Journal of Inventive Engineering and Technology (JIET)
ISSN: 2705-3865
Volume-6, Issue-2, pp-46-52
www.jiengtech.com
Research Paper Open Access

Strength Characteristics of Partially Replaced Fine Aggregate with Laterite in Concrete Production

[1]Nurudeen Yusuf and [2]Abdulhameed Musa Ogirima

[1&2]Department of Civil Engineering, Usmanu Dan Fodiyo University, Sokoto State, Nigeria.

The Corresponding author[1]: ny.kwami@yahoo.com

ABSTRACT: Sustainability development has become a strategy for the building industry, and it is widely acknowledged that searching for innovative, creative, and eco-friendly materials is worthwhile. Because concrete is used so often in civil engineering applications, there is a greater need for concrete ingredients. Because it is so scarce, sand is an expensive but essential component of concrete. The absence of components has led to many searches and studies looking into using laterite soil instead of sand as fine aggregate. This work conducted an experimental investigation of the strength characteristics of lateritic concrete; the laterite used is classified as low plasticity clay (CL) in the Unified Soil Classification System (AASHTO soil classification A-7-6 (10)). This laterite has kaolinite as its predominant clay mineral and is located in zone four of the gradation, which is characterized by fine laterite. As part of the experiment, 36 cubes will be fabricated, and their compressive strength will be evaluated. According to tests, lateritic concrete cubes had a 28-day compressive strength of 25.29N/mm^2, 28.15N/mm^2, and 20.00N/mm^2 for 10%, 20%, and 30% replacement, compared to 30.23N/mm^2 for concrete cubes. The results of this study showed that lateritic concrete behaves similarly to regular concrete; there aren't many differences between the two types of concrete in terms of their physical characteristics. Conversely, compared to the lateritic materials, the concrete materials displayed superior strength characteristics. Even though lateritic concrete has varying strengths, it is nevertheless perfectly suitable for structural grade concrete.

KEYWORDS: *Compressive strength, curing age, Structural grade concrete, lateritic concrete.*

Date of Submission: 08-10-2024 Date of acceptance: 10-10-2024

I. INTRODUCTION

In Nigeria and many other countries across the world, concrete is the most commonly used building material. Concrete is arguably the most adaptable building material available. When strength, flexural strength, enhanced workability, durability, impermeability, fire resistance, and abrasion resistance are required, this is the material of choice. Cement concrete is one of the seemingly simple but intricate materials. To make full use of this content, it is still required to identify many of its compound behaviors. Since concrete is integral to all building activities, it affects every individual on a daily basis. It is an artificial compound that is often created by appropriately combining cement, fine and coarse aggregates, water, and admixtures with binding material. After being mixed and placed, concrete does not solidify through drying; instead, hydration and chemical reaction between the cement and water—occurs. Because it is manufactured on-site, unlike other building materials, concrete can have a wide range of qualities, characteristics, and performance because it is made mostly of natural resources rather than cement.

An in-depth understanding of the interactions between the several ingredients that go into manufacturing concrete, both in fresh and hardened situations, is necessary to go from materials with different properties to concrete with specified qualities. Both site engineers and concrete technologists need to be aware of this; the rising demand for using large amounts of concrete raises the price of cement, the binding material, and causes natural sources of fine aggregate to run out, raising the overall cost of concrete.

Owing to the aforementioned reason, laterite must be used in place of fine aggregate to some extent or entirely. Severe sub-aerial weathering produces laterite. Leaching alkalis, bases, and silica while complementing enrichment of alumina, iron, and a few trace elements is the process of lateralization. In the past few decades, a relatively novel material known as lateralitic concrete has been developed. Its reddish-brown color comes from the laterite soil, which is high in iron and aluminum oxides. Tropical locations are home to laterite, which has been used for construction purposes for ages. For instance, medieval Europe used laterite for walls and roofing, and ancient Egyptians used it to make bricks.

