PLA replacement showed an increase in strength at 14 days, a decrease at 21 days, and another increase at 28 days, with the highest strength observed at 14 days. On the other hand, the samples with 10%, 15%, and 20% BLA and PLA replacement demonstrated a consistent increase in strength, although a decrease in strength was observed at 28 days. The experiment revealed that the highest compressive strength was achieved at 28 days with 0% BLA and PLA replacement, while the lowest compressive strength was observed at 7 days with 20% BLA and PLA replacement. These findings indicate that the rate of strength development in BLA and PLA blended cement concrete is slower during the early curing period (7 days) but accelerates during later ages (14 days and 21 days), with a slight decrease at 28 days. In contrast, the control sample without BLA and PLA replacement exhibited slow strength development initially (7 days) but showed faster progress at later ages. Based on the test results, 20% replacement was found to be the optimum level for both compressive strength and workability of concrete with cement partially replaced with BLA and PLA.

KEYWORDS: Compressive strength, Bamboo leaf ash, Pawpaw leaf ash, Blended cement concrete

1.0 INTRODUCTION

The shelter is often seen as second only to food on the list of things essential to humans. This is a significant concern developing countries around the world are dealing with. The physical structure and the surrounding local environment are addressed while providing homes for human habitation. Concrete has long been a popular construction material. It is used more often than other construction materials due to its inexpensive cost and availability of constituent elements. Concrete, whose main component is cement, is one of the most extensively used construction materials. For instance, the demand for cement in Nigeria rose from 6.9 million tonnes in 1986 to 7.7 million tonnes in 1990 and increased beyond 10.0 million tonnes by 2000 (Ezeonu, 2004). As the bulk of the population falls below the poverty line, the cost of building materials continues to rise, making construction projects more expensive. As a result, numerous academics are looking for strategies to cut construction project costs.

One of the most prominent recommendations has been to source, create, produce and use widely available alternative natural materials suited for manufacturing any building component as alternatives to the more expensive traditional building materials (Morel et al., 2001). Cement alternatives are one type of alternative natural material. Cement replacements such as pawpaw leaf ash (PLA) and bamboo leaf ash (BLA) can be used in place of cement to increase attributes like strength and durability. Because of the environmental benefits gained from their diversion from the waste stream, the reduced energy required in their re-purposing (as compared to the manufacture of cement), and the conservation of raw materials such as silica, alumina, and iron oxide, the use of cement substitutes is generally encouraged. Portland cement manufacture is not only expensive and energy-intensive, but it also emits a significant quantity of CO_2. One ton of Portland cement emits about one ton of CO_2.

Cement that has been blended is now used in various regions of the world (Baker et al., 2010). One of the hydration products of Portland cement is calcium hydroxide [$Ca(OH)_2$], which contributes significantly to the degradation of cement composites. When locally available materials such as pozzolans are used with Portland cement, it combines with the lime to form more calcium-silicate-hydrate (C-S-H), the primary cementing ingredient. As a result, the pozzolanic substance reduces the amount of lime while increasing the amount of C-S-H. As a result, if a pozzolan is combined with Portland cement appropriately, the cementing quality is improved (Padney et al., 2003).

Bamboo is one of the most common plants in tropical and subtropical climates. Bamboo has the potential to be the area's most important economic resource. These woody-stemmed grass species are noted as being some of the world's fastest-growing plants. One native plant in Asia plays a significant economic role in the livelihoods of the people who live in this region. Bamboo has been identified as an excellent herb and classified as a non-timber forest product (NTFP) plant due to rapid growth, high biomass, quick production, and high efficiency in a few years (Emamverdian et al., 2020). As the use of this material grows, so does the possibility of repurposing waste generated during the manufacturing process to create new materials. Even though many studies explore bamboo for structural reinforcement of concretes, few publications currently report bamboo leaf (BLA) ash as a replacement for cement due to the diversity of available species.

