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Study on The Effectiveness of Calcined Lateritic Soil as A Mineral Admixture in Normal Weight Concrete

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ABSTRACT :*This research examined the effectiveness of calcined lateritic soil as a plasticizer. To achieve the research objectives, lateritic soil was sourced from Abudu in Orhionwo Local government area of Edo State, Nigeria, and were calcined (burnt in a controlled temperature) at 200^{O}C, 400^{O}C and 600^{O}C respectively, using a Furnace in the Department of Civil Engineering, Niger Delta University. The Calcined Lateritic soil (CLS) samples were pounded using mortar and pistol and sieved using Sieve No. 200 to obtain a very fine lateritic soil sample. The calcined lateritic soil (CLS) specimen was used as admixture for 5, 10, 15 and 20% relative to cement for each of the calcined temperature to make concrete cube samples. Batching was done by weight and a ratio of 1:2:4 and water-cement ratio of 0.5 was adopted. 0% addition of lateritic soil samples of concrete cube samples were produced with the same mix ratio and considered as control. The concrete cubes were cured in water for 7, 14, 21 and 28 days and thereafter tested for the compressive strength using a compression machine. The results that the best addition dosages of Calcined lateritic soil at 600^{0}C are 15% and 20%. Generally, 20% addition of Calcined lateritic soil at 600^{0}C exhibited about a 40% increment in compressive strength at 28 days while 15% addition of Calcined lateritic soil (CLS) at 600^{0}C exhibited about 37.2% increment in compressive strength 28 days. It was also observed that as the calcined laterite content increased, the compressive strength also increased with age at curing for 600^{0}C calcined temperature. it is recommended that the use of calcined lateritic soil as mineral admixtureshould be includedin the production of concrete as an admixture with 5% - 20% for 600^{0}C respectively.*

KEYWORDS: *Lateritic Soil,Mineral Admixture,Concrete Strength,Calcination*

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I. INTRODUCTION

The most universally utilized construction material is concrete because of its stability and strength performance. In recent times, the cost of concrete construction has been relatively high and also generating environmental conflicts. In the bid to create concrete development more conventionally, the need to lessen the utilization of toxic components in concrete should be considered. The use of admixtures in the making of concrete is generally utilized for different purposes mainly for the reduction of cement requirement in concrete production which helps to reduce the cost in the development of concrete structures. Ninety percent of pozzolanic materials are by-products which when used effectively, helps in reducing waste, keeping the environment safe from the hazard, freeing up valuable land, and also resuscitates the energy utilized in the production cement.

One of the salient constituents in concrete is cement and it has no substitute in the construction sector. In the course of production of cement, an enormous quantity of carbon-dioxide gas is discharged into the atmosphere which contributes majorly to the green-house effect and global warming. Hence, exploration of other materials that can be added to cement or partially replacing cement should be considered. When pozzolanic materials are introduced in the making of concrete, the silica compound (SiO_2) present in pozzolanic materials react with the calcium hydroxide released during the hydration of cement and yields additional calcium silicate hydrate which enhances the mechanical properties and durability of concrete.

The demand for locally sourced construction materials has been emphasized in various states in Nigeria. The significant expense of construction materials has been the bane of the construction sector in the undeveloped countries because of the importation of the majority of construction materials. As prices increase abruptly, there is a rising awareness to relate research to local materials as substitutes for the construction of functional but low-cost structures both in the urban and rural areas. One of such materials available locally, that is being investigated is lateritic soil. The main reason lies in the fact that it is readily available and the cost of obtaining it is comparatively low [1].

Lateritic soils are formed in the tropics through weathering processes that aid the formation of iron, aluminum, manganese and titanium oxides (Fetra et al., 2010). These processes crushes silicate raw materials into clay mineral deposits such as kaolinite and illite. Iron and aluminum oxides are prominent in lateritic soils, and with the seasonal instability of the water table, these oxides result in the reddish-brown color that is seen in lateritic soils [2].

Asiedu and Allan [3] researched on the utilization of laterite fines as a replacement for sand in the production of Sand Crete bricks as masonry units. The data results showed that the laterite fines used could suitably substitute the sand up to 30% for the construction of structural brickwork units although bricks need to be protected when it’s been used in waterlogged areas or below ground level.

