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EFFECT OF MIX RATIO, CURING TIME AND CALCINATION TEMPERATURE ON ABRASION RESISTANCE AND WATER ABSORPTION OF CEMENT-PERIWINKLE SHELL ASH LATERIZED CONCRETE

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ABSTRACT

This study investigates the performance of periwinkle shell ash in resisting the effect of abrasion and water absorption in laterized concrete. PSA was calcined at three temperature levels (600, 800 and 1000°C) and two mix proportion (1:1:2 and1:2:4) with four levels of percentage replacement of PSA with cement (0, 10, 20, 30, 40%) were used. The specimen was subjected to two curing periods (28 and 56 days). It was observed that mix proportions significantly affect the abrasion resistance while an increase in abrasion resistance was observed with specimen cured for 56 days over those at 28 days whereas specimen with calcined periwinkle shell ash produced high resistance to abrasion over the control specimen. The rate of water absorption decreases as calcined PSA level increases whereas no significant different was observed in the curing period while for mix proportion, 1:1:2 produces a high resistance rate to water absorption than 1:2:4 across all level of calcined PSA replacement level, and curing ages with the control experiment absorbing more water than all level of replacement

KEYWORDS*: Abrasion, water absorption, periwinkle shell ash, cement, concrete*

1. INTRODUCTION

Deterioration of concrete surfaces occurs due to various forms of wear such as erosion, cavitations, and abrasion due to various exposures. Abrasion wear occurs due to rubbing, scraping, skidding, or sliding of objects on the concrete surface. This form of wear is observed in pavements, floors, or other surfaces on which friction forces are applied due to relative motion between the surfaces and moving objects. Concrete abrasion resistance is markedly influenced by a number of factors including concrete strength, aggregate properties, surface finishing, and type of hardeners or toppings [1]. Previous studies have indicated that abrasion resistance depend on compressive strength of the concrete; factors such as air entrainment, water-to-cement ratio, type of aggregates and their properties, etc. that affect the concrete strength, influences abrasion resistance [2,3], [4] submission concludes that concrete subjected to abrasion should have at least 28 MPa compressive strength, while [5] stated that to develop concrete for high abrasion resistance, it is desirable to use hard surface material, aggregate, and paste having low porosity and high strength. [1] submit the following conclusions; testing under air-dry conditions produces approximately 30 to 50 percent less wear than under wet conditions: the addition of fibers (synthetic and steel fibers) does not cause an appreciable change in abrasion resistance; improper moist-curing conditions produce more negative effects on surface quality than on compressive strength. [6] studied compressive strength and durability of concrete containing substitute materials at 50% replacement level by weight of Portland cement, fly ashes together with a limestone as an inert -6- filler material (silica flour), were used as replacement materials, the results revealed that the presence of fly ash at high levels of cement replacement decreased the weight loss due to abrasion at all ages relative to the concrete without fly ash.[3] determined abrasion resistance of fly ash concretes proportioning both Class C and Class F mixtures as 20-50% and 40% (cement replacement), respectively; with a super plasticizer added to the Class F mixture in order to keep the water-to-cementitious materials ratio below 0.36. Test results showed that the Class C fly ash concrete mixtures 20-50% had similar results; while the 40% Class F fly ash concrete mixture indicated higher depth of wear relative to the Class C fly ash mixtures; hence for high abrasive resistance, there is need to include pozzolanic materials in the concrete mix which is what this research seeks to investigate with the use of periwinkle shell ash.

Water absorption is a popular method of determining the tightness of water in concrete. It measures the amount of water that penetrate into concrete samples when submerged in water and is an important factor in determining te durability of concrete. [7] argued that water absorption by immersion only gives an estimation of the total reachable pore volume of concrete but gives no indication of concrete permeability which is important to durability of concrete, while [8] submit that permeability coefficient increased with increase in surface water absorption. This indicate that surface water absorption provides great influence on permeability of concrete while internal water absorption had no impact on permeability

2. **Materials and Methods**

2.1 Calcination of periwinkle shell

Periwinkle shell were washed, sun dried before subjecting to heat for calcination. 15 kg each of periwinkle shell were calcined at temperature level of 600, 800 and 1000 ^{o}C in a gas furnace at the Firing Chamber of the Ceramic Section of the Department of Fine and Applied Art, Obafemi Awolowo University, Ile-Ife, Osun State; the ashes obtained were ground and sieved with a 45 µm sieve to obtain the required particle sizes.