2.0 LITERATURE REVIEW

Several natural waste items are already used in mortar or concrete as mineral admixtures to improve mortar or concrete qualities in fresh and/or hardened condition, such as pawpaw leaf ash, palm kernel shell ash, groundnut shell ash, banana leaf powder, and cattle bone powder (Ettu et al., 2013, Fadele and Ata 2018, Mujedu and Adebara 2016, Ramya and Mercy 2016). Another potential supply is the 20 million tons of bamboo that are processed industrially each year for a variety of uses, such as bamboo furniture, construction materials, and even the high-tech sector (Vrancic 2012). These wastes are either burned or dumped in landfills, which harms the environment by contaminating the air and taking up valuable land. Additionally, bamboo, a naturally occurring lignocellulosic composite, biodegrades (Das & Chakraborty 2006) and emits methane, with an atmospheric heating effect of 72 times higher than that of CO_2 (Karade, 2010).

The impact of bamboo leaf ash (BLA) as a cement substitute on the compressive strength and durability properties of concrete was studied by Asha et al (2014). They discovered that as the amount of BLA was increased, the concrete's compressive strength decreased, but they also noted an improvement in acid and chloride resistance at a 10% replacement of cement with BLA. As a result, they came to the conclusion that BLA concrete should be utilized for civil engineering projects rather than high-strength concrete.

Ademola & Buari (2014) evaluated the strength behavior of bamboo leaf ash-blended cement concrete in a sulphate environment and came to the conclusion that it might be employed in building projects and civil engineering where early strength is not a key requirement in sulphate settings. Umoh & Odesola (2015) looked into the properties of cement paste and mortar containing bamboo leaf ash. They came to the conclusion that the physical properties of the pastes met the requirements set forth by pertinent standards, and the results of the mortar cube tests showed that the compressive strength generally increased with curing age and that, at 28 days and above, the mix containing 15% BLA by mass competes favorably with the reference mix.

Ademola and Ojediran (2019) conducted experiments on PLA-blended concrete and observed that PLA incorporation improved the compressive strength compared to plain concrete. Both PLA and BLA have been found to enhance the compressive strength of concrete when used as partial replacements for cement (Olubajo & Ogunbode, 2020; Oyenuga, et al, 2017).

3.0 MATERIALS AND METHOD

3.1 Materials

The cement used in this experiment was regular Portland Cement (OPC) and was purchased in Akure, Ondo state. The cement was partially replaced with Bamboo leaf ash and Pawpaw leaf ash at various percentages to determine the effect of the replacement on the compressive strength, slump, compaction factor, setting time etc. The aggregates that was used for this experiment was purchased in Ondo state. The aggregates comprised of both the fine aggregate and the coarse aggregate. The sharp sand was used as the fine aggregate and the particle size distribution of the aggregate was determined later in the course of the study. For the coarse aggregate, granite was used, and the size was determined later in the study

Bamboo leaf ash (BLA): The bamboo leaves were gotten collected in Akure, Ondo state, Nigeria. The leaves were dried thoroughly and burnt in an incinerator at a temperature of 600°C to obtain amorphous ash. This was be done at the industrial design workshop, of Federal University of Technology, Akure, Ondo state. After the burning process, the ash was collected and cooled before it was later sieved with a 45 um sieve to get finer ash. Pawpaw leaf ash (BLA): The pawpaw leaves were collected in Akure, Ondo state, Nigeria. The leaves was dried thoroughly and burnt in an incinerator at a temperature of 600C to obtain amorphous ash. This was be done at the industrial design workshop, of Federal University of Technology, Akure, Ondo state. After the burning process, the ash was collected and cooled before it was later sieved with a 45 um sieve to get finer ash.

3.2 Sieve Analysis Test

This test is also known as the gradation test. The test was carried out to assess the particle size distribution of these materials; sand, BLA and PLA. This was done by allowing the material to pass through a series of sieves of progressively smaller mesh size and weighing the amount of material that is retained by each sieve as a fraction of the whole mass.

3.3 Specific Gravity Test

The specific gravity of any material is defined as the ratio of the weight of a given material to the weight of an equal volume of water. The specific gravity of sand, BLA and PLA were carried out to determine their fluid characteristics compared to standard, usually water at a specified temperature.

