# STRUCTURAL CHARACTERISTICS OF LATERIZED CONCRETE AT OPTIMUM MIX PROPORTION

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**ABSTRACT**

***The astronomical increase in prices of materials for building construction in Nigeria is causing a lot of concern, creating need for research into indigeneous materials as alternatives in building and rural infrastructures. Research efforts are directed towards enhancing the use of locally and readily available material such as lateritic soils for the construction of low-cost but effective dwellings, farm structures and other rural infrastructures.***

***The knowledge of characteristics and performance of laterized concrete is a prerequisite to the accurate design of structures built of this material. Some of the structural characteristics of laterized concrete are studied at the predetermined optimum mix proportion and that used for general reinforced cement concrete work. The results show that the values obtained for elasticity Modulus, rigidity Modulus, flexural strength, poisson's ratio are higher at optimum mix proportion than at the conventional mix ratio in cement concrete. Only density value is lower at the former mix ratio than the latter.***

***Key Words:*** *Laterized concrete; lateritic soils; structural characteristics*

## 1. 0 INTRODUCTION

Lateritic soils are widely used as a construction material in Nigeria and other under-developed and developing countries of the world. In addition to Mud walls, brick masonry (dried or burnt type) are made from lateritic soils in both rural and urban areas of the country, Nigeria. According to Lasis and Osunade [1], the use of laterite to replace sand component of concrete either wholly or partially, is becoming widespread among the low-income earners for building construction. The utilization of laterites enables the provision of low-cost houses and other rural infrastructures. However, laterites have not been extensively used in constructing medium to large-size building structures. This is probably due to lack of adequate data needed in the analysis and design of structures built of lateritic soils. To improve the utilization of this locally available materials, investigations into the properties of both stabilized and unstabilzed lateritic soils have been carried out. Some of the basic engineering properties of laterized concrete have been determined but only at specific conditions. Osunade et al [2] have studied shear and tensile properties of unreinforced laterized concrete at specific curing ages. Ductility, shear and tensile properties of fibre-reinforced laterized concrete have been determined by Osunade and Ogundeko [3]. The effect of chemical admixture on the compressive strength of lateritic soil materials for masonry units has been investigated [4]. The compressive strength as affected by types and sizes of coarse aggregates have been studied [5]. The effect of grain size and optimum moisture content on the cement-stabilized and unstabilized lateritic soils have also been studied [6]. Lasis and Osunade [6] reported that the strength properties of lateritic soil is a function of probable formation processes and the source where they are collected. With the afore-mentioned research work on laterized concrete, data on some structural characteristics such as elasticity modulus, rigidity modulus and poisson's ratio is not found in literature. Only limited information on flexural strength of laterized concrete is available. In the recent study by Nwakonobi (2005) the optimum mix proportion that will produce maximum strength value of laterized concrete was determined. The objective of this study is to determine some of the structural characteristics of laterized concrete at both optimum mix proportion and that used for general reinforced cement concrete work.

## 2.0 MATERIALS AND METHOD

### 2.1 Sources of Material

The lateritic soil for this investigation was collected from a borrow-pit at Nsukka in Enugu State, Nigeria. The coarse aggregate used was crushed granite of igneous origin with a size range of 9 – 14mm. Ordinary Portland Cement the properties which conform to the British Standard BS [8] part 2 of 1970 was used in this study.

### 2.2 Sample Preparation

The lateritic soil was sieved so as to exclude the clay content as well as the coarse aggregate contents of lateritic soils. The range of size used was 0.3 mm to 4.75mm. The size ranges of coarse aggregates were chosen in compliance with BS [9] part 18:1983 that the maximum size of coarse aggregate should not exceed one-third of the smaller dimension of the concrete member. For this study, the maximum size used was 14 mm and is less than one-third of 100 mm – the smallest dimension of the test specimen.

### 2.3 Batching and Mixing of Specimens

The pre-determined optimum mix proportions of 1:1:2 of cement, laterite and gravel at a water – cement ratio of 0.650 was used for this report Nwakonobi [7]. The pre-determined concrete mix proportion of 1:2:4, which is used for general reinforced cement concrete work, was also used for this report [10]. The water-cement ratio of 0.791 used for this mix proportion of 1:2:4 was adopted from the optimization study carried out by Nwakonobi [7] for a workable mix. Batching was by weight using Avery weighing scale. Different mixtures of cement, lateritic soil and gravel were prepared and 'worked' manually using shovel to stir. The working process involved the gradual addition of predetermined quantity of water to the mixtures already obtained and a continuous stirring with a shovel until a workable mix was obtained.