Biju et al. [4] conducted a study that, natural M- Sand was substituted with laterite at a proportion of 10%, 20% and 30 % by weight for design mix of C25 controlled concrete. A total of 36 samples were made to examine the compressive strength, and bending strength. From the research results, the supplement of laterite reduces workability in concrete. Compressive strength reduces with an increase in the percentage of laterite substitution with river sand. The bending strength has no significant variation with controlled concrete.

Santhiyaa and Ramasundarm [5] researched the physical properties of laterite, such as specific gravity, particle size distribution and density. An effort was made to utilizelaterite as a fine aggregate in concrete. The amount of laterite varies from 0% to a 100% at step of 25% in this research. The 1:1.5:3 mix of concrete was used for examining the mechanical strength and durability features. At 50% replacement of sand with laterite sand yields very high compressive strength juxtaposed with traditional concrete.

Nwakonobi[6] the best mix proportion that will produce the highest strength value of laterite concrete was determined. The purpose of the study was to examine some of the structural features of laterite concrete at an optimum mix proportion.

The possibility of this investigation is more about the examination of the compressive strength of concrete with the addition of calcined lateritic soil as a mineral admixture and find out the effect on the concrete strength.

II. MATERIALS AND METHOD

Materials

Portland Limestone Cement (PLC) of grade 42.5 according to EN 197-1 [7] was used in the forming of the 150mm x 150mm concrete cube specimens. The size of the coarse aggregate used in this research was 12.5mm and fine aggregate (sand) was gotten from Amassoma river sand. It conformed to B.S. 882; 1992 [8] Water free from impurities was used in the mixing of concrete as specified by BS 3148:1980 [9]. The lateritic soilused for this study was collected from Abudu in Orhionwo Local Government Area, Edo State, Nigeria.

Method

The sourced Lateritic soil samples were sundried for 3 to 4 hours to eliminate moisture content, and calcined (burnt at control temperature) in a furnace with temperatures of 200^0C, 400^0C, and 600^0C respectively. The calcined (burnt) lateritic soil samples were pounded after cooling using mortal and pistol after which the burnt samples were sieved through sieve No 50, the portion passing through the sieve would have the required fine degree of cement.

(a) (b) (c)

Fig. 1. Calcined lateritic Soil: (a) 200^0C Calcination, (b) 400^0C Calcination, (c) 600^0C Calcination

Mix proportion

Batching by weight was adopted in this research. A mix ratio of 1:2:4 with a water/cement ratio of 0.5 by weight was adopted in this research. A mould of size 150 x150 x150mm was adopted for the production of the concrete cubes. The moulds were assembled and properly lubricated before mixing for easy removal of hardened concrete cubes.

Fresh Concrete Test

A slump test was conducted to measure the workability of fresh reference concrete and concrete containing calcined lateritic soil.

Compressive Strength Test

One hundred and fifty-six cubes specimens of size 150 mm × 150 mm × 150 mm were formed for this research, twelve for reference (0% addition of calcined lateritic soil) and twelve cubes specimens for each percentage (5%, 10%,15%, and 20%) per calcined temperatures (200^{0}C 400^{0}C and 600^{0}C) of lateritic soil addition. The concrete cube samples were filled with concrete in three layers and each layer was tamped 25 times with a tamping rod to prevent void and allow even distribution of concrete in the mould. The concrete samples were allowed to set for 24 hours before demolding and thereafter stored in water (curing process) in order to increase the strength of concrete, eliminate shrinkage, and absorb the heat of hydration until the age of the test. Compressive Strength was tested for 7, 14, 21 and 28 days. At the crushing day, concrete samples were removed from the curing bath, allowed to drain for about an hour, weighed using a weighing balance and then the concrete cubes were crushed. Failure load for each sample was recorded and compressive strength was determined from the recorded failure load. The compressive strength of the specimen is calculated by dividing the maximum load attained during the test by the cross-sectional area of the specimen.

III. RESULTS AND DISCUSSION

This section presents and analyzes the study results of the effectiveness of calcined lateritic soil as a mineral admixture in normal-weight concrete.Table 1, Figures 2 and 3 presentcompressive strengths with different dosage of 200^{0}C calcined lateritic soil at 7, 14, 21 and 28 days. Table 2, Figures 4 and 5presentcompressive strength of 400^{0}C calcined lateritic soil at 7, 14, 21 and 28 days for 0% to 20% addition. Also,Table 3, Figures 6 and 7 present compressive strengths of 600^{0}C calcined lateritic soil addition (0% to 20%) at 7, 14, 21 and 28 days. Table 4 presents the classification of Lateritic soil.