3.4 Production of Specimen

The combination of BLA and PLA is used to replace ordinary Portland cement at 0%, 5%, 10%, 15%, and 20% by weight while concrete cubes with 0% of BLA and PLA serve as the control experiment. A total number of 60 concrete cubes was cast using 100mm x 100mm x 100 mm cube moulds.

3.5 Casting of Specimen

100mm x 100mm x 100mm cube moulds were used to cast the concrete cubes. The cube moulds were put together before mixing and properly lubricated with engine oil for easy removal of the hardened concrete cubes. each mould was filled with freshly prepared concrete in three layers and each layer was tamped with a tamping rod using thirty-five (35) strokes evenly distributed across the seldom of the concrete in the mould. With a hand trowel, the tops of each mold were leveled and smoothed, and the exterior surfaces were cleaned afterwards. The cast cubes were allowed at room temperature for 24 hours to solidify before the moulds were taken off. The cubes were placed in the curing tank for curing after 24 hours.

3.6 Compressive Strength Test

Compressive strength test was carried out to determine the test specimen ability to withstand loads without any crack or deflection. The concrete cubes was crushed at 7, 14, 21, and 28 days to determine the compressive strength using the Compression testing machine. Before crushing, the cubes was removed from the storage curing tank and kept for about 20 minutes for the water to wipe off. The cubes were taken to the digital compression machine with a maximum capacity of 1000kN in accordance with BS 1881: part 116 (1983). The compressive strength value is the average of the three concrete cubes for each percentage replacement. The load was applied at a constant rate of stress equal to 0.01N/mm^2 per second. The compressive strength at which the samples failed was then recorded to the nearest 0.01N/mm^2. Compressive strength is evaluated using the relation; Compressive strength (N/mm^2) = Crushing Load/Cross-sectional Area of Specimen.

4.0 RESULTS AND DISCUSSION

4.1 Sieve Analysis Test

Tables 1 to Table 3 give the findings of the sieve analysis of the fine aggregates sand, BLA, and PLA) used. The goal was to establish the grading of each sample used and whether or not each sample was appropriate for the intended application. The fine aggregates' particle size distribution curves (sand, BLA, and PLA) were plotted as shown in figures 1 to 3. to determine the coefficient of uniformity for each sample type.

Sample mass = 100g

Table 1: Sieve analysis bamboo leaf ash

Sieve Size (mm)	Mass of Sieve (g)	Mass of Sample + Sample Retained (g)	Mass of sample retained (g)	Percentage Retained (%)	Percentage Passing (%)
4.75	378.9	381.7	2.8	2.8	97.2
2.36	478.6	481.0	2.4	2.4	94.8
1.7	367.3	369.0	1.7	1.7	93.1
1.18	361.4	366.1	4.7	4.7	88.4
0.6	341.7	346.8	5.1	5.1	83.3
0.5	363.5	378.0	14.5	14.5	68.8
0.425	356.2	361.9	5.7	5.7	63.1
0.212	345.2	366.6	21.4	21.4	41.7
0.15	346.8	357.3	10.5	10.5	31.2
0.072	340.5	343.3	2.8	2.8	28.4
pan	138.6	167.0	28.4	28.4	0.00

