

## Enhancing The Compressive Strength Of Sandcrete Blocks Through Improved Sand Grading: A Case Study Of Erosion Sand From Ekpoma

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**ABSTRACT:** This study investigates the suitability of locally sourced erosion sand from Ekpoma, Edo State, Nigeria, for the production of sandcrete solid blocks, with emphasis on the effect of sand grading and stabilization (particle size distribution improvement) on block density and compressive strength. In this study, sand stabilization refers to grading correction through sieving and the addition of deficient particle sizes to achieve a well-graded aggregate; it does not imply chemical stabilization. Sand samples were collected from three locations—Ambrose Alli University Campus, Ujemen, and Ihumudumu—and subjected to sieve analysis to determine their particle size distribution characteristics. Sandcrete blocks were produced using three aggregate conditions: untreated erosion sand, stabilized (sieved and grading-improved) erosion sand, and conventional riverbed sand as a control. All blocks were cast using a 1:6 cement–sand mix ratio and cured under laboratory conditions. Compressive strength tests were conducted at 7, 14, 21, and 28 days, while density and moisture content were also determined. Results indicate that stabilized erosion sand produced blocks with higher density (up to 1807 kg/m<sup>3</sup>) and improved compressive strength (up to 2.86 N/mm<sup>2</sup>), comparable to blocks produced with riverbed sand. The findings demonstrate that poorly graded local erosion sand can be effectively improved through grading correction for sandcrete block production. This provides a cost-effective and environmentally sustainable alternative to riverbed sand, with significant implications for low-cost housing and resource optimization in Nigeria.

**KEYWORDS:** Erosion sand, Sandcrete blocks, Compressive strength, Density, Sieving, Local building materials

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### I. INTRODUCTION

Soil is a natural assemblage of mineral and organic particles that form a porous structure with interconnected voids and varying particle sizes, shapes, and compositions (e.g., clay, silt, sand), which influence its engineering behaviour and suitability for construction use (Oghenerukewve & Omotor, 2024). Fine aggregates such as sand are

critical components in the manufacture of sandcrete blocks and mortar, serving to enhance the binding surface and contribute to strength development in masonry units (Alejo, 2020). Sand consists predominantly of silicon dioxide particles ranging in size from approximately 0.06 mm to 2.0 mm in diameter, and its gradation significantly affects workability, water demand, and compressive strength of the resultant blocks (Ibhaddode et al., 2020;

Oghenerukewve & Omotor, 2024). Poorly graded sand containing excessive fines or silt not only increases water requirement but also reduces packing density, thereby lowering compressive strength and increasing shrinkage and porosity in masonry mortar and blocks (Oghenerukewve & Omotor, 2024; Odeyemi et al., 2019). Research on the influence of sand quality on mechanical properties of sandcrete blocks has shown that sands with high fine content often produce blocks with compressive strengths below national standards, highlighting the importance of particle size distribution and grading in block manufacture (Ikpeseni et al., 2023; Oghenerukewve & Omotor, 2024). Studies also indicate that mixing sand with lateritic materials or combining different sand types can improve grading and enhance block strength when optimized, although the specific effects depend on the physical characteristics of the aggregates (Bobola, Akinwunmi & Akintayo, 2025). Additionally, the influence of cement content, compaction pressure, and mix proportions on strength properties has been widely documented, demonstrating that higher cement content and effective compaction can increase compressive strength and reduce water absorption in sandcrete blocks (Okonkwo, Ubani & Anagbaoso, 2023). Variations in aggregate source, grading, and mix design also significantly influence water absorption, density, and durability properties of sandcrete and soil-cement blocks (Ewa et al., 2022). The particle size distribution and grading of sand affect mortar rheology and mechanical behaviour; finer sands require more water to achieve workability, which can weaken hardened strength and increase shrinkage, illustrating the balance needed between grading and mix design (Currie et al., 2007; Olalere et al., 2025). In the context of Nigeria and similar developing environments, poor sand grading and variability in raw material properties continue to challenge efforts to achieve consistent quality in sandcrete block production, often resulting in blocks that do not conform to standards set by regulatory bodies such as the Standards Organization of Nigeria (Ibhadode et al., 2020; Ikpeseni et al., 2023). This study focuses on addressing these issues by examining the influence of poorly graded sand and strengthened sands on the strength characteristics of sandcrete blocks, with the aim of identifying techniques for improvement and contributing to more reliable, economically feasible block production. The use of strengthened or optimized local sands in block manufacture can offer a way to reduce production costs and improve material performance, addressing both economic and technical constraints in the local construction industry.