Table 1: Compressive Strength of 200^{0}C Calcined Lateritic Soil at 7, 14, 21 and 28 days

Percentage Addition	7 Days (MPa)	14 Days (MPa)	21 Days (MPa)	28 Days (MPa)
0%	16.00	18.89	20.44	23.85
5%	14.00	18.67	17.70	20.22
10%	14.37	17.11	17.33	20.22
15%	17.63	12.81	16.82	16.22
20%	18.94	14.30	18.88	18.15

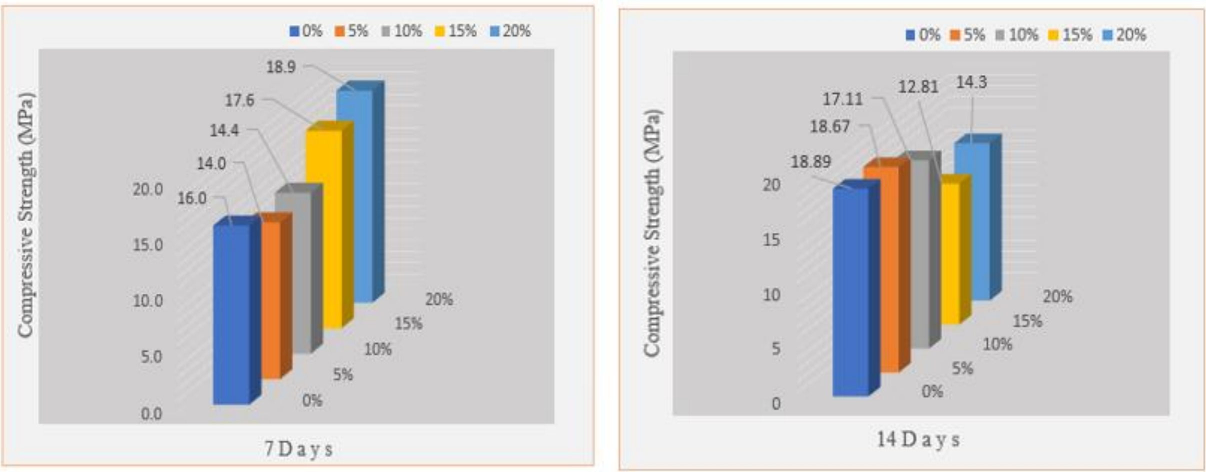

Fig. 2. Compressive Strength against 7 and 14 Days for 0%. 5%, 10%, 15%, and 20% addition of 200^{o}C Calcined Lateritic Soil

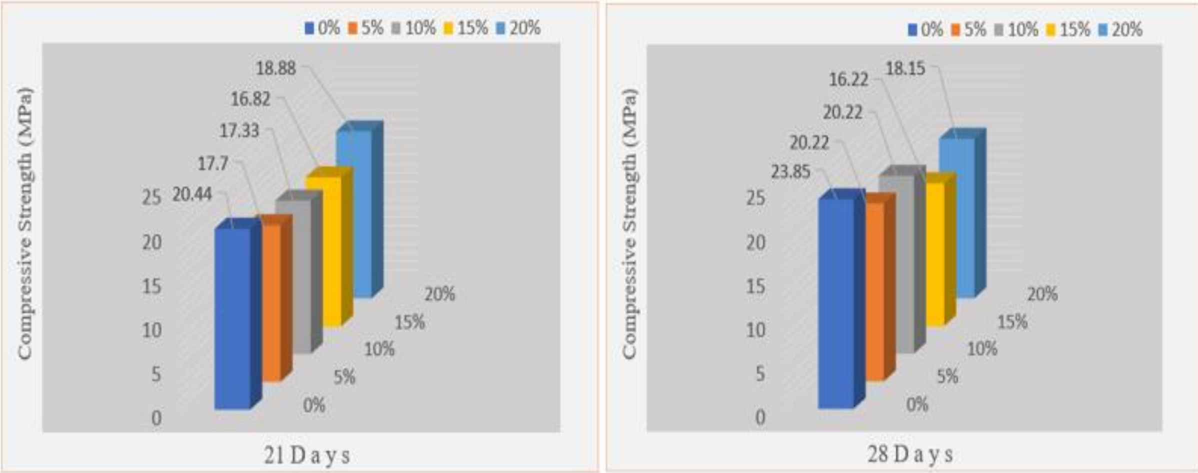

Fig. 3. Compressive Strength against 21and 28 Days for 0%. 5%, 10%, 15%, and 20% addition of 200^{o}C Calcined Lateritic Soil