Lateritic soils are one of these easily accessible and affordable materials. Large amounts of lateralitic soils can be found throughout Nigeria and the majority of tropical nations. Originating from regions where natural drainage is hindered, they are byproducts of weathering in tropical or subtropical climates [1]. The use of laterite in place of sand in regular cement concrete has been studied [2;3;4]. In building and civil engineering buildings, normal cement concrete has been widely employed as a construction material [5]. The development of building materials from readily available, inexpensive material sources has been spurred by the rising cost of producing concrete. This has resulted in a reduction in construction costs while maintaining the advancement of indigenous technology [2;3;4]. Laticrete, Latcon, or lateritic concrete is concrete in which the sand component is either entirely or partially replaced by laterite [2;1].

According to [6], the compressive strength of laterized mortar with variations in the laterite-fine aggregate ratio rises when exposed to magnesium sulphate (Mg2SO4) and falls when it is treated to alternating soaking and drying. Additionally, the ideal compressive strength was found in a lateralized cement mortar that was conditioned to a temperature range of 1000C and had a 20% laterite-fine aggregate ratio. In their study [7] they, focused on the specific gravity, density, and particle size distribution of laterite. The use of laterite as a fine aggregate in concrete was attempted. In this investigation, the amount of laterite varies at intervals of 25% from 0% to 100%. The mechanical strength and durability properties are determined using the 1:1.5:3 concrete mix. When the amount of laterite in concrete rises, the density of the mixed laterite concrete also rises. The outcomes of concrete blended with laterite sand and traditional concrete are contrasted. High compressive strength is achieved when laterite sand replaces sand to the extent of 50%. As the percentage of laterite sand increases, so do the tensile and flexural strengths.

II. METHODOLOGY

A. MATERIALS

Cement

The cement used was ordinary Portland cement sold under the brand name Sokoto cement, which is a Nigerian made from Sokoto located at KM 10 Kalambaina Road. The following tests were performed on the cement that was purchased from the market: fineness, consistency, initial setting time, and final setting time.

Fine Aggregate

The sand used in this research work was bought from a local supplier which was gotten from the river before Usmanu Dan Fodiyo University second gate.

Coarse Aggregate

The coarse aggregates used were crushed granite, bought from a local supplier in the Arkila area of Sokoto; the maximum nominal size of coarse aggregates is 20mm.

Laterite

The laterite used in this research was dug from a borrow pit located at the Dundaye area of Sokoto State at a depth of 0.5m. the laterite is free from debris and inorganic materials.

Water

As recommended by the code [8], portable water was used for casting specimens from the concrete laboratory of the Department of Civil Engineering, Usmanu Dan Fodiyo University Sokoto.

B. TESTS ON MATERIALS

Physical properties test on fine and coarse aggregates

The BS code [9] was used to conduct the specific gravity test. The fine and coarse aggregate's particle size distribution was determined in accordance with to the code [10].

Physical properties of the laterite

A moisture content test was conducted using BS code [11]. In accordance with BS code [12] the tests for the plastic and liquid limitations were conducted.

Physical Properties of Cement

The consistency, setting time, and soundness of cement were carried out in accordance with BS code provision.

Mix proportion and Specimen production

The mix proportions were ascertained by applying the design of experiment (DOE) method. The volume of the 150 mm^3 cube was used to calculate the material quantity for a design goal strength of 25 N/mm^2 concrete grade. In the laboratory, a total of thirty-six cubes were cast and cured in a water tank for seven, twenty-one, and eighteen days. Of the 36 cubes, nine were evaluated with no laterite applied as the control specimen and nine cubes with laterite replacement percentages of 10%, 20%, and 30%.

III. RESULTS AND DISCUSSION

Physical properties of cement

The results obtained from cement tests are presented in table 1, all the results were compared with the code provision [13] and are found to be within the limit provided by the code.

Table 1: physical properties of cement

Parameter	Value	Code of specification BS EN 196 Part3:1983
Soundness	2.5mm	Satisfactory
Consistency	28.85%	Satisfactory
Initial Setting time	78 minutes	Satisfactory
Final Setting time	175 minutes	Satisfactory

Physical properties of fine aggregates

The Specific gravity of the sand is 2.54, which is in accordance to the specification provided by the code of practice. It was observed that 59.4 per cent of the sand passes BS sieve size 500µm which shows that the sand is classified as belonging to zone two gradation, characterized by medium sands, which is good for concrete in accordance to the code. Fig. 1 shows the particle size distribution graph for the fine aggregates.