2.2 Proportioning and Mixing of Constituents

The mix proportions were carried out in accordance to the IS456 – 2000 mix-design approach of 28-days characteristics strength of 25 N/mm^2 for mix ratio of 1:1:2, and 15 N/mm^2 for mix ratio of 1:2:4; with (0% PSA and 100% cement) as control. Two mix proportions of 1:1:2 and 1:2:4 was used for each of the level of periwinkle shell ash replacement. The choice of these mix proportions was based on the envisage use to which they could be put in actual practical application, the 1:1:2 mix proportion is mainly use for farm storage structures while the 1:2:4 mix proportion is used for general reinforced concrete work. Potable water was used in mixing the concrete, while the optimum water/cement ratios were calculated from the equation as adopted by [9]:

$$Y = -0.94 + 3.85X \quad \text{...} \quad 1$$

Where;
Y = lateritic soil/cement ratio and
X = optimum water/cement ratio

Five replacement levels of 0, 10, 20, 30 and 40% of cement with periwinkle shell ash were used in the preparation of the specimen, while slump test in accordance with the requirement of [10] was carried out to determine the workability of each mix.

2.3 Casting and Curing of Test Specimen

Moulds of 100 × 100 × 100 mm was used for molding of test specimen, The molds were thoroughly cleaned and coated with mold oil before casting to ensure easy de-molding and smooth surface finish, casting was done in accordance to the requirement of [11], the cubes were de-molded after 24 hours and immersed in water curing tank.

2.4 Water Absorption procedures: Water absorption was determined at the curing ages of 28 and 56 days while using the method postulated by [12]. The cube specimens were dried in an oven at 110 ^{o}C for 6 hours and the weight taken as dry weight, the specimen was submerged in water for 24 hours before weighing; the values. Water absorption were calculated with the formula below:

$$water\ absorption = \frac{wsd - wd}{wd} \times 100 \ldots 2$$

2.5 Abrasion Test

Abrasion test was carried out using a 100 ×100 × 100 mm cube specimens after 28 and 56 curing in water. The weights of the specimen (w_1) were taken before subjecting them to abrasion test for 24 hours as specified by [10] using the abrasion testing machine in the Material Testing laboratory of the Department of Agricultural and Environmental Engineering, Obafemi Awolowo University. The weight w_2 of the specimens were obtained and the rate of abrasion was obtained from the differences of $w_1 - w_2$ between the weight of the specimens

3. RESULTS AND DISCUSSION

Anova result for abrasion at 28 days hydration period presented in table 1 shows that all the factors have a significant effect in the rate of abrasion at 95% confident interval. This means that they contribute to the increase in the rate of abrasion and significantly affect the resistance of periwinkle shell ash laterized concrete to physical and mechanical damage.

Effect of mix proportion on Abrasion of PSA-Cement Laterized concrete

At 56 hydration period, result of the Anova as presented in table 2 shows that for the level of replacement, temperature and the interactions between mixed ratio and level of replacement, mixed ratio and temperature as well as level of replacement and temperature, no significant difference occurred, pointing to the fact that these factors do not affect the rate of abrasion whereas a significant difference was obtained in the mixed ratio and the interaction between the mixed ratio, level of replacement and temperature. This shows that mixed ratios 1:1:2 and 1:2:4 significantly affect the rate of abrasion.

Effect of curing time on Abrasion of PSA-Cement Laterized concrete

Figures 1-6 reveals that there is a reduction in the rate of abrasion at 56 days of curing over 28 days in both mix proportion use. This implies that longer period of curing (up to 56 days) can produce effective resistant to periwinkle shell ash laterized concrete against physical and mechanical damage.

