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# STRENGTH COMPARISON OF CALCINED AND UNCALCINED LATERITES IN A LATERIZED CONCRETE

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**Abstract:** The objective of this research is to assess the effect of calcining laterite in laterite concrete by comparing the compressive strength of calcined and uncalcined laterite in laterite concrete. Three trial batches of cement concrete using 1:1:4 proportions of cement, river sand, and coarse aggregate. 20% of the coarse aggregate was substituted with calcined and uncalcined laterite for workability and compressive strength testing of specimens for three trial mixes with maturities of 7, 14, and 28 days. The compressive strength of calcined laterite in laterite concrete increases from 16.5 to 33.9N/mm2 at 7, 14, and 28 days.

**Keywords:** compressive strength, calcined laterite, uncalcined laterite, workability

## I.INTRODUCTION

According to the Encarta English Dictionary, laterite is a reddish mixture of clayey iron and aluminum oxides and hydroxides produced by the weathering of basalt in humid, tropical conditions (2008). Laterite is both a type of soil and a type of rock that is rich in iron and aluminum, and it is generally believed to have developed in hot, rainy tropical regions. Due of its high iron oxide content, nearly all laterites have a rusty-red hue.

Laterite is a mixture of clayey iron and aluminum oxides and hydroxides that is abundant in Nigeria and other tropical climates. Utilizing laterites permits the construction of affordable homes and other rural infrastructures. However, laterites have not been widely employed in the construction of medium- to large-scale buildings. This is likely owing to the transformation of the source rock, which comprises primary feldspars, quartz, and ferromagnesian minerals, into a porous clayey system including kaolinite, equipoises, and a small amount of residual quartz. The process of soil weathering is highly dependent on the environmental circumstances in which soils exist. Laterite is comprised of both cohesive and non-cohesive soils. Consequently, laterites are referred to as C- (C-Phi) soils. The cohesionless component consists of gravel, sand, and silts, whereas the cohesive portion consists of small particles of silt and Clay. Lateritic soils respond differently to changes in relative humidity, with some altering their volume while others stay unchanged. However, as clay dries, shrinkage cracks can form in the clay mass, resulting in a reduction in strength. Throughout consecutive wetting-up processes, fractures function as water pathways. When clay is used exclusively as a building material, this presents a substantial issue. Therefore, a blend of stable materials, such as gravel, silt, and clay, creates the optimal construction soil. In this aspect, lateritic soils appear to be the best option as they are composed of all of these different particle sizes in varying proportions (well-graded) (Oyelami & VanRooy, 2016).

Laterites are economically important for mineral deposits such as bauxite. In addition, robust, hardened laterite varieties are occasionally carved into blocks and utilized as building materials for dwellings. By the twelfth century, Khmer architects had mastered the use of sandstone as the major building material. Prior to the twelfth century, laterite was extensively utilized to construct temples in Cambodia. The majority of Angkor Wat's visible areas are comprised of sandstone blocks, with laterite used for the outer wall and secret structural components that have endured for more than a millennium. Hardened Laterite has been utilized rudimentarily for highway construction). In aquaria, solid lateritic gravel encourages the growth of tropical plants (Oyelami &Van Rooy, 2016). The economic and environmental benefits of laterized concrete are garnering academic attention.

Man was reportedly using concrete 7,000 years before the birth of Jesus Christ. Few individuals are aware of its production versatility and longevity. Even yet, concrete remains a versatile material for the development of infrastructure worldwide. In order to develop additional physical infrastructures, concrete resource scarcity imposes a greater burden on the environment due to the ongoing need for concrete resources. Ettu et al. (2013) integrated laterite on traditional concrete. He used laterite in place of aggregates (BS 8110, 1999). In building construction in underdeveloped nations, laterite can be substituted for fine aggregate reinforced concrete requiring low characteristic strength, according to the findings of numerous sources of a similar nature. It was determined that the durability of concrete incorporating laterite

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is comparable to that of conventional concrete in a sulfate environment. Khairunisa et al. (2015) discovered that 20% laterite rock as a partial replacement of aggregates in concrete production can be one of the solutions to lessen the concrete industry's reliance on the supply of granite aggregates, hence conserving resources for the future. Their experiment revealed that the durability of laterized concrete in a sulphate environment was comparable to that of pure cement concrete. The rising cost of concrete binders has increased interest in the cost of alternatives to cement. According to Alireza et al. (2010), there is a current interest in the recycling of waste materials for development. In the creation of concrete-strengthening compounds that can either replace or supplement binders, there is minimal or no strength loss. The strength of concrete with binders or partially replaced source material improves with age of the test sample, whereas the strength of concrete with unsubstituted cement binders decreases with age. Dense concrete is characterized by low porosity or few voids. As a porous material, concrete possesses air/water permeability capabilities, and this has a significant impact not only on its strength but also on its longevity, according to Kumar et al. (2014). The porosity of concrete is influenced by its elements, the prevailing ambient conditions, and the production techniques and systems. The objective of the present study is to examine the effects of calcined and uncalcined laterite in laterized concrete, with a view toward enhancing the environmental value of Laterites in the building industry.

