

Influence of Laterite and Compaction Methods on the Compressive Strength of Sandcrete Blocks

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ABSTRACT

The recent policies mitigating against excessive dredging of the river course in pursuit of sharp sand to produce sandcrete blocks which affects aquatic lives in the long run is of great concern as far as sustainability is concerned. There is need to source for alternative aggregate in making blocks to help reduce the dependence on river sand. Laterite which is readily available was used to partially replace the fine content in sandcrete blocks up to about 20% and the resulting compressive strength was observed. The physical properties of the fine aggregates were determined. After which, a mix proportion of 1:8 (one by part of cement and eight by part of the aggregate) and water cement ratio of 0.55 was adopted with lateritic content varying between 0 and 20% at 5% intervals. Manual and mechanical compaction methods were used in the production. Thereafter blocks produced were cured and subjected to compressive strength tests at 7, 14, 21 and 28 days of curing. The results showed that for each compaction method, the compressive strength decreases with an increasing lateritic content as the age of curing increases. Machine compacted hollow sandcrete blocks with 5% lateritic content had the highest 28-day compressive strength of 3.24 N/mm² which was slightly higher than 10% lateritic blocks with a compressive strength of 3.23 N/mm². However, both values fall within the range of 2.5 N/mm² and 3.45 N/mm² as specified by NIS 87:2000 for load bearing and Non-Load bearing walls respectively. Also, it was considered cost effective to incorporate laterite in sandcrete blocks from an economical point of view.

1. INTRODUCTION

One important decision often made during the construction of buildings is the choice of material to be used for the walls, this material varies from country to country depending largely on climatic condition that is readily available in such countries. In cold regions of the world much preference is usually given to materials that have low thermal conductivity while in countries with very hot weather the choice of material is always that which loses its heat more rapidly especially during the very hot weathers. There are quite a number of materials that can be used for walls in buildings, the most common in this part of the world is sandcrete hollow blocks.

Seeley (1993) defines sandcrete blocks as materials used for walls which is a combination of natural sand or crushed rock dust mixed with cement and water in a specific proportion and moderately compacted into different sizes. On moulding, these blocks set, harden and attain adequate strength required for it to be used as walling material. Of the materials used in the production of sandcrete blocks, cement is often considered to be the most expensive. However, the price of fine aggregate which is a major constituent of sandcrete block has been on the increase due to strict policies put in place by the government against sand mining. In addition, the cost of haulage which is usually incorporated into the material cost is on the increase especially in regions where there are no direct access to the sea for dredging. As a result of this, the prices of sandcrete blocks has been on the increase.

Furthermore, uncontrolled dredging of the sea bed has a devastating effect on aquatic life. Hence it is important that effort should be made to reduce the quantity of sand to be consumed in sandcrete hollow block production by supplementing with a close substitute which is readily available in large quantities, thereby reducing the price of the blocks. A critical review of lateritic soil from geological point of view concluded that soil is one of the best natural materials used in the production of compressed earth blocks. According to Tijani *et al.* (2017), most laterites in southwestern part of Nigeria are sandy-clay, incompressible and easily compactable.

Joshua *et al.* (2014) explored ways in which lateritic soil could be utilized in hollow sandcrete block production in Ota, Ogun State, Nigeria. Sandcrete blocks were made with lateritic soil taken from different sources replacing the conventional fine aggregate (local river sand) in steps of 10% up to 60%. Their compressive strengths determined to check for conformity with standard sandcrete block as specified in the Nigerian National Building Code (2006) with a view to determine the acceptable percentage replacement. Soil tests were performed on the lateritic soil samples to characterize the soils. Classification of the lateritic soil samples within Ota, revealed that the lateritic soils are mostly sandy clay of high plasticity and may replace sand by up to 20%, though an approximate linear decrease in strength with increasing sand replacement with lateritic soil was observed. Odeyemi *et al.* (2015) compared the compressive strengths of sandcrete blocks produced from two major brands of cement in Nigeria, the results of the investigation revealed that mechanically compacted sandcrete blocks had a strength improvement of about 2.4% when compared with manually compacted blocks for the brands of cement considered.