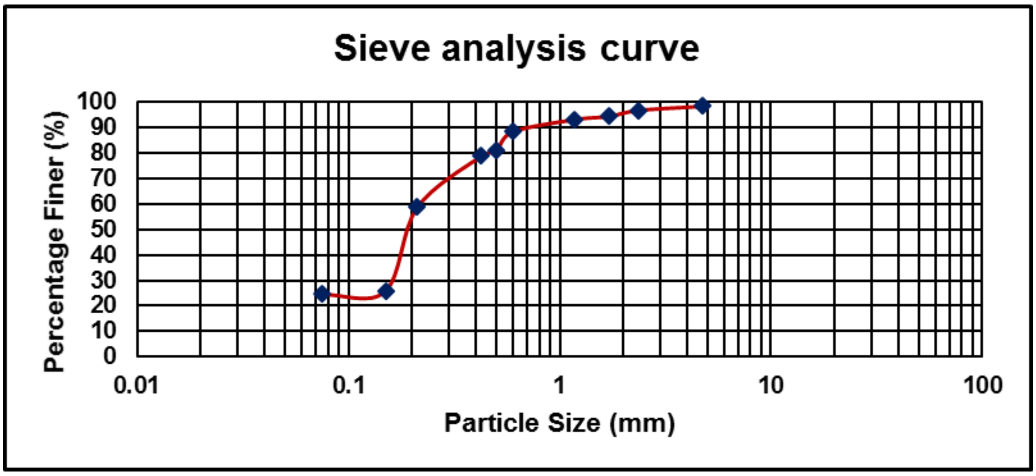

Figure 1: Sieve analysis bamboo leaf ash graph

Fineness Modulus (FM) = $\frac{cummulative\ percentage\ retaines\ on\ standard\ seive}{100}$

$= \frac{2.8+2.4+1.7+4.7+5.1+14.5+5.7+21.4+10.5+2.8+28.4}{100}$

=4.10

Sample mass = 100g

Table 2: Particle size distribution pawpaw leaf ash

Sieve Size (mm)	Mass of Sieve (g)	Mass of Sample + Sample Retained (g)	Mass of sample retained (g)	Percentage Retained (%)	Percentage Passing (%)
4.75	378.9	380.5	1.6	1.6	98.4
2.36	478.7	480.3	1.6	1.6	96.8
1.7	367.2	369.6	2.4	2.4	94.4
1.18	361.4	362.6	1.2	1.2	93.2
0.6	341.5	346.3	4.8	4.8	88.4
0.5	363.1	370.5	7.4	7.4	81.0
0.425	354.9	357..1	2.2	2.2	78.8
0.212	345.2	365.3	20.1	20.1	58.7
0.15	346.2	379.1	32.9	32.9	25.8
0.072	340.5	341.7	1.2	1.2	24.6
pan	138.6	163.2	24.6	24.6	0.00

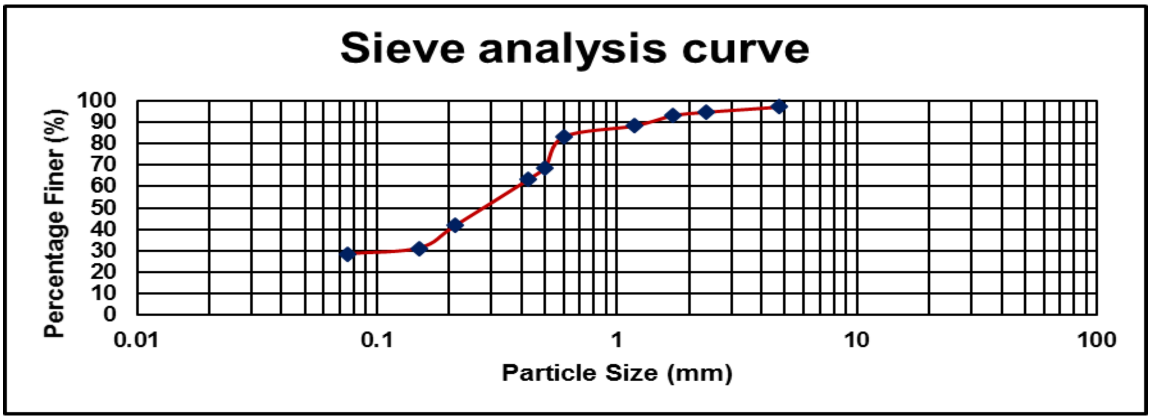

Figure 2: Sieve analysis pawpaw leaf ash graph

Fineness Modulus (FM) = $\frac{cummulative\ percentage\ retaines\ on\ standard\ seive}{100}$