## II. MATERIALS AND METHODS

### 2.1 Research Design

This study adopted an experimental laboratory-based research design to evaluate the suitability of locally sourced sands for the production of sandcrete solid blocks. The methodology focused on assessing the effects of sand grading, moisture content, curing age, and density on the compressive strength of sandcrete blocks. Comparative analyses were carried out between blocks produced using untreated erosion sand, sieved and strengthened erosion sand, and riverbed sand under controlled laboratory conditions.

### 2.2 Description of Study Area

The study was conducted in Ekpoma, Edo State, Nigeria. Ekpoma experiences significant surface erosion during the rainy season, resulting in the deposition of erosion sand along floodwater pathways. Three locations within Ekpoma were selected for sand collection: Ambrose Alli University main campus, Ujemen community, and Ihumudumu community. These locations were chosen due to the abundance of erosion sand and ease of access.

### 2.3 Materials

The materials used in this study included Portland Lime Cement, fine aggregates (erosion sand and riverbed sand), potable water, and wooden moulds for solid sandcrete blocks. The erosion sand was collected from floodwater pathways, while riverbed sand was obtained from a conventional source and used as a control material. All materials were cleaned of organic matter and debris prior to testing.

Bulk samples of erosion sand were collected from shallow depths at the selected locations to avoid contamination by organic materials. The samples were air-dried in the laboratory for 24 hours to reduce natural moisture content. Each sample was weighed to approximately 1200 g for sieve analysis. Based on the results of the particle size distribution, deficient particle sizes were introduced to strengthen the erosion sand and achieve a well-graded aggregate suitable for block production.

### 2.4 Sieve Analysis of Fine Aggregates

Sieve analysis was conducted to determine the particle size distribution of both erosion sand and riverbed sand in accordance with British Standard BS 882. A dry sieve analysis method was adopted using a mechanical sieve shaker fitted with British Standard sieves ranging from 4.75 mm to 150  $\mu$ m, with a collector pan at the base. The mass of material retained on each sieve was recorded, and the cumulative percentage passing was calculated. The

grading curves were used to classify the sands into standard grading zones and to identify the need for grading improvement.

### 2.5 Moisture Content Determination

The natural moisture content of the sand samples was determined to ensure proper control of the water-cement ratio during block production. The oven-drying method was employed, where samples were weighed, dried in an electric oven at 105–110°C for 24 hours, cooled, and reweighed. Moisture content was calculated as the ratio of the mass of water lost to the mass of dry sand, expressed as a percentage.

### 2.6 Preparation of Sandcrete Solid Blocks

Sandcrete solid blocks were produced using a mix ratio of 1:6 (cement to sand by weight). Three categories of blocks were prepared using untreated erosion sand, sieved and strengthened erosion sand, and riverbed sand. Dry mixing was carried out thoroughly before water was gradually added to achieve workable consistency. The fresh mix was placed into wooden moulds and compacted in three layers using a wooden rammer. The moulds were then removed, and the blocks were placed on wooden pallets.

### 2.7 Curing of Sandcrete Blocks

Curing was carried out under ambient laboratory conditions. Due to prevailing wet weather during the experimental period, artificial curing was not required. The blocks were covered with plastic sheets to prevent excessive moisture loss, and the covers were periodically removed to allow controlled drying. The blocks were cured for 7, 14, 21, and 28 days before testing.

### 2.8 Density Measurement

Density measurements were conducted in accordance with BS 2028. The dimensions (length, width, and height) of each block were measured, and the mass was determined using a weighing balance. Density was calculated as the ratio of mass to volume. The results were used to classify the blocks into density categories and to assess conformity with standard requirements.