In this research, effort was made to partially replace the conventional fine aggregates used in the production of sandcrete with laterite up to 20% and study the behavior of the compressive strength obtained from the two common modes of production available within Osogbo, Osun State, Nigeria.

2. MATERIALS AND METHOD

In this research, Ordinary Portland cement of grade 42 conforming to BS EN 196-1:2016 standards was used for this study. Fine aggregates used for this study was sourced within Osogbo, Osun state, Nigeria and it conformed to the requirements of BS EN 12620:2013, samples of laterite used in this research was obtained within the premises of Osun State University, Osogbo main campus.

To have a knowledge of the physical and mechanical properties of the fine aggregates used the following test were conducted in accordance with the set standards, particle size distribution, atterberg limit test, compaction test, natural moisture content test, specific gravity test. Sandcrete blocks were then produced mechanically and manually using a cement to fine ratio of 1:8 (one by part of cement and eight by part of the aggregate) by volume of the constituent materials the fine content being a binary of sand and laterite, laterite fines were incorporated into the mix at various percentages ranging from 0-20%. The resulting blocks were then cured and the compressive strength obtained for 7, 14, 21 and 28-days respectively.

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3. RESULTS AND DISCUSSIONS

Physical properties of fine aggregates

The results of the index properties of sand and laterite used for the study are summarized in Table 1. A property that is worthy of note is the natural moisture content, it was observed that the natural moisture content of laterite used was about 16 times that of the fine sand suggesting that the laterite had a very high water content within its pore structure, the values of the specific gravity for laterite and sand were 2.60 and 2.63 respectively which is typical for the materials in consideration. Figure 1 shows the particle size distribution curve for both materials the coefficient of uniformity for sand and laterite are 1 and 5 respectively indicating that the sand is uniformly graded while the laterite is well graded and is in agreement with the recommendation of BS 1377 (1990) for clean quartz and flint sands.

Table 1. Physical Properties of the Natural Laterite and Sand

| Property | Laterite | Sand |
|--|--------------|-----------|
| Natural moisture content (%) | 11.4 | 0.68 |
| Percentage passing BS No. 200 sieve (%) | 35.2 | 0 |
| Liquid Limit (%) | 54.2 | - |
| Plastic Limit (%) | 30.85 | - |
| Plasticity Index (%) | 23.35 | - |
| AASHTO classification | A-7-5 | - |
| Maximum Dry Density (kg/m ³) | 1.94 | - |
| Optimum Moisture Content (%) | 10.77 | - |
| Specific Gravity | 2.60 | 2.63 |
| Condition of Sample | Air-dried | Air-dried |
| Color | Brownish-red | Brown |