$= \frac{1.6+1.6+2.4+1.2+4.8+7.4+2.2+20.1+32.9+1,2+24.6}{100}$

=3.60

Table 3: Particle size distribution sand

Sample mass = 500g

Sieve Size (mm)	Mass of Sieve (g)	Mass of Sample + Sample Retained (g)	Mass of sample retained (g)	Percentage Retained (%)	Percentage Passing (%)
4.75	378.9	415.9	37.0	7.4	92.6
2.36	478.7	514.3	35.6	7.12	85.48
1.7	367.2	377.0	9.8	1.96	83.52
1.18	361.4	391.3	29.9	5.98	71.54
0.6	341.5	437.8	96.3	19.26	58.28
0.5	363.1	454.3	91.2	18.24	40.04
0.425	354.9	377.1	22.2	4.44	35.60
0.212	345.2	454.4	109.2	21.84	13.76
0.15	346.2	373.4	27.2	5.44	8.32
0.072	340.5	341.1	0.6	0.12	8.2
pan	138.6	223.0	41.0	8.2	0.00

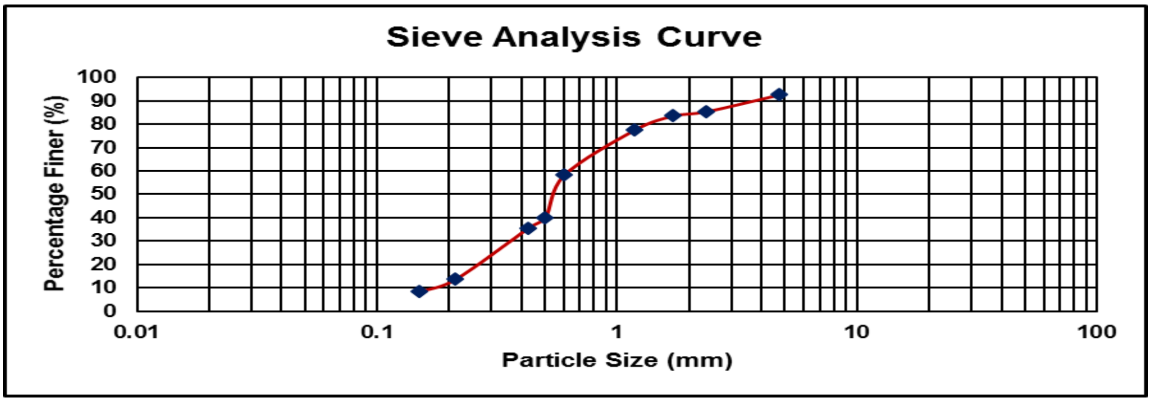

Figure 3: Sieve analysis sand

Fineness Modulus (FM) = $\frac{cummulative\ percentage\ retaines\ on\ standard\ seive}{100}$

$= \frac{7.4+7.12+1.96+5.98+19.26+18.24+4.44+21.84+5.44+0.12+8.2}{100}$

= 5.97

The formula gives the coefficient of uniformity:

For Sand, $C_U = \frac{D60}{D10} = \frac{0.68}{0.17} = 4$

$C_c = \frac{(D30)2}{D60 \times D10} = \frac{(0.37)2}{0.68 \times 0.17} = 1.18$

The coefficient of uniformity was calculated to be roughly 4. A well graded soil is indicated by a uniformity coefficient value greater than 4 to 6. As a result, the soil that was utilized as the fine aggregate can be said to be well graded.

4.2 Specific gravity Test

Table 4 shows the average specific gravity of bamboo leaf ash to be 3.34, Table 5 indicated that the specific gravity of pawpaw leaf ash was found to be 3.01 and Table 6 indicated that the specific gravity of the fine aggregate (sand) was found to be 2.95.