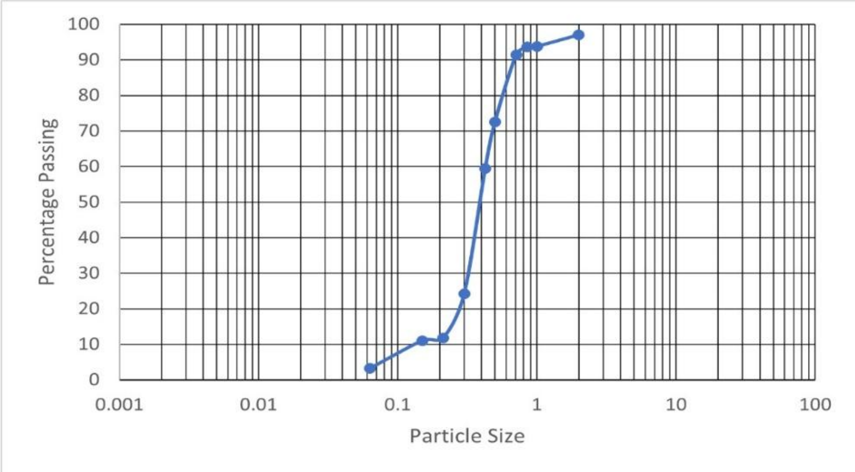

Fig. 1: Particle size distribution of sand

Physical properties of coarse aggregates

The coarse aggregate's specific gravity of 2.63 complies with the requirements specified by the code of practice. The study's coarse aggregate particle size distribution is shown in Fig. 2. It was found that the aggregate is uniformly distributed, making it suitable for achieving the necessary workability for improved concrete production.

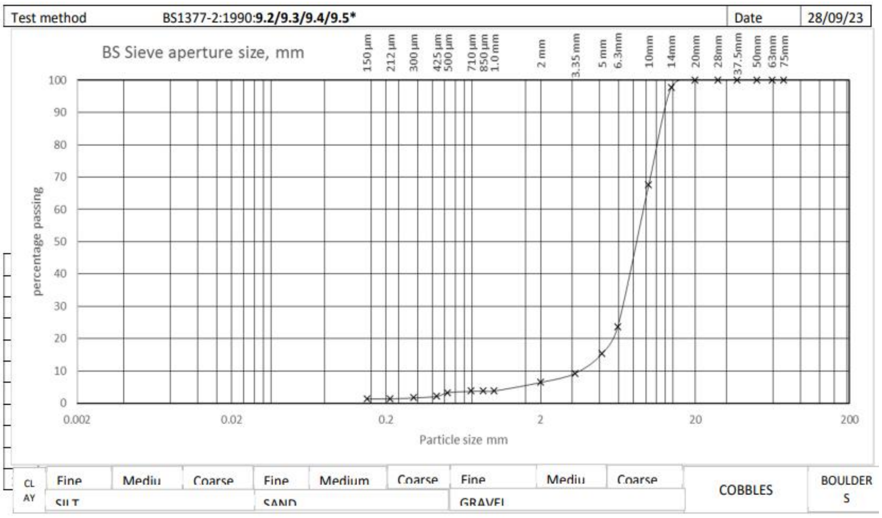

Fig. 2: Particle size distribution of coarse aggregate

Physical properties of laterite

It is discovered that the lateritic soil has a specific gravity of 2.54, which is within the acceptable range. Table 2 displays the lateritic soil's physical characteristics.

Table 2: Physical properties of lateritic soil

Property	Laterite
Colour	Reddish brown
Liquid Limit	41.3%
Plastic Limit,	20.6%
Plasticity Index	20.7%

Compressive strength of concrete

The compressive strength results for the 0%, 10%, 20% and 30% replacement is presented in Tables 3-6 below.