### 2.9 Compressive Strength Test

Compressive strength tests were performed using an electro-hydraulic compression testing machine. Blocks were tested at curing ages of 7, 14, 21, and 28 days. Each block was placed centrally in the machine, and load was applied gradually until failure occurred.

The maximum load at failure was recorded, and compressive strength was calculated as the crushing load divided by the loaded area. All results were converted to N/mm<sup>2</sup> for standard comparison.

### 2.10 Data Analysis

Experimental data obtained from sieve analysis, moisture content, density, and compressive strength tests were analyzed using descriptive statistical methods. Average values were computed for each test category, and comparative evaluations were conducted to assess the effects of sand grading and curing age on block performance. The analyzed data formed the basis for interpretation and discussion in the subsequent chapter.

## III. RESULTS AND DISCUSSION

The laboratory experiments conducted investigated the properties and performance of sandcrete blocks produced from erosion sand and riverbed sand, both sieved and unsieved. The tests included sieve analysis, moisture content determination, density measurement, and compressive strength testing at 7, 14, 21, and 28 days.

### 3.1 Particle Size Distribution

Sieve analysis was carried out to assess the gradation characteristics of erosion sand and riverbed sand used in the production of sandcrete blocks. The particle size distribution curves obtained are presented in Fig. 1.

The results revealed significant differences in the gradation profiles of the two sands. Erosion sand exhibited a sharp reduction in percentage passing across the intermediate sieve sizes, indicating a poorly graded distribution with an excess of fine particles and insufficient medium-sized fractions. In contrast, riverbed sand showed a smoother and more continuous gradation curve, reflecting a more uniform spread of particle sizes.

To support the interpretation beyond visual inspection, gradation coefficients such as the coefficient of uniformity (**C<sub>u</sub>**) and coefficient of curvature (**C<sub>c</sub>**) were determined from the characteristic particle diameters (D<sub>10</sub>, D<sub>30</sub>, and D<sub>60</sub>). The computed values confirmed that erosion sand was poorly graded, while riverbed sand demonstrated relatively improved gradation. This suggests that erosion sand would require grading enhancement or blending with coarser fractions to improve particle packing and suitability for block production.

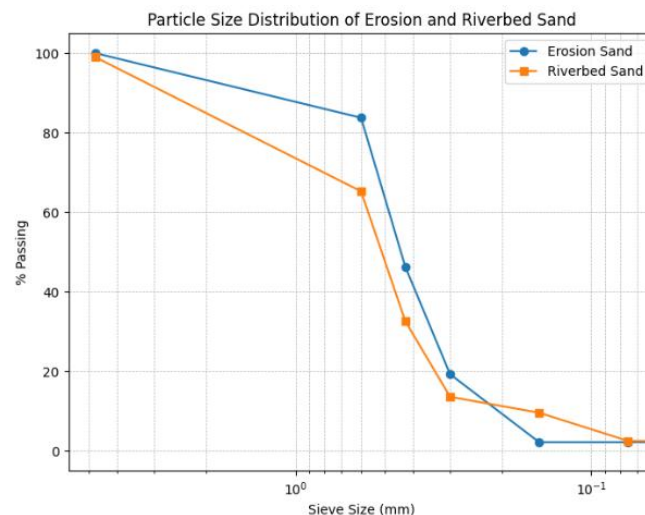


Fig. 1: Particle Size Distribution of Erosion and Riverbed Sand

### Moisture Content

The average moisture content of erosion sand was **1.55%**, while that of riverbed sand was slightly higher at **1.82%**. This difference is strongly influenced by the conditions under which the materials were harvested and stored.

Riverbed sand is typically saturated prior to excavation due to its submerged natural environment, which contributes to higher initial moisture levels. Conversely, erosion sand is often sourced from exposed deposits and may undergo drying during stockpiling and transportation, resulting in comparatively lower moisture content.