Effect of calcination temperature on Abrasion of PSA-Cement Laterized concrete

For mix proportion of 1:1:2,it was observed that the rate of abrasion with 600 ˚C Calcined Periwinkle Shell Ash **(PSA)** at 10% replacement of PSA with cement at 28 days of curing was found to be lower than the control experiment (100% cement : 0%PSA), also 10% replacement level of 800 ˚C Calcined Periwinkle Shell Ash and 10 and 20% replacement level of PSA with cement at 1000 ˚C Calcined Periwinkle Shell Ash at 56 days of curing were lower than the control experiment (100% cement : 0%PSA) while for mix proprtion of 1:2:4, 10% replacement level of 600 ˚C calcined PSA at 28 days of curing and 10% replacement level of 1000 ˚C calcined PSA of both

28 and 56 curing ages produced a lower rate of abrasion when compared to the control experiment.

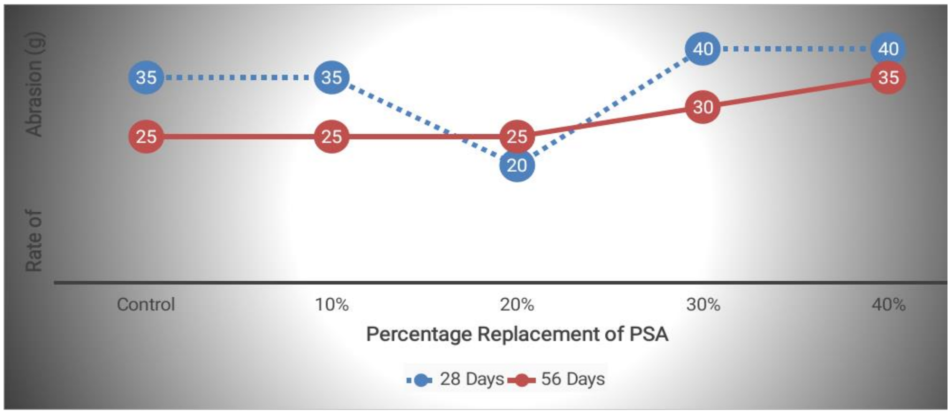

Fig. 1 Plot of Rate of Abrasion of 600 ˚C Calcined Periwinkle Shell Ash on Laterized Concrete for Mix Ratio 1:1:2

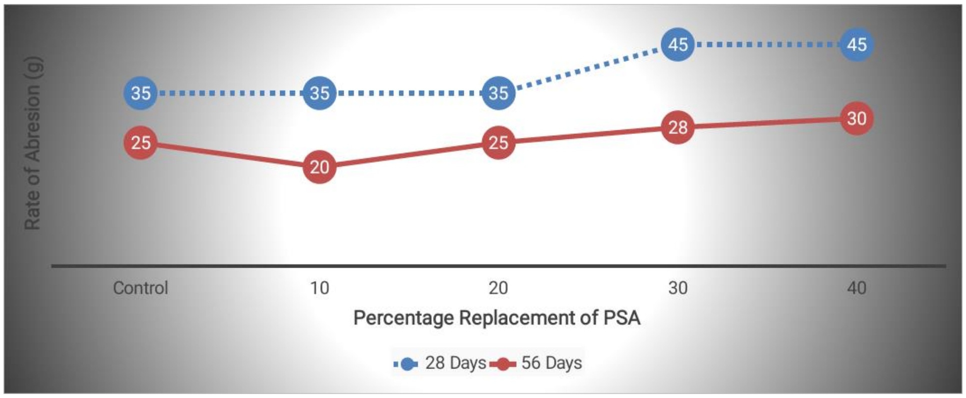

Fig 2 Plot of Rate of Abrasion of 800 ˚C Calcined Periwinkle Shell Ash on Laterized Concrete for Mix Ratio 1:1:2

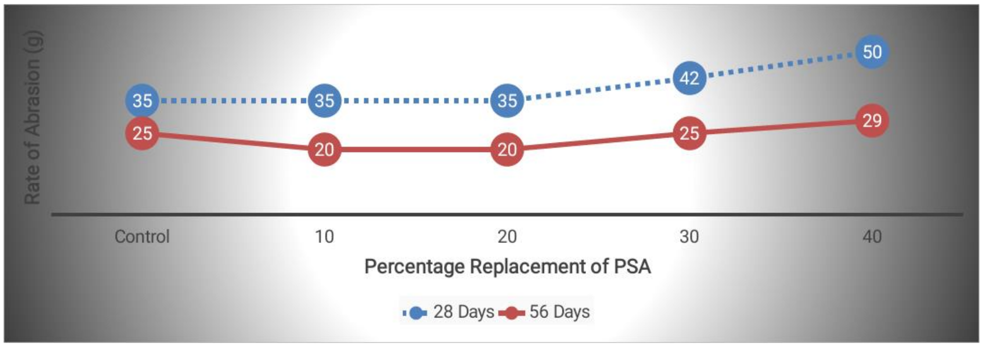

Fig. 3 Plot of Rate of Abrasion of 1000 ˚C Calcined Periwinkle Shell Ash on Laterized Concrete for Mix Ratio 1:1:2