### 2.4 Flexural Strength Test

Beam specimens of size 100 × 100 × 500 mm were moulded and tested for flexural strength. The specimens have a slenderness ratio of 5. The making, curing and the method of test were in accordance with BS [9]. Three replicate samples were prepared for each of the laterized concrete mix proportions used. A total of six beam specimens were cast and tested. Each specimen was made by filling each mould in three layers. Each layer was compacted manually by using 25mm diameter rod to deliver 150 strokes on the layer. The specimens were water-cured at ambient temperature and to standard curing age of 28 days. For the flexural strength of the beam specimens, the "third-point" loading method was used (Fig. 1).

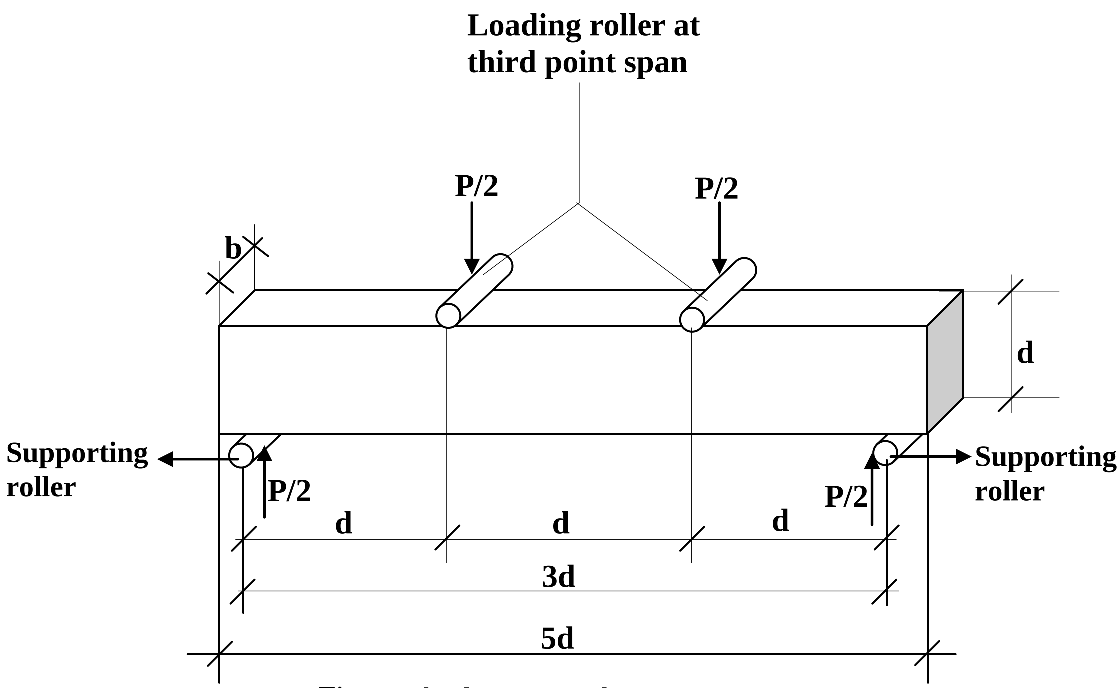


Fig. 1: Third-point Loading Arrangement

The beam was simply supported over a span 3 times the beam depth on a pair of supporting rollers. Two additional loading rollers were placed at the third points between the supports diameter rod to deliver 150 strokes on the layer. The specimens were water-cured at ambient temperature and to standard curing age of 28 days. For the on top of the beam. The load was applied without shock at a loading rate of 120 $KNmin^{-1}$. The flexural strength is related to the load and cross-sectional area as follows:

$$F_{tb} = \rho L / bd^2 \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where, $F_{tb}$ = flexural strength, $\frac{N}{mm^2}$

$\rho$ = maximum total load, N

L = length of the beam specimen, mm

d = depth of the beam, mm

b = width of the beam, mm

**2.5 Modulus of Elasticity**

Cylinder specimens of size 100 mm in diameter and 200 mm in length were made, cured and stored in accordance with BS [9]. Three replications of each of the two different mix ratios used were made. Therefore, a total of six cylinder specimens were cast and tested. All the specimens were tested in moist condition i.e. immediately after removal from the water tank at the curing age of 28 days.