Moisture content remains a critical factor in block molding, as it affects the effective water–cement ratio and consequently the hydration process and strength development of the blocks. Therefore, moisture control during batching was necessary to ensure consistency in block quality.

### Density Measurement

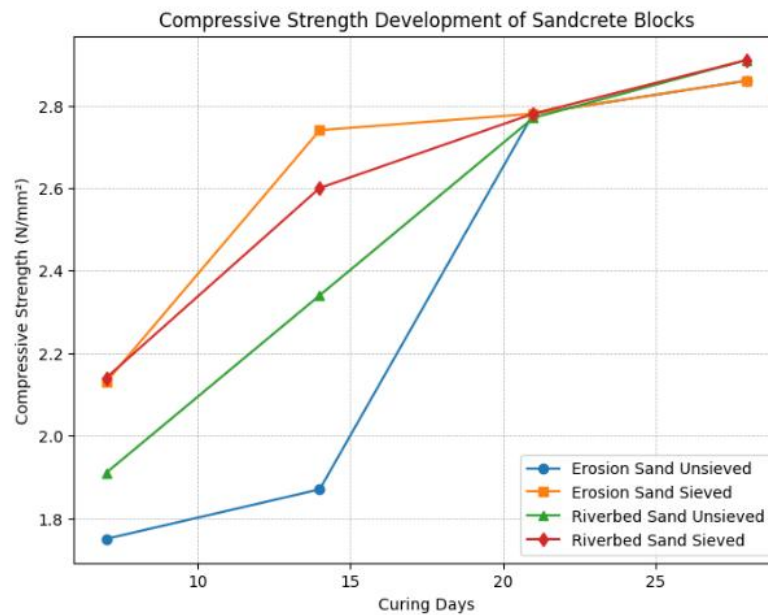
Density measurements of the produced sandcrete blocks showed noticeable variation between the

sieved and unsieved sand samples. The blocks produced with **sieved erosion sand** achieved an average density of **1807 kg/m<sup>3</sup>**, while those produced with **sieved riverbed sand** recorded a slightly lower average density of **1730 kg/m<sup>3</sup>**.

In comparison, blocks produced with **unsieved erosion and riverbed sands** exhibited lower densities. This reduction is attributed to poorer particle packing, resulting in higher void ratios and less compact block structures.

It should be noted that sieving in this study was carried out primarily to improve particle size distribution by removing oversized particles and achieving a more consistent grading, rather than solely for soil classification purposes. The sand used for block production was therefore restricted to particles passing through the selected sieve range (state sieve size here, e.g.,  $\leq 4.75$  mm), ensuring uniformity in the mix.

Based on the density requirements specified in **BS 2028 (1968)** and **BS 1364 (1968)**, all the tested blocks fall within the **Type A dense concrete block classification**, as their densities exceeded the minimum threshold of **1500 kg/m<sup>3</sup>**.



**Fig.2: Density vs Compressive Strength of Sandcrete Blocks**

The scatter plot shows a direct relationship between block density and compressive strength: denser blocks generally exhibited higher compressive strengths.

### 3.2 Compressive Strength

#### Compressive Strength Development

The compressive strength development of sandcrete blocks produced with erosion sand and riverbed sand, in both sieved and unsieved conditions, is presented in Table X and illustrated in Fig. X.

The results showed that compressive strength increased steadily with curing age for all block categories, confirming the progressive hydration of cement and improvement in bonding within the block matrix.

At 7 days, unsieved erosion sand blocks recorded the lowest strength of  $1.75 \text{ N/mm}^2$ , while sieved riverbed sand blocks achieved  $2.14 \text{ N/mm}^2$ , indicating an early strength advantage when finer and more uniformly graded particles were used. By 14 days,

sieved erosion sand blocks exhibited a marked increase to  $2.74 \text{ N/mm}^2$ , compared with  $1.87 \text{ N/mm}^2$  for the unsieved counterpart.