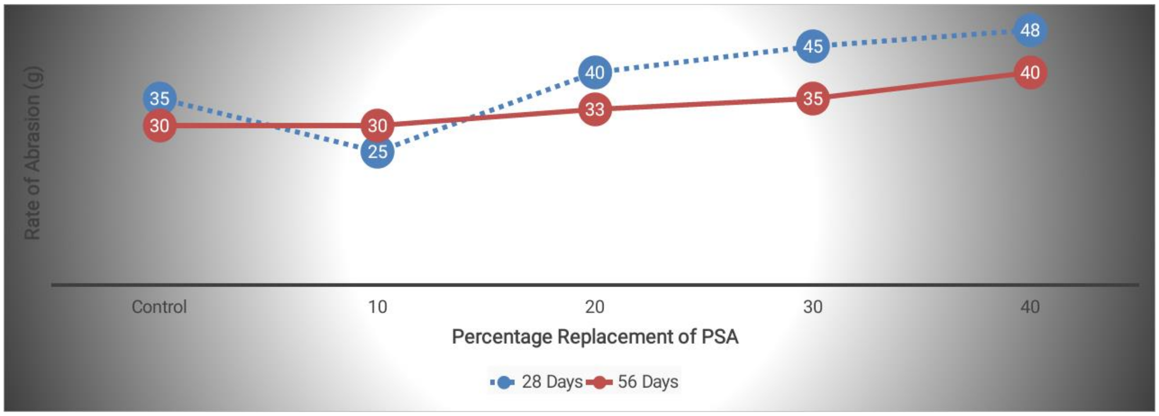

Fig. 4 Plot of Rate of Abrasion of 600 ˚C Calcined Periwinkle Shell Ash on Laterized Concrete for Mix Ratio 1:2:4

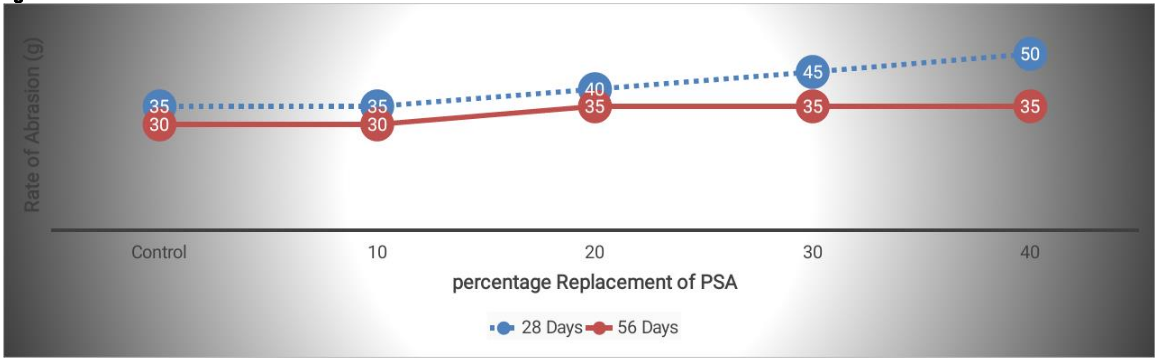

Fig. 5 Plot of Rate Abrasion of 800 ˚C Calcined Periwinkle Shell Ash on Laterized Concrete for Mix Ratio 1:2:4