## II.MATERIALS AND METHODS

**1.1. Experiment Site:** The experiment was carried out at the concrete laboratory, Civil Engineering department, Federal Polytechnic Ado-Ekiti, Ekiti state.

**1.2. Sampling and analysis:** The batch consisted of a total of 28 concrete cubes. 7 days, 14 days and 28 days were used to cure the samples, respectively. For each date of crushing, three cubes were made. Three cubes were made for the slump test and three more for the porosity test. 28 cubes were cast altogether having dimensions 150mm by 150mm by 150mm cubes.

Figure 1.1: compressive strength machine

### 1.3. Materials

Laterites were acquired outside the school gate of the federal polytechnic in Ado Ekiti, one piece for calcination and the other for uncalcination. Fine and Coarse Aggregate was acquired from local sellers in Ado Ekiti. Open market procurement of commercial ordinary portland cement.

### 1.4. Processing and Test of Materials

Around the polytechnic's entrance, laterite was dispersed into the air to minimize humidity for three days. To Calcine the Laterites, a portion of the sun-dried laterite was transferred to a blast furnace at 750°C for two hours. After cooling, the calcined Laterite was submitted to physical and chemical examination. Coarse aggregate and calcined laterites were subjected to a test of impact.

Concrete mixes with a ratio of 1:2:4 were mixed with replacement aggregates containing 20% Calcined and uncalcined laterites. Before casting a 150 x 150 x 150mm steel mold, the wet mixtures of calcined and uncalcined laterized concrete had to undergo a slump test and a compaction Factor test. In three studies, cast samples were cured in 7, 14, and 28 days.

### 1.5. Compressive strength test

The specimens were tested by compression testing machine after 7days,14days and 28 days curing. Load was applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gave the compressive strength of concrete.

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### 1.5.1. Calculations

$$\textbf{Size of the cube} = \mathbf{15cmx15cmx15cm}$$

$$\text{Area of the specimen (calculated from the mean size of the specimen } = 225\ \text{cm}^2$$

$$\text{Characteristic compressive strength (fck)at 7 days} = \text{Expected maximum load } = \text{fck x area x f.s}$$

### 1.6. Slump Test

The purpose of the concrete slump test or slump cone test is to measure the workability or consistency of concrete mix prepared in the laboratory or on the job site as the work progresses.

### 1.7. Porosity Test

Porosity is a measurement of the volume of concrete cavities. Porosity is the ratio of the amount (or volume) of void in a rock to its entire mass. Void/total is expressed as a mathematical ratio: volume of voids divided by entire volume. Typically, this ratio is multiplied by 100 percent so that we can communicate and compare in percentages rather than decimals, as seen by the following equation:$\text{Porosity } = \text{ (Volume of Voids /Total Volume) x } 100\%$

### 1.8. Compaction factor

The compacting factor is defined as the ratio between the weights of partially compacted and fully compacted concrete. It must typically be stated to the second decimal place. The compaction factor test is used to determine the workability of fresh concrete based on the amount of internal energy necessary to calculate the concrete's density precisely.
Typically, the compaction factor is computed (equ.1) by dividing the value of partially compacted concrete by the value of fully compacted concrete, and reported to the second decimal place.
$\text{Compaction factor } = \text{ (W1} - \text{W) /(W2} - \text{W) } \quad \text{equation } 1$

## III.RESULTS AND DISCUSSION

### 3.1. Chemical Analysis

Table 4.1 displays the oxides found in lateritic soil samples obtained from four distinct locations and then burned at 750°C for five hours. After burning, it was found that the color of the soil samples changed.

**Table 3.1: Results of Chemical Analysis of Soil Sample**

| Oxide Composition | $Na_2O$ | CaO | $K_2O$ | MgO | $Fe_2O_3$ | $Al_2O_3$ | $SiO_2$ | $MnO_2$ |
|---|---|---|---|---|---|---|---|---|
| Percentage | 0.150 | 0.304 | 0.152 | 2.100 | 44.620 | 10.260 | 12.800 | 0.103 |

The engineering properties (impact value, crushing value, specific gravity, silt content, and flakiness) of Calcined laterite aggregate, fine aggregate, and Coarse aggregate are detailed in Table 1. According to the table, the aggregate impact value for laterite is 12.64, whereas the aggregate impact value for coarse aggregate is 16.56, indicating that calcined laterite aggregate also have a high aggregate effect value.
In contrast, the crushing value of coarse aggregate is nearly double that of calcined laterite aggregate, indicating that a higher proportion of aggregate replacement will ultimately result in a decrease in the compressive strength of the concrete. The specific gravity of calcined laterite aggregate and coarse aggregate are 3.80 and 2.89, whereas the silt content of fine aggregate is 1.84 percent. The flakiness of laterite aggregate is 2, while coarse aggregate is 8.