Effects of 200^{0}C Calcined Lateritic Soil(CLS) on Concrete Workability

The slump values of the research concrete samples withvariouspercentages of 200^{0}C calcined lateritic soilas mineral admixture are shown in Tables 5.Generally, CLS in concrete reduces the slump values of the concrete samples, however, different CLS's proportions confirmed little variation. This is because the 200^{0}C CLS in the concrete can absorb a certain amount of water in CLS's concrete.

Effects of 200^{0}C Calcined Lateritic Soil(CLS) on Compressive Strengths

The 7, 14, 21- and 28-days compressive strengths results of concrete with 200^{0}C calcined lateritic soil as mineral admixture and the reference concrete (0% dosage) are presented in Table 1 and Figures 2- 5 respectively.

By examining Table 1 and Figures 1- 4, the study results reveal that the 7 days compressive strength reduces with 5 and 10% of CLS dosage but increases with 15 and 20% addition. That is, when CLS percentages relative to cement are 5% and 10%, the 7 days strengths decrease by 12% and 10.2%, respectively, and when CLS percentage relative to cement increases to 15% - 20%, the 7 days strengths increase by 9.5% and 15.5%, respectively compared to their control concretes. The low compressive strength of concrete with CLS at 7 days is as a result of the low early day's activities of the constituents of CLS, which lead to reducing cement hydration products when CLS is introduced in concrete. The 14, 21, and 28-days compressive strengths decrease with the increase of 200^{0}C Calcined Lateritic Soil (CLS) dosage.

Table 2: Compressive Strength of 400^{0}C Calcined Lateritic Soil at 7, 14, 21 and 28 days

Percentage Addition	7 Days (MPa)	14 Days (MPa)	21 Days (MPa)	28 Days (MPa)
0%	16.00	18.89	20.44	23.85
5%	18.74	16.15	19.11	19.63
10%	19.63	16.00	18.81	19.73
15%	18.81	17.78	18.59	18.66
20%	19.41	20.89	23.26	19.93

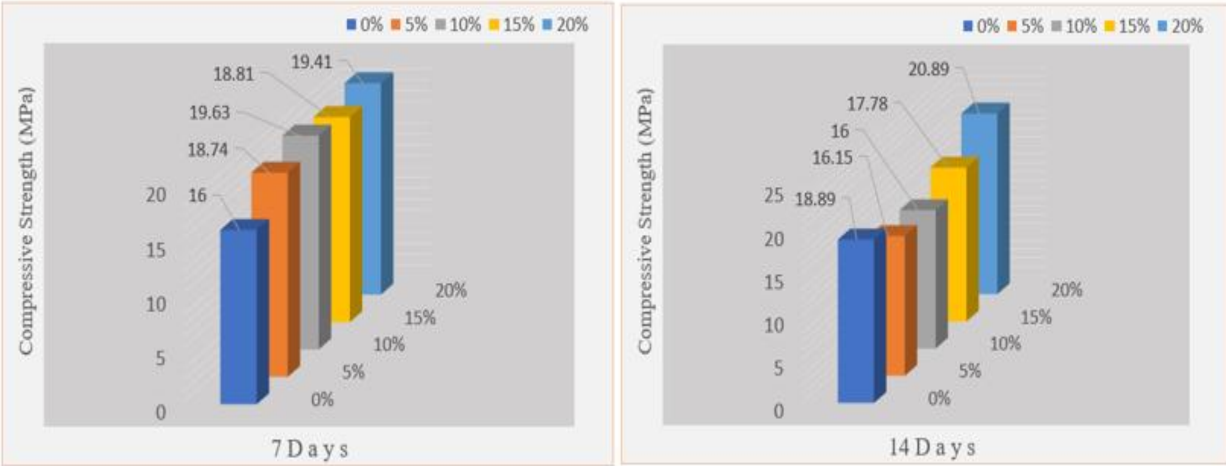

Fig. 4. Compressive Strength against 7 and 14 Days for 0%. 5%, 10%, 15%, and 20% addition of 400°C Calcined Lateritic Soil