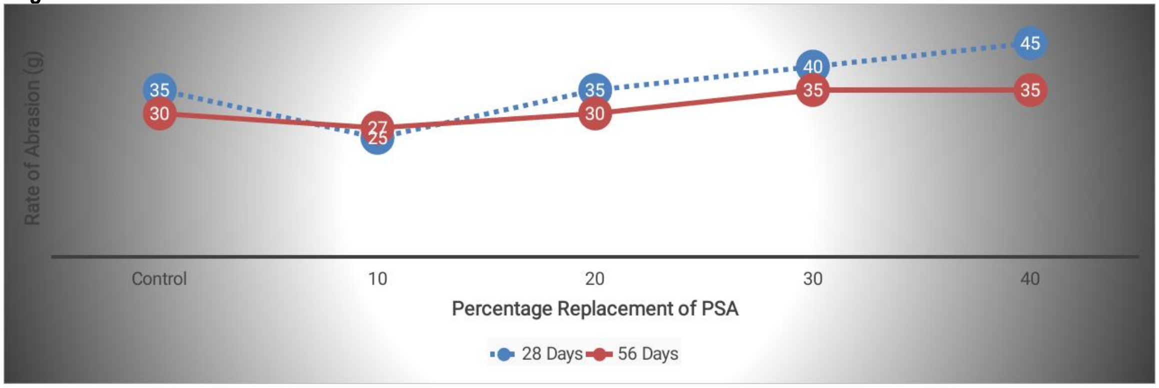

Fig. 6 Plot of Rate of Abrasion for 1000 ˚C Calcined Periwinkle Shell Ash on Laterized Concrete for Mix Ratio 1:2:4

Table 1 Anova Result for Abrasion at 28 Curing Age

Sources of Variance	Degree of Freedom	Sum of Squares	Mean Square	F-Values	Prob.<F
Mean	1	22426.67			
Level	4	499.83	124.96	5.63	P>.001*
Mixed Ratio	1	4.263	4.263	254.3	P>.001*
Calcined temp.	2	25.23	12.615	19.5	P>.001*
Mixed Ratio *Level	1	56.56	56.56	254.3	P>.001*
Level*Temperature	2	34.6	17.3	19.54	P>.001*
Mixed Ratio* Level* Temperature	5	565.38	113.1	4.36	P>.001*
Error	20	22604,6	1130.23		

*Factors that are not significant at P>0.

Table 1 Anova Result for Abrasion at 56 Days Curing Age

Sources of Variance	Degree of freedom	Sum of Squares	Mean Squares	F-Values	P>F
Mean	1	12673.067`	12673.067		
Mixed Ratio	1	160.01	160.01	4.35	P>.001*
Level	4	118.433	29.61	2.87	P>.001
Temperature	2	26.133	13.066	3.49	P>.001
Mixed Ratio *Level	3	107.187	35.729	3.10	P>.001
Mixed Ratio* Temperature	1	2.59	2.59	4.35	P>.001
Level*Temperature	2	32.367	16.183	3.49	P>.001
Mixed Ratio* Level*Temperature	4	360.9	90.225	2.89	P>.001*
Error	20	316.213	15.81`		

*Factors that are not significant at P>0.05

3.1 Water Absorption

Effect of calcination temperature on Water absorption of PSA-Cement Laterized concrete

For 1:1:2 and 1:2:4 mix ratio with 600˚C replacement of periwinkle shell ash with cement, water absorption rate was found to be decreasing as periwinkle shell ash replacement level increases, while 800 and 1000˚C periwinkle shell ash with mix proportion of 1:1:2 shows an increase in the rate of water absorption as replacement level increases. Only specimen with 40% replacement of periwinkle shell ash calcined at 800˚C with 1:1:2 mix ratio recorded a value of 5.9% which was higher than the control experiment, indicating that periwinkle shell ash calcined at these temperature offers concrete high resistance against water absorption.

For 800 and 1000˚C with 1:2:4 mix proportion, no water was absorbed at 10 and 20% replacement level while at 30 and 40% the values were 0.08 and 3.6%. it is worthy to note that the values obtained at 800 and 1000˚C were the same. All the values obtained were lower than the value for control experiment. This shows that periwinkle shell ash plays a significant effect in hardening of laterized concrete and gives the concrete a high resistance to water absorption. Wilcoxon rank sum test shows that the differences exist, as periwinkle shell ash at 600 ˚C has a p-value of 0.4429 which is greater than 0.05 while 800 and 1000 ˚C has p-values of 0.02954 and 0.02877. hence with 600 ^{0}C periwinkle shell ash, there is no significant increase in the water absorption at 28 days compared to water absorption at 56 days while with 800 and 1000 ^{0}C periwinkle shell ash, there is significant increase in the water absorption at 28 days compared to water absorption at 56 days at 95% confidence interval