**Table 3.2: Test results on aggregate**

| Engineering properties | Calcined Laterite Aggregate | Fine aggregate | Coarse aggregate |
|---|---|---|---|
| Aggregate Impact Value | 12.64 | ________ | 16.56 |
| Aggregate Crushing Value | 23.56 | ________ | 40.00 |
| Specific Gravity | 2.80 | 2.67 | 2.89 |
| Silt Content (%) | | 1.84 | |
| Flakiness | 2 | | 8 |

### 3.2. Concrete workability

Slump tests were used to evaluate the workability of Calcined lateritic concrete and uncalcined lateritic concrete mix. Table 2 presents the results of the workability tests conducted during the recession.

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**Table 3.3: Test results on aggregate**

| Laterite Replacement | Slump (mm) |
|---|---|
| Calcined | True slump/90 |
| Uncalcined | True slump 60 |

**3.3. Compressive strength:**

To establish the effect of calcined and uncalcined laterite, compressive strength tests are reported in Table 4.1 and Table 4.2. The variation in compressive strength of the samples is displayed in the following table.

**Table 4.1: Compressive strength of calcined Laterized concrete**

| NumberofDays | Trial1 | Trial2 | Trial3 | Average Compressive strength (N/mm$^2$) |
|---|---|---|---|---|
| 7days | 25.24 | 25.43 | 25.47 | **25.43** |
| 14days | 29.07 | 29.26 | 29.29 | **29.20** |
| 28days | 32.89 | 33.08 | 33.12 | **33.91** |

**Table 4.2: Compressive strength of uncalcined laterized concrete**

| Number of days | Trial 1 | Trial 2 | Trial 3 | Average Compressive strength (N/mm$^2$) |
|---|---|---|---|---|
| 7 days | 14.37 | 17.63 | 18.94 | **16.50** |
| 14 days | 17.11 | 16.50 | 17.30 | **16.97** |
| 28 days | 20.22 | 16.22 | 18.15 | **18.20** |

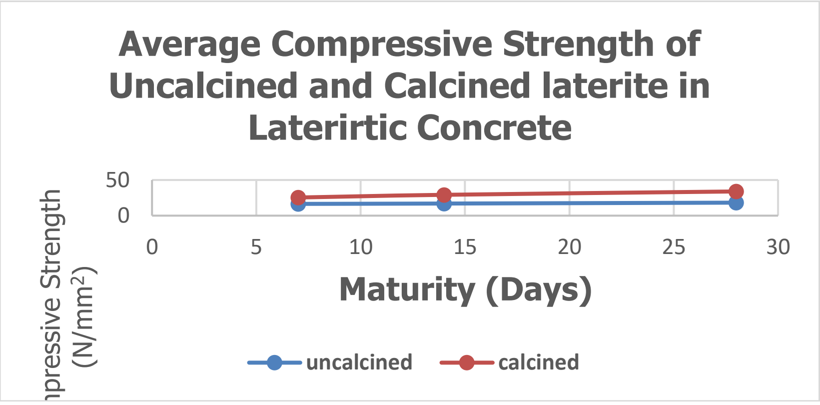


**Figure 1: Graph pf average compressive strength of calcined and uncalcined concrete against age**

From Fig. 1, uncalcined laterite in the lateritic concrete has an average compressive strength of 16.5N/mm$^2$ on day 7 and increased with maturity to 18.2N/mm$^2$ on day 28 indicating a strength gain of 11.70% from day 7 to day 28. Calcined laterite in the laterized concrete has a strength of 25.43 N/mm$^2$ on day 7 and increases to 33.9N/mm$^2$ on day 28 indicating

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a strength gain of 25.4%. Compared to uncalcined laterite, the compressive strength of calcined laterite in laterized concrete is greater for 7, 14, and 28 days by 35, 42, 12 percent, and 46, 31 percent, respectively.

## IV.CONCLUSION

In comparison to calcined laterite, the uncalcined laterite of Polytechnic gate has inhibitory volatile elements that reduce the compressive strength of laterite concrete. 20% of the mass of the coarse aggregate can be calcined or uncalcined laterite, depending on the desired strength of the concrete. Calcination of the laterite despite the fact that it increased the energy consumption of laterite concrete in comparison to laterite concrete containing uncalcined laterite..

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