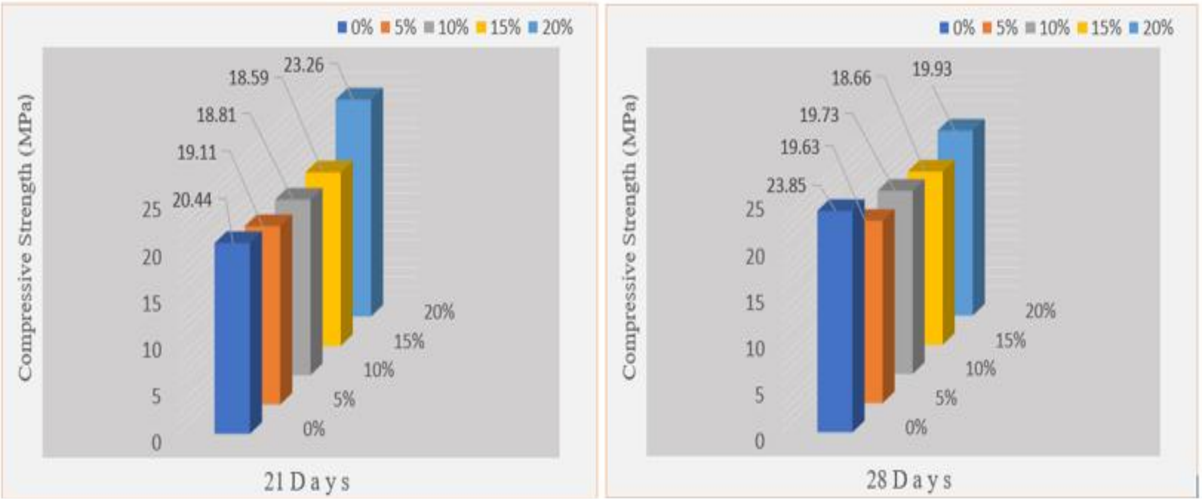

Fig. 5. Compressive Strength against 21 and 28 Days for 0%. 5%, 10%, 15%, and 20% addition of 400°C Calcined Lateritic Soil

Effects of 400^{0}C Calcined Lateritic Soil (CLS) on Concrete Workability

The study confirmed that the slumps of the concrete with different percentage dosage of 400^{0}C calcined lateritic soil decreases the slumps of the concrete. The 400-degree Celsius Calcined Lateritic Soil imbibed a certain amount of mixing water in concrete.Tables 6 shows the slump values.

Effects of 400^{0}C Calcined Lateritic Soil (CLS) on Compressive Strengths

The experimental results of 7, 14, 21- and 28-days compressive strengths of concrete with 400^{0}C calcined lateritic soil as mineral admixture and the control concrete (0% addition) are shown in Table 2 and Figures 6- 9 respectively. By analyzing Table 2 and Figures 6- 9, the results confirmed that the 7 days compressive strength increases with the increase of CLS percentage addition. Such as, when CLS percentage addition is 5%, 10%, 15%, and 20% the 7 days strengths of CLS concrete increase by 14.6%, 18.5%, 15%, and 17.6%, respectively, juxtaposed to their reference compressive strength. The compressive strengths at 14, 21, and 28-daysdecrease with the increase of 400^{0}C Calcined Lateritic Soil (CLS) percentage dosage except for 20% at 14 and 21 days. For instance, 20 percent addition of 400^{0}C CLS at 14 and 21 days increase by 9.6% and 13.5% respectively.