Effect of mix proportion on water absorption rate of PSA-Cement Laterized concrete

For mixed ratio 1:1:2, 5.3% of water was absorbed by the control specimen at 28 days hydration period. At 56 days hydration period, the control recorded a value of 7.44%, analysisof Variance in T able 2 shows that in mix ratio 1:1:2, the p-values (0.3383) is greater than 0.05 which is the level of significance of the test, as a cross validation test (post hoc analysis), the wilcoxin Pairwise comparisons test in Table 3 also give a set of p-values (1.00, 0.65, 0.65, 1.00) which are greater than 0.05, therefore in all the periwinkle shell ash variations, there is no significant difference between the mean water absorption of the control group and mean water absorption of the different periwinkle shell ash percentage variation. It can hence be recommended at 95% confidence level that replacement of the control with any of the periwinkle shell ash variations will not increase the water absorption.

For 1:2:4 mix proportion, the control specimen recorded 4.8 and 2.1% for 28 and 56 hydration periods respectively. At 28 days' hydration period, only 10% of periwinkle shell ash calcined at 1000˚C recorded a lower value of 1.8% than that of the control, while at 56 days hydration period, 10% of periwinkle shell ash at 600 and 1000˚C recorded a lower value of 1.3 and 1,4% than that of the control. Figure 10 shows an increase in water absorption as the periwinkle shell ash increases for 600 ˚C for both curing ages while for figures 11 and 12 which represent 800 and 1000˚C the trend remain the same for both curing ages

Effect of curing time on Abrasion of PSA-Cement Laterized concrete

Considering the differences in the water absorption test between 28 and 56 hydration period analysis of variance test in Table 1 for mixed ratio 1:1:2 recorded a P-value of 0.02502 while for mixed ratio 1:2:4, the test recorded a P–value of

0.3047. This signifies that for mixed ratio 1:2:4, there is no difference in water absorption at 28 days and water absorption at 56 days, whereas for mixed ratio 1:1:2, since the p–value is less than 0.05, there are differences between water absorption at 28 days and water absorption at 56 days.

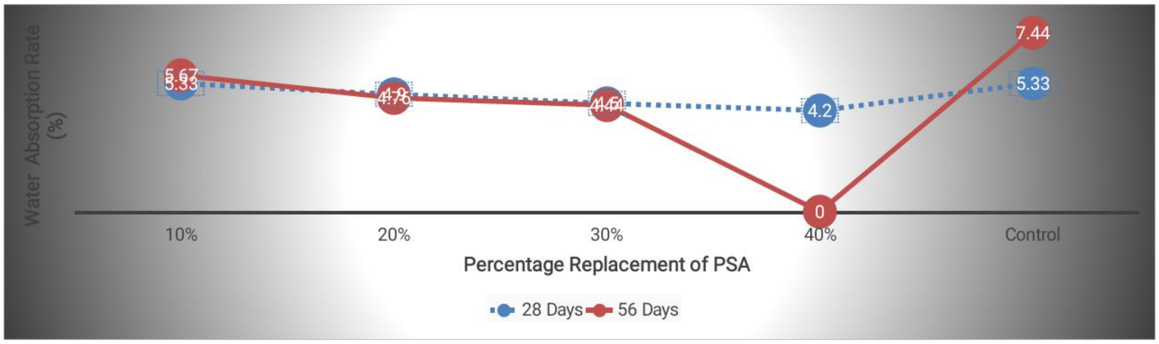

Fig. 7 Plot of Water Absorption Rate of 600 ˚C Calcined Periwinkle Shell Ash on Laterized Concrete for Mix Ratio 1:1:2