The test specimen was placed centrally in the compression machine and strain gauges carefully fixed to measure strain in both lateral and longitudinal directions (Fig. 2). The basic load of 0.5 N/mm2 was applied and the dial/strain gauge readings taken in both lateral and longitudinal directions. The load was increased at a constant rate of 1 N/mm2.s until the load equal to one-third of the predetermined compressive strength of laterized concrete was reached as upper load [7]. The load was maintained for 60 seconds and strain readings recorded

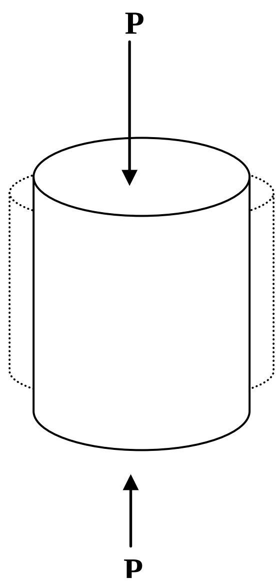


**Fig. 2: Deformation of Test Cylinder under axial compression**

within 30 seconds. One additional preloading cycle was carried out by using the same loading and unloading rate. The specimen was reloaded to upper loading level at the specific rate and the strain readings recorded within 30 seconds.

The static modulus of elasticity in compression was estimated using the formula:

$$E_{LC} = \frac{\Delta\sigma}{\Delta\varepsilon} = \frac{\sigma_a - \sigma_b}{\in_a - \in_b} \quad \text{……………..(2)}$$

where, $E_{LC}$ = modulus of elasticity of laterized concrete, $N/mm^2$

$\sigma_a$ = the upper loading stress in $N/mm^2$

($\sigma_a = \frac{F_c}{3}$)

$\sigma_b$ = the basic loading stress (ie. 0.5 $N/mm^2$)

$\in_a$ = mean strain under the upper loading stress

$\in_b$ = mean strain under the basic stress

$F_c$ = compressive strength of laterized concrete.

### 2.6 Poisson's Ratio

The lateral strain accompanying the axial strain to the applied axial compressive stress was recorded in static modulus of elasticity tests BS [9]. The poisson's ratio, μ, is calculated as the ratio of lateral strain $\in_L$ to longitudinal strain, $\in_C$

$$\mu = \frac{\in_L}{\in_c} \quad \text{……………………(3)}$$

### 2.7 Modulus of Rigidity

The modulus of rigidity of laterized concrete was calculated utilizing experimental values for elasticity modulus, $E_{LC}$ and poisson's ratio μ, in the equation:

$$G = \frac{E}{2(\mu + 1)} \quad \text{………………….(4)}$$

### 2.8 Density

Cube specimens of size 150 mm x 150 mm were prepared for the density determination. The preparation of the cubes was done in accordance with BS [9]. Each specimen was made by filling each mould in three layers and compacting manually with 25 mm diameter rod. On each layer, 35 strokes were delivered.

Demoulding was performed in accordance with BS [9]. The specimens were then submerged in a water tank for using Avery weighing scale. The density was estimated from the relation:

$$\rho = \frac{m}{V}$$

where; $\rho$ = density of hard laterized concrete, kg/m$^3$

m = mass of hard laterized concrete cube, kg

curing. The cubes were cured for 28 days. The hard laterized concrete cube after removal from curing tank was weighed

V = volume of the cube specimen, m$^3$

## 3. RESULTS AND DISCUSSION

The results of determinations of physical and structural characteristics of laterized concrete at optimum mix proportion as well as conventional mix ratio used for cement concrete are shown in Table 1.

**Table 1: Structural Characteristic of Laterized Concrete**

| Material Property | Mix Ratio | |
|---|---|---|
| | 1:1:2: 0.650 | 1:2:4: 0.791 |
| Density (kg/m$^3$) | 2,400 | 2,474 |
| Flexural strength (N/mm$^2$) | 4.12 | 3.17 |
| Compressive strength (N/mm$^2$) | 27 | 20 |
| Modulus of Elasticity (N/mm$^2$) | 18,888.9 | 10,163.9 |
| Modulus of Rigidity (N/mm$^2$) | 7,495.6 | 4,199.9 |
| Poisson's ratio | 0.26 | 0.21 |

It is clearly seen that the values obtained for flexural strength, compressive strength, young modulus, shear modulus and poisson's ratio are higher for the optimum mix ratio of 1:1:2 at water cement ratio of 0.650 when compared with those of the mix ratio 1:2:4 at water cement ratio of 0.791. Only density is lesser for te former mix ratio than the latter. The results in the above Table 1 indicate that the optimum mix ratio of 1:1:2:0.650, which has the highest strength, reflects on the quality of other properties of the laterized concrete material. Thus, results in Table 1 provide data needed for the accurate analysis and design of structures such as silos, water reservoirs, etc built of laterized concrete.

## 4. CONCLUSIONS

The data provided on the structural characteristics of laterized concrete at optimum mix proportion in this study can be adopted in the analysis and design of structures built of laterized concrete. The optimum mix which will have long lasting effect due to adequate strength should therefore be adopted particularly for heavily loaded laterized concrete structures such as silos, reservoirs, etc. However, mix ratio of 1:2:4:0.791 may be adopted for the construction of low cost housing and other rural infrastructure.

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