Table 3: Compressive Strength of 600^{0}C Calcined Lateritic Soil at 7, 14, 21 and 28 days

Percentage Addition	7 Days (MPa)	14 Days (MPa)	21 Days (MPa)	28 Days (MPa)
0%	16.00	18.89	20.44	23.85
5%	14.96	16.67	18.07	18.96
10%	15.70	19.26	21.78	20.96
15%	18.22	19.26	35.85	38.00
20%	19.85	20.29	38.07	39.56

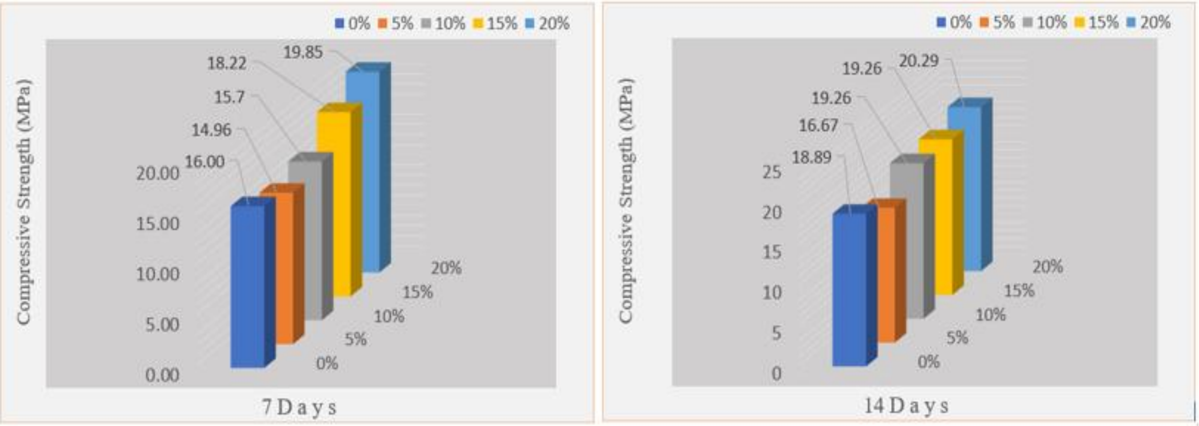

Fig. 6. Compressive Strength against 7 and 14 Days for 0%. 5%, 10%, 15%, and 20% addition of 600°C Calcined Lateritic Soil

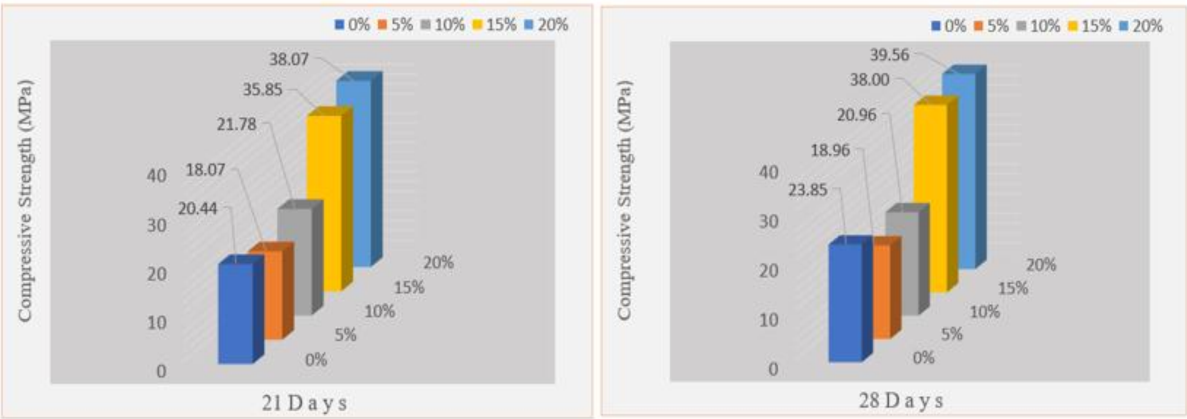

Fig. 7. Compressive Strength against 21 and 28 Days for 0%. 5%, 10%, 15%, and 20% addition of 600°C Calcined Lateritic Soil

Effects of 600^{0}C Calcined Lateritic Soil (CLS) on Concrete Workability

By examining the study results (Table 7) of the Effectiveness of Calcined Lateritic Soil as a mineral admixture in normal weight Concrete, we find that the slump value reduces with an increase in percentage dosage of the 600-degree Celsius Calcined Lateritic. The CLS absorbs the mixing water in the concrete.

Effects of 600^{0}C Calcined Lateritic Soil (CLS) on Compressive Strengths

The compressive strength results of concrete cubes with difference percentage dosage ranging from 0 – 20% of 600^{0}C CLS as mineral admixture are given in Table 3 and Figures 10 - 13 respectively.