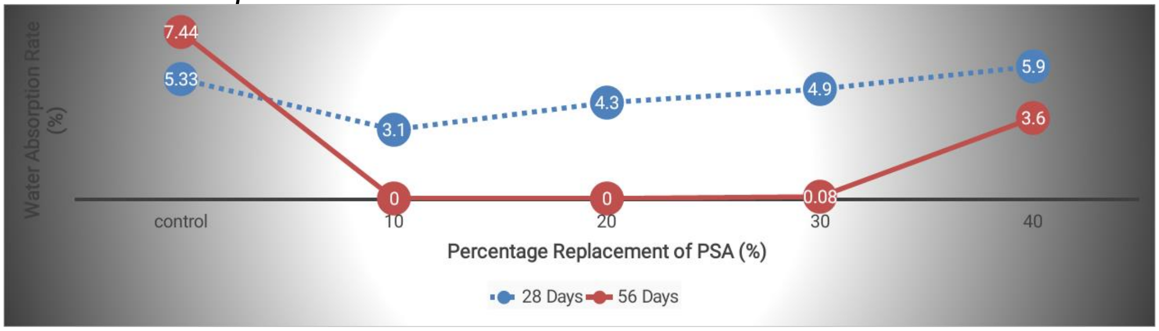

Fig. 8 Plot of Water Absorption Rate of 800 ˚C Calcined Periwinkle Shell Ash on Laterized Concrete for Mix Ratio 1:1:2

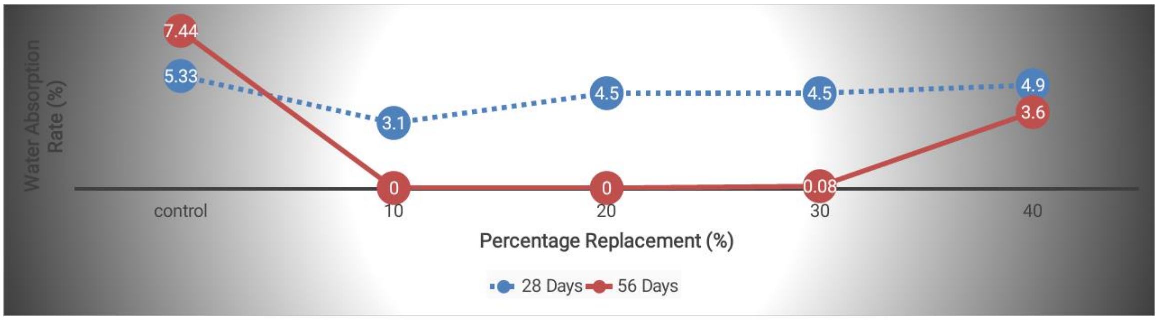

Fig. 9 Plot of Water Absorption Rate of 1000 ˚C Calcined Periwinkle Shell Ash on Laterized Concrete for Mix Ratio 1:1:2

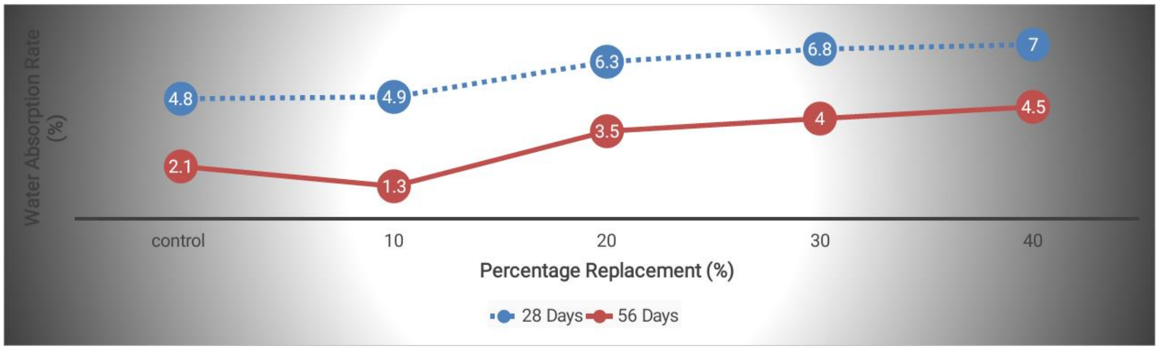

Fig. 10 Plot of Water Absorption Rate of 600 ˚C Calcined Periwinkle Shell Ash on Laterized Concrete for Mix Ratio 1:2:4