Table 3: Compressive strength of concrete specimen 0% lateritic soil

Curing age	**Specimen no.**	**Compressive strength (N/mm^2)**	**Average compressive strength (N/mm^2)**
7days	1	20.79	21.81
	2	21.48	
	3	23.18	
21days	1	27.90	26.96
	2	26.19	
	3	26.79	
28days	1	29.80	30.23
	2	30.25	
	3	30.63	

Table 4: Compressive strength of concrete specimen with 10% lateritic soil

Curing age	**Specimen no.**	**Compressive strength (N/mm^2)**	**Average compressive strength (N/mm^2)**
7days	1	19.60	18.69
	2	18.80	
	3	17.68	
21days	1	24.00	24.05
	2	25.10	
	3	23.04	
28days	1	25.67	24.29
	2	23.4	
	3	23.8	

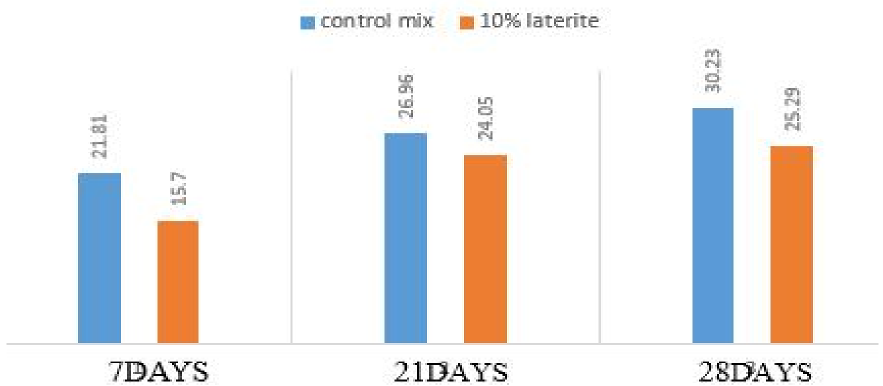

Fig. 3: Comparisons between different proportions

From Fig.3, it was observed that, the 10% laterite concrete's compressive strength rose, but it still fell short of the control mix's value. Twenty percent of the compressive strength was lost after 28 days.

Table 5: Compressive strength of concrete specimen with 20% lateritic soil

Curing age	Specimen no.	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
7days	1	17.13	17.21
	2	20.00	
	3	14.49	
21days	1	21.40	21.66
	2	18.90	
	3	24.70	
28days	1	24.56	28.15
	2	31.90	
	3	28.00	

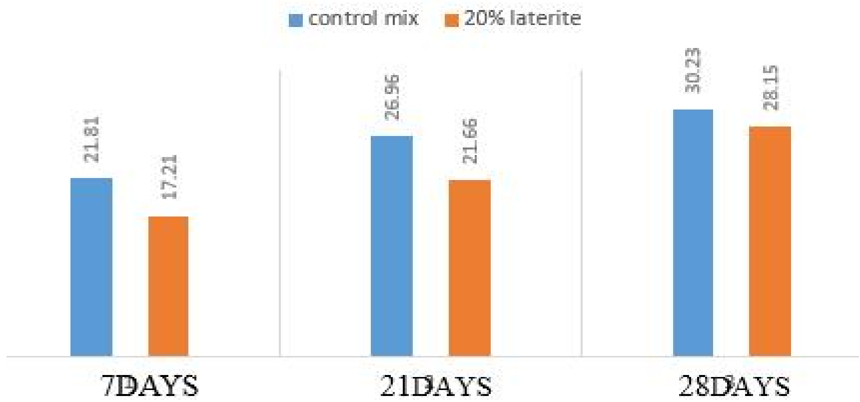

Fig. 4: Comparisons between different proportions

For that of 20% laterite replacement it has the highest strength of all the replacement at 28 days strength with a reduction of only 7% as compared to the control specimen as shown in Fig. 4.