By evaluating Table 3 and Figures 10- 13, we confirmed that the 7 days compressive strength reduces with 5 and 10% of CLS addition but increases with 15 and 20% addition. For instance, when CLS percentages additions are 5% and 10%, the 7 days compressive strengths reduce by 9.4% and 1.9% respectively, and when CLS addition increases to 15% - 20%, the 7 days compressive strengths increase by 12.2% and 19.4%, respectively compared to 0% dosage of CLS compressive strength. The 28 days compressive strength of 5% and 10% with 600^{0}C CLS is lower than that of 0% dosage by 20% and 12.1% respectively, at 15 and 20% addition, 28 days compressive strength increase by 37.2% and 39.7% respectively. The 14 days and 21 days compressive strengths show similar variations, for instance, decreasing with 5% and 10% dosage and then increasing with 15% and 20% CLS addition.

Table 4: Lateritic SoilClassification

` TEST NO	PSD (%)			ATTERBERG LIMIT		USC SYSTEM	AASHTO CLASSIFICATIO N
	SIEVE NO 10	**SIEVE NO 10**	**SIEVE NO 10**	**LL**	**PI**		
1	99	72.0	49.2	44.2	17.5	OL	A-7
2	92	72.3	39.3	38.5	18.7	CL	A-6
3	94	89	64.7	45.8	15.5	OL	A-7

Soil Classification

From Table 4. the predominant soil type collected from the site is **A7** and **OL** by AASTHO and USC system of soil classification. The laboratory test results are in the appendix.

IV.CONCLUSION

Based on the results from the researched work of the effectiveness of calcined lateritic soil as a mineral admixture, the following conclusions have been drawn:

i. It was concluded that Concretes with 15% and 20% at 600^{0}C of calcined lateritic soil addition can be of great value to construction considering its compressive strength
ii. The compressive strength of concrete increased steadily with increasing percentage admixture of calcined lateritic soil at 600^{O}C of calcined temperature
iii. The compressive strength of concrete increased with the addition of 20% of 400^O C calcined lateritic soil at age 7, 14 and 21 days cured in water but reduced at age 28 days
iv. The workability of the concrete increases with an increase in calcined lateritic soil content
v. The best addition dosages of Calcined lateritic soil at 600^{0}C are 15% and 20%
vi. 20% addition of Calcined lateritic soil at 600^{0}C exhibited about a 40% increase in compressive strength at 28 days.
vii. 15% dosage of Calcined lateritic soil at 600^{0}C exhibited about 37.2% increase in compressive strength 28 days.

REFERENCES

[1]. Isaac O. A. and Manaseh J. (2008) Use of cement-sand Admixture in Lateritic Brick Production for Low Cost Housing. Leonardo Electronic Journal of Practices and Technologies Issue 12. ISSN 1583-1078, p. 163-174.
[2]. IS: 3495 – (1992): Methods of tests of burnt building bricks – Part 2: Determination of water absorption, Bureau of Indian Standards, India.
[3]. Asiedu Emmanuel and Agbenyega Allan, (2014) "Suitability of laterite fines as a partial replacement of sand in the production of Sandcrete bricks", International Journal of Emerging Technology and Advanced Engineering, Vol. 4, Issue 10.
[4]. Biju Mathew, Benny Joseph and C. Freeda Christy, (2013) "Strength performance of concrete using laterite as sand replacement", International Journal of Civil Engineering Research & Applications (IJCERA), Vol. 1 Issue 3.
[5]. Nwanokobi, T.U. (2007) Analysis and Design of laterized concrete Cylindrical shells for Farm Storages. A Thesis submitted to the Department of Agricultural and Bioresources Engineering University of Nigeria, Nsukka.
[6]. B.S. EN 196-0; 2016. Method of Testing Cement. Determination of fineness. British Standards Institute. London, United Kingdom
[7]. B.S. 882; 1992.Specification for Aggregates from natural sources for concrete. British Standards Institute. London, United
[8]. BS 3148; 1980. Methods of test for water for making concrete. British Standards Institute. London, United Kingdom

Nwankwo E,etal. "Study on The Effectiveness of Calcined Lateritic Soil as A Mineral Admixture in Normal Weight Concrete." *American Journal of Engineering Research (AJER)*, vol. 9(04), 2020, pp. 239-245.