Table 4: Specific gravity Bamboo leaf ash

	Sample A	Sample B	Sample C
Mass of empty glass, W_1	77.6	77.6	77.6
Mass of glass + sample, W_2	86.5	86.5	86.4
Mass of glass + sample + water, W_3	379.5	380.6	380.2
Mass of glass + water, W_4	375.1	374.3	373.7
Specific Gravity	1.98	3.42	4.63
Average specific gravity		3.34	

Table 5: Specific gravity Pawpaw leaf ash

	Sample A	Sample B	Sample C
Mass of empty glass, W_1	78.3	78.3	78.3
Mass of glass + sample, W_2	106.2	106.5	106.4
Mass of glass + sample + water, W_3	395.0	393.7	394.0
Mass of glass + water, W_4	375.0	376.3	375.9
Specific Gravity	3.53	2.66	2.85
Average specific gravity		3.01	

Table 6: Specific gravity sand

	Sample A	Sample B	Sample C
Mass of empty glass, W_1	78.4	78.4	78.4
Mass of glass + sample, W_2	184.3	184.2	184.5
Mass of glass + sample + water, W_3	440.5	450.9	449.0
Mass of glass + water, W_4	380.2	379.0	374.9
Specific Gravity	2.32	3.12	3.41
Average specific gravity		2.95	

Specific gravity = $\frac{W2-W1}{(W2-W1)+(W4-W3)}$

4.3 Compressive Strength of bamboo and pawpaw leaf ash

A compression test on a 100mm cube was performed for each curing age at the percentage replacement level of cement with BLA and PLA at 0% 5% 10% 15% 20% and its compressive strength at the different curing age are shown in table 7, while figures 4 and 5 show the graphical variation of the compressive strength, with curing age and percentage replacement of BLA and PLA blended cement concrete. The strength was assessed at the research-selected ages of 7, 14, 21, and 28 days.

The results shown in figure 4 and figure 5 indicated that the compressive strength of the control (0% BLA and PLA replacement) has the highest at 28 days and lowest at 7 days. The compressive strength of 5% BLA and PLA replacement shows an increase at 14 days, a decrease at 21 days and an increase at 28 days with the highest at 14 days. The compressive strength of 10%, 15% and 20% of BLA and PLA replacement shows a steady increase but a decrease in strength at 28 days. The highest compressive strength achieved during the course of this experiment was achieved at 28days with 0% BLA and PLA replacement while the lowest compressive strength was achieved at 7days with 20% BLA and PLA replacement.

The result of the compressive strength reflects that the rate of strength development of BLA and PLA blended cement concrete was slow at early curing age (7 days) but faster at later ages (14 days and 21 days), and decreases slightly at 28 days unlike the strength development of the control (i.e. 0 % BLA and PLA normal concrete) which was slow at the initial stage (7 days) and then was faster at later ages. This implies that BLA and PLA blended cement concrete is not advisable for use when early strength is required.

Table 7: Compressive Strength of BLA and PLA Blended Cement Concrete Specimen at all curing ages

% Replacement	Curing age	Mean mass (KN)	Mean sample pick load (KN)	Mean stress (mpa)
0%	7 days	2.50	139.93	13.99
	14 days	2.73	200.9	20.08
	21 days	2.57	190.93	19.09
	28 days	2.57	258.27	25.83
5%	7 days	2.30	105.87	10.59
	14 days	2.27	135.17	13.52
	21 days	2.28	120.17	12.02
	28 days	2.13	130.43	13.04
10%	7 days	2.33	105.93	10.59
	14 days	2.25	152.9	15.29
	21 days	2.40	152.3	15.23
	28 days	2.27	141.1	14.11

15%	7 days	2.23	102.43	10.24
	14 days	2.23	153.73	15.37
	21 days	2.30	157.3	15.73
	28 days	2.27	153.2	15.32
20%	7 days	2.22	101.33	10.13
	14 days	2.20	156.47	15.65
	21 days	2.27	164.70	16.47
	28 days	2.23	154.97	15.50