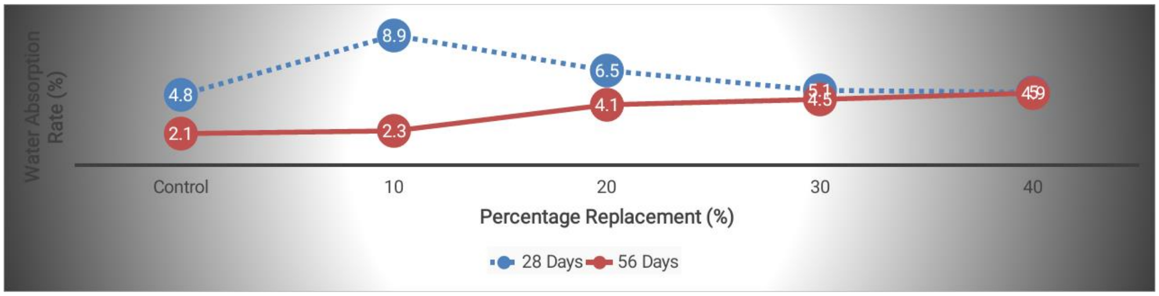

Fig. 11 Plot of Water Absorption Rate of 800 ˚C Calcined Periwinkle Shell Ash on Laterized Concrete for Mix Ratio 1:2:4

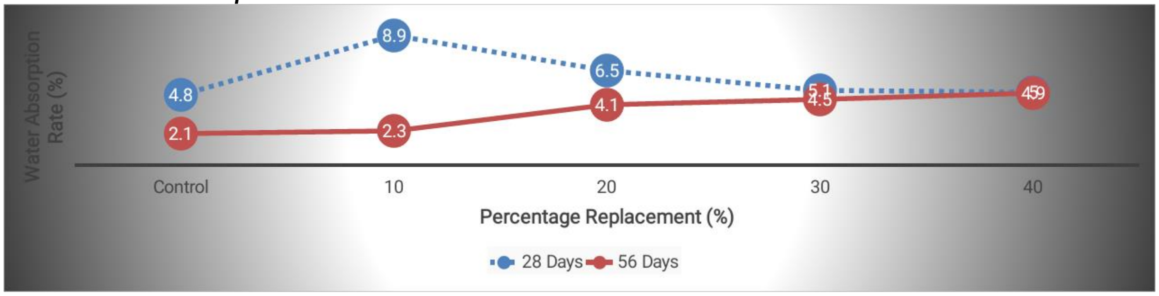

Fig. 12 Plot of Water Absorption Rate of 1000 ˚C Calcined Periwinkle Shell Ash on Laterized Concrete for Mix Ratio 1:2:4

Table 3Inferential Data Analysis for Water Absorption for Mixed Ratio 1:1:2

Temperature	Test	w-statistics	95 percent confidence interval	p-value
600^0C	water absorption at 28 days versus water absorption at 56 days	9	(-1.17 Inf)	0.4429
800^0C	water absorption at 28 days versus water absorption at 56 days	15	(0.6900751 Inf)	0.02954
1000^0C	water absorption at 28 days versus water absorption at 56 days	15	(0.8999449 Inf)	0.02877

4. CONCLUSION

Periwinkle shell ash blending with cement was subjected to abrasion and water absorption test, the two durability characteristics of concrete discussed in this study.

Optimum resistance to Abrasion effect was achieved when concrete is cured for longer period (56 days and above) with optimum temperature of calcination (800 and 1000 **˚C)** and usage of adequate level of replacement (10 and 20%). Both mix ratio used in the study (1:1:2 and 1:2:4) significantly affect abrasion resistance in PSA-Laterized concrete as compared to the control experiment. While an increase in replacement level result in increase in the rate of abrasion

Cement blended Periwinkle shell ash laterized concrete can offer high resistance to water absorption being one of the durability characteristics of concrete when the ash is calcined at a temperature of 800°C and above. Curing of test samples for 56 days will ensure little or no water is absorbed. For mix proportion of 1:1:2, replacement of the control with any of the periwinkle shell ash temperature variations will not increase the water absorption over the control, an impressive replacement level of 40% and above is required if a lower calcined temperature below 800°C is to be used which is highly recommended whereas for calcined temperature greater than 800°C, replacement level should not exceed 40%. Further research should be encouraged with other durability characteristics like weathering effect, chemical attack such as sulphate etc.

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