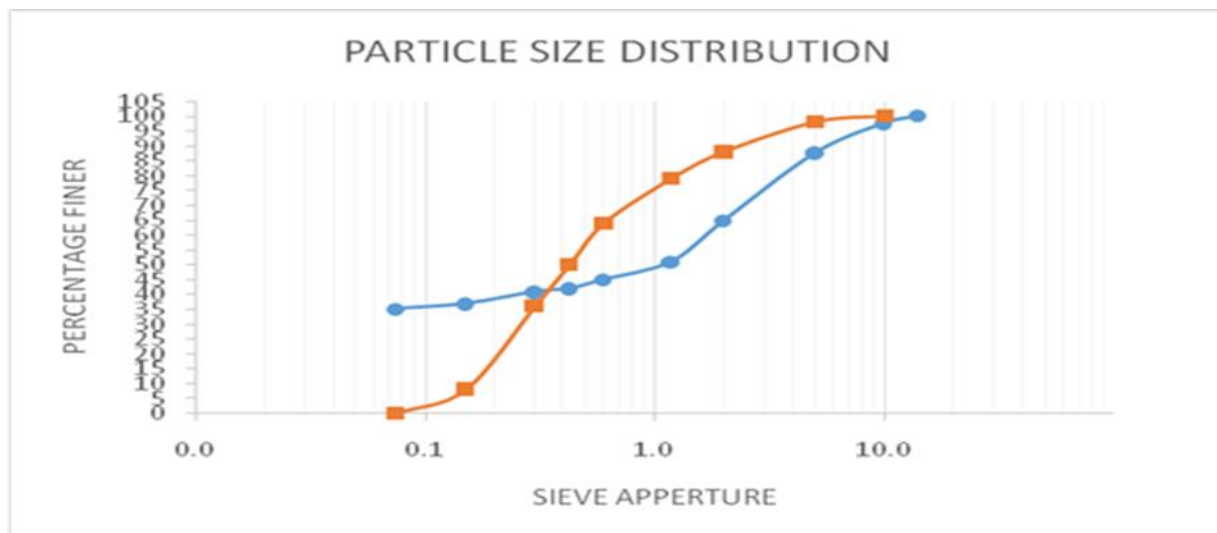


Figure 1: Particle size distribution of aggregates

Physical Properties of Latcrete and Sandcrete

The average densities for the two types of blocks shows that the density of laterite-cement block is higher than that of sandcrete by 46.04%. This could be attributed to the texture of the laterite which allows the particles to be closely packed thereby reducing the voids in the blocks unlike sandcrete blocks which are more porous and allows water. This was evident in the result of the absorption test as it was observed that the sandcrete blocks absorbed more water than the latcrete blocks. Table 2 shows some technical properties of sandcrete and latcrete blocks.

Cost Analysis

Cost analysis for production, transportation and labour for building 1m² of wall in Osogbo, Nigeria was carried out for both sandcrete and latcrete blocks respectively. It was found that laterite-cement blocks cost ₦2,040 for every square metre while a sandcrete block cost ₦2,650, this represents a 29.9% difference in production cost

Table 2. Technical properties of Sandcrete and Latcrete blocks

| Property | Latcrete | Sandcrete |
|--------------------------------------|----------|-----------|
| Average Density (kg/m ³) | 1935 | 1325 |
| Water Absorption (%) | 7.75 | 11.85 |
| Cost per unit area of wall (₦) | 2040 | 2650 |

Compressive strength test results

Compressive strength results obtained for the two methods of production at different ages of curing are presented in Figures 2 and 3. At 0%, the compressive strength obtained for manually compacted blocks were 3.94, 4.02, 4.12 and 4.17 MPa while the values obtained for machine compacted blocks were 4.10, 4.18, 4.28 and 4.33 MPa for 7, 14, 21 and 28 days respectively. The notable 4% increase in compressive strength at the 28 days suggest that the method of production employed has a direct influence on the compressive strength of the blocks produced. At 5% inclusion of laterite, the compressive strength obtained for the manually compacted blocks at various ages of curing were 3.92, 3.47, 3.29 and 3.08 MPa while the values for the mechanically vibrated blocks were 4.08, 3.63, 3.45 and 3.24 MPa. The percentage increase in 28-day compressive strength at this percentage of replacement is 5.24%. When the laterite content was further increased to 10% of the fine content the decreased the compressive strength obtained for both mechanical and manual mode of compaction across the ages of curing. Mechanically compacted samples were observed to be denser than manually compacted samples and this led to improved strength. The values obtained for manual compaction were 3.67, 3.35, 3.24 and 3.07 MPa while 3.83, 3.51, 3.40 and 3.23 MPa were obtained for mechanical compaction for 7, 14, 21 and 28 days respectively.

At 15% replacement of laterite, the compressive strength obtained for manually compacted blocks were 3.62, 3.17, 3.04 and 2.87 MPa for 7, 14, 21 and 28 days. While the values obtained for machine compacted blocks were 3.33, 3.2, 3.03 and 3.78 MPa for 7, 14, 21 and 28 days respectively. Compressive strength results obtained for 20 % replacement of laterite were the lowest of all, due to having the highest fine content, considered in this research, manually compacted blocks were 3.29, 2.84, 2.75, and 2.59 MPa while 3.45, 3.00, 2.91 and 2.75 MPa were obtained for machine compacted blocks for 7, 14, 21 and 28 days respectively. The laterite-cement blocks consistently reduced in compressive strength for all the curing ages

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of 7, 14, 21 and 28-days for both the hand and machine compacted blocks. The unsoundness of laterite incorporated into the mixture could be responsible for the loss in compressive strength with age.