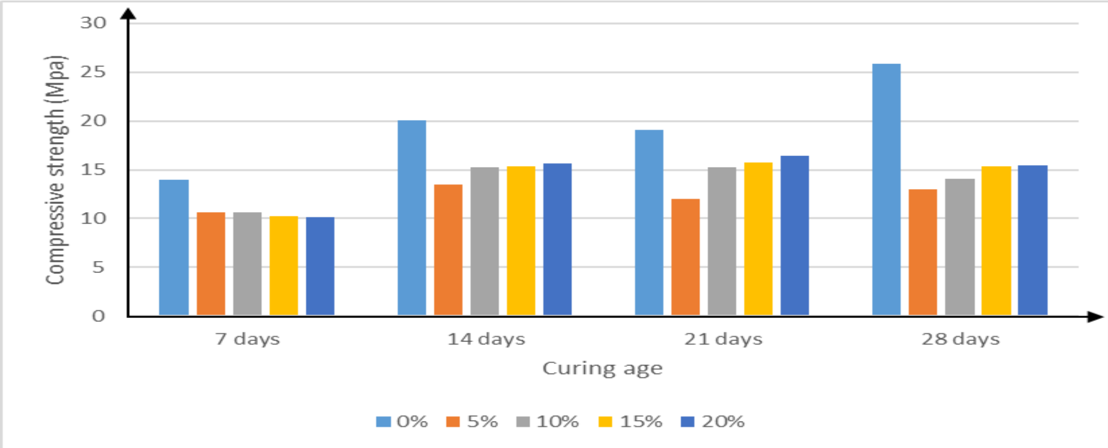

Figure 4: Compressive strength of BLA and PLA blended cement concrete for different percentage of BLA and PLA content

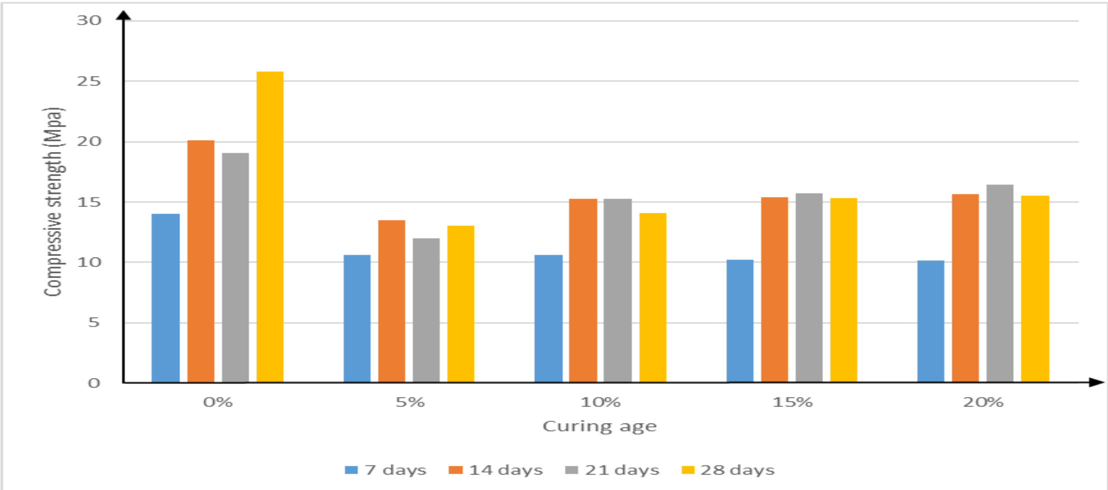

Figure 5: Compressive strength of BLA and PLA blended cement concrete for different curing ages

5.0 CONCLUSION

This research study was conducted to determine the effects of curing age on the compressive strength characteristics of pawpaw leaf ash and bamboo leaf ash blended cement concrete as well as the effect of percentage replacement of pawpaw leaf ash and bamboo leaf ash blended cement concrete on compressive strength. The following findings were drawn from this. When compared to plain concrete (control - 0%), the compressive strength of BLA and PLA blended cement concrete is lower at the early curing age. However, even though the compressive strength increases at later curing ages and then slightly declines at 28 days, the control's (0%) compressive strength is higher at curing ages 7 to 28. The slump value decreases when BLA and PLA content increases. This shows that concrete stiffens and loses workability when BLA and PLA content increases. Therefore, the requirement for water increases as BLA and PLA content does. According to this research, a 20% replacement is the optimum level for both compressive strength and workability of concrete with cement partially replaced with BLA and PLA.