Table 6: Compressive strength of concrete specimen with 30% lateritic soil

Curing age	Specimen no.	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
7days	1	15.20	15.70
	2	15.11	
	3	16.95	
21days	1	18.43	18.88
	2	19.20	
	3	19.00	
28days	1	16.30	20.00
	2	22.40	
	3	21.00	

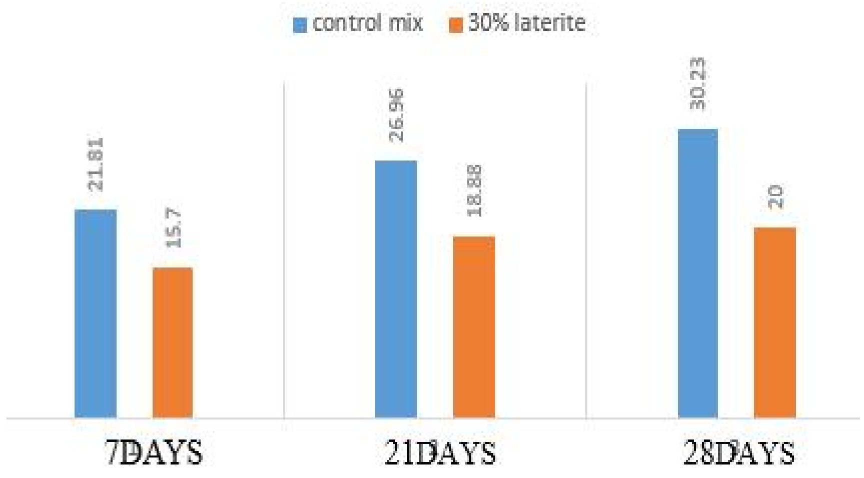

Fig. 5: Comparisons between different proportions

Although it grew with age, the 30% laterite concrete's compressive strength is 34% lower than that of the control mix as shown in Fig. 5. The study's findings indicate that, in cases where replacing sand in concrete is preferred, it is ideal to replace it partially, up to 20%, with laterite, which is thought to be somewhat stronger than the 25N/mm^2 goal strength for structural grade concrete.

REFERENCES

[1] Ata, O. (2007), "Effects of varying curing age and water/cement ratio on the elastic properties of laterised concrete". *Civil Engineering Dimension, Vol.9, No.2, Sept., pp.85 – 89.*

[2] Adepegba, D., (1975a)," A Comparative Study of Normal Concrete with Concrete which contained Laterite Instead of Sand". *Building Science, 10(2), pp.135-141.*

[3] Ata, O. (2003), The effects of Applied Stress on the Modulus of Elasticity and Modulus of Deformability of Terracrete, *Unpublished M.Sc Thesis, Department of Building, Obafemi Awolowo University, Ile-Ife.*

[4] Osunade, J.A. (2002), Effect of Replacement of Lateritic Soils with Granite Fines on the Compressive and Tensile Strength of Laterized Concrete. *Building and Environment. 37(6), pp.491-496.*

[5] Neville, A M (1995). Properties of Concrete, 4th ed. Harlow, UK: Longman Group

[6] Olubisi A. Ige. (2013): Performance of lateritic concrete under environmental harsh condition", International Journal of Research in Engineering and Technology, Volume: 02 Issue: 08, Aug-2013

[7] Santhiyaa J. Jenifer & S. Ramasundarm (2015) "Experimental Investigation on Strength Parameters of Laterised Concrete after Adding Silica Fume" *International Journal of Science and Research.*

[8] BS EN1008 (2002): Mixing water for concrete – Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete.

[9] BS 812, Part 2 (1975): Method of determination of physical properties of aggregates. British Standard Institution, London

[10] ASTM C136 (1978). Standard Method for Sieve Analysis of Fine and Coarse Aggregates. American Society for Testing and Materials, Philadelphia

[11] BS 1377 part 2, (1990): Standard Method of Test for Soils for Civil Engineering purposes- Classification tests.

[12] BS 1377 part 4, (1990): Standard Method of Test for Soils for Civil Engineering purposes- Compaction related tests.

[13] BS EN 196 Part 3:1983: Methods of testing cement- Determination of setting time and soundness.