In summary, it was observed that the compressive strength of the laterite-cement blocks decreased with increasing quantity of laterite from 5 - 20% for both the hand compacted and the machine compacted specimens at all ages of curing. The optimum percentage of laterite replacement was obtained at 5% for both methods of production with 28 days compressive strengths of 3.08 and 3.24 MPa respectively. However, machine compacted blocks had better compressive strength when compared with the manually compacted blocks owing to improved density. According to NIS 87, the lowest crushing strength of individual non-load bearing blocks shall not be less than 2.5N/mm^2 for machine compaction and 2.0N/mm^2 for hand compaction as recommended. This suggests that even at 20% replacement values of laterite in sandcrete blocks can still be used as non-load bearing walls but only 5 - 10% of laterite in mechanically compacted sandcrete blocks is most beneficial when load bearing walls are considered. This result is in agreement with the findings of Alutu *et al.* (2006). The decrease in compressive strength with increase in laterite content could be due to decreased bonding within the aggregates of the blocks which could as well decrease the density. This trend was noted by Metcalfe (1977) that in general, the strength increases is in direct proportion to cement content, but at different rates for different soils. However, higher cement contents result in prohibitive cost of blocks which places the sand-cement blocks at a disadvantage.

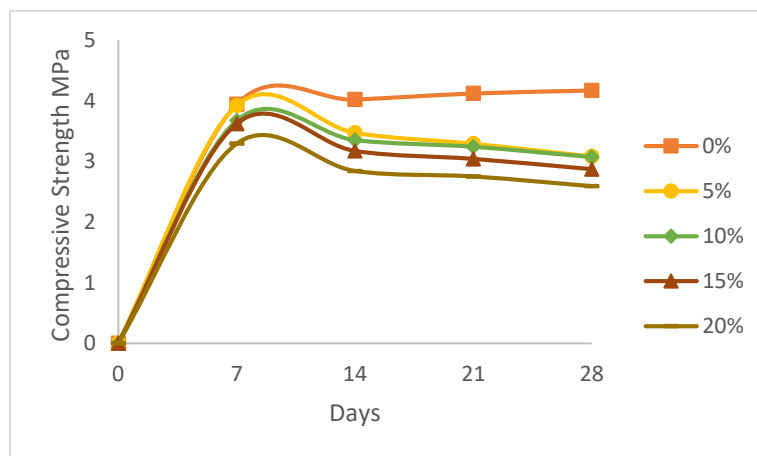


Figure 2: Compressive Strength of Manually Compacted Latcrete

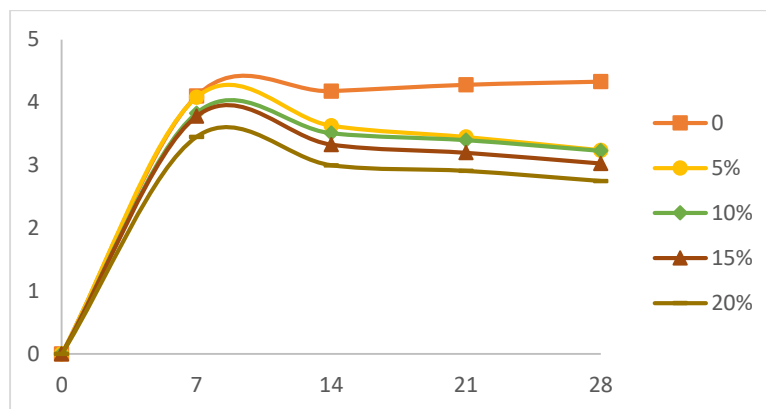


Figure 3: Compressive Strength of Mechanically Compacted Latcrete

4. CONCLUSION

The following conclusions were drawn from the study:

- i. Lateritic soils classified as A-7-5 under AASHTO classification systems are good materials for production of latcrete blocks for walling units in buildings.
- ii. The densities of latcrete blocks are generally higher than that of sandcrete blocks.
- iii. The compressive strengths of latcrete blocks though lesser than that of sandcrete blocks can still be used as load bearing walls for replacement values between 5-20% of laterite. With 5% replacement being the optimum.
- iv. Latcrete blocks produced by mechanical compaction do have better compressive strengths than those vibrated manually.
- v. Latcrete blocks are more economical building materials for walling units than the sandcrete blocks.
- vi. In order to provide housing for the ever-increasing population, the use of laterite-cement blocks should be encouraged as by individual and government at all levels.

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