REFERENCES

1. Ademola, O. M., & Ojediran, J. O. (2019). Enhancing the compressive strength of concrete using pawpaw leaf ash as partial replacement for

cement. Journal of Civil Engineering and Management, 25(5), 470-479.

2. Ademola, S. A., & Buari, T. A. (2014). Behaviour of Bamboo Leaf Ash Blended Cement Concrete in Sulphate Environment. IOSR Journal of Engineering, 4(6), 1-8.
3. Asha, P., Salman, A., & Arun Kumar, A. (2014). Experimental Study on Concrete with Bamboo Leaf Ash. International Journal of Engineering and Advanced Technology (IJEAT), 3, 46-51.
4. Bakar, B. H. A., Putrajaya, R. C., & Abdulaziz, H. (2010). Malaysian Sawdust Ash - Improving the Durability and Corrosion Resistance of Concrete: Pre-review. Concrete Research Letters, 1(1), 6-13.
5. Das, M., & Chakraborty, D. (2006). Influence of Mercerization on the Dynamic Mechanical Properties of Bamboo: a Natural Lignocellulosic Composite. Industrial & Engineering Chemistry Research, 45, 6489-6492.
6. Emamverdian, A., Ding, Y., Ranaei, F., & Ahmad, Z. (2020). Application of Bamboo Plants in Nine Aspects. ScientificWorld Journal, 2020.
7. Ettu, L. O., Arimanwa, J. I., Nwachukwu, K. C., Awodiji, C. T. G., & Amanze, A. P. C. (2013). Strength of Ternary Blended Cement Concrete Containing Corn Cob Ash and Pawpaw Leaf Ash. The International Journal of Engineering and Sciences (IJES), 2(5), 84-89.
8. Ezeonu, F. C. (2004). Occupational health hazards among cement industry workers. African Newsletter, 14(3), 63.
9. Fadele, O. A., & Ata, O. (2018). Water absorption properties of sawdust lignin stabilised compressed laterite bricks Case Studies in Construction Materials (9), 1-10.
10. Karade S. R. (2010) : Cement – Bonded Composites from Lignocellulosic Wastes. Construction and Building Materials, 24, 1323 – 1330.
11. Morel J.C., Mesbah A., Oggero M., Walker P. (2001) Building houses with local materials: means to drastically reduce the environmental impact of construction.
12. Mujedu, K. A., & Adebara, S. A. (2016). The Use of Groundnut Shell Ash as a Partial Replacement for Cement in Concrete Production. International Journal of Sciences, Engineering and Environmental Technology (IJOSEET), 1(3), 32-39.
13. Olubajo, O. A., & Ogunbode, E. B. (2020). Compressive strength and microstructural properties of bamboo leaf ash blended cement mortar. Journal of Building Engineering, 30, 101198.
14. Oyenuga, O. O., Olutoge, F. A., & Ojediran, J. O. (2017). Influence of bamboo leaf ash on the compressive strength of concrete. International Journal of Civil Engineering and Technology, 8(6), 33-43.
15. Padney, S. P., Singh, A. K., Sharma, R. L., &Tiwari, A. K. (2003). Studies on high-performance blended/multiblended cements and their durability characteristics. Cement and Concrete Research, 33: 1433-1436.
16. Ramya M. and Mercy Shanthi R. (2016) : Evaluation of Sustainable Green Concrete With Partial Replacement of Cement by Banana Leaf Powder and Cattle Bone Powder, Indian Journal of Applied Research, Volume 6, Issue 3, pp. 7 – 10.
17. Umoh A. A. and Odesola I. (2015) Characteristics of Bamboo Leaf Ash Blended Cement Paste and Mortar. Civil Engineering Dimension, Vol. 17, No. 1, pp. 22 – 28
18. Vrancic, T. (2012). Bamboo as Construction Material. Gradevinar, 64(5), 430-432.