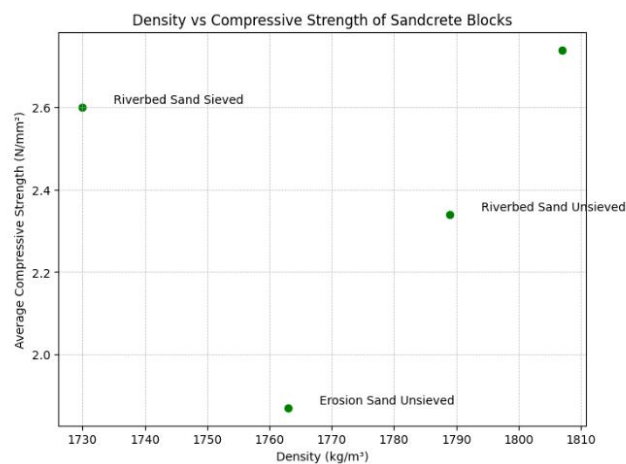
At 21 days, the compressive strengths converged around  $2.77\text{--}2.78 \text{ N/mm}^2$  across all mixes, suggesting that long-term strength gain became less dependent on initial grading differences. By 28 days, the highest strength values of  $2.91 \text{ N/mm}^2$  were obtained for both sieved and unsieved riverbed sand blocks, while erosion sand blocks reached  $2.86 \text{ N/mm}^2$ .

It should be noted that sieving in this study was carried out to obtain a more uniform sand fraction for block production. The sieved sand consisted of particles **passing through the 4.75 mm sieve**, ensuring that oversized grains were removed and the material used fell within the fine aggregate size range suitable for sandcrete block manufacture.

Overall, the findings indicate that sieving improved early-age strength performance due to enhanced particle packing and reduced void content, although the differences became less pronounced at later curing ages.

**Table 1: Compressive strength by Sand Type and Number of Days**

Sand Type	Sieved/Unsieved	7 Days (N/mm <sup>2</sup> )	14 Days (N/mm <sup>2</sup> )	21 Days (N/mm <sup>2</sup> )	28 Days (N/mm <sup>2</sup> )
Erosion	Unsieved	1.75	1.87	2.78	2.86
Erosion	Sieved	2.13	2.74	2.78	2.86
Riverbed	Unsieved	1.91	2.34	2.77	2.91
Riverbed	Sieved	2.14	2.60	2.78	2.91

**Fig. 3: Compressive Strength Development of Sandcrete Blocks**

The line chart illustrates that sieved erosion sand consistently produced stronger blocks than unsieved sand. Riverbed sand blocks were naturally stronger due to better initial gradation.

The data indicates that grading significantly influences both density and compressive strength. Sieved erosion sand achieved comparable strengths to riverbed sand, demonstrating that poor natural sand can be strengthened effectively by particle size adjustment. All blocks satisfied the Nigerian Federal Ministry of Works and Standards Organization (SON) requirements, with 14-day minimum strength above 2.41 N/mm<sup>2</sup> and individual blocks exceeding 1.7 N/mm<sup>2</sup>.

### Discussion

The results confirm that particle size distribution is a critical factor in sandcrete block quality. Poorly graded erosion sand, when sieved and strengthened, achieves higher density and compressive strength, highlighting the importance of aggregate gradation in block production. Additionally, the direct correlation between block density and compressive strength suggests that optimizing packing reduces voids, improving structural performance.

The findings support the feasibility of using locally available erosion sand in Ekpoma for sandcrete block production, provided the sand is properly graded. This can reduce costs and reliance on riverbed sand while maintaining compliance with standard construction requirements.

## IV. CONCLUSION AND RECOMMENDATION

### 4.1 Conclusion

The study established that the quality of sandcrete blocks is strongly influenced by the grading and particle size distribution of the sand used. Erosion sand from Ekpoma, initially poorly graded, produced weaker blocks in its natural state. However, after sieving and strengthening to improve gradation, the blocks achieved densities up to 1807 kg/m<sup>3</sup> and compressive strengths of 2.86 N/mm<sup>2</sup>, satisfying both the Nigerian Standards Organization (SON) and BS 2028 Type A dense concrete specifications. Riverbed sand naturally produced slightly higher strengths due to better initial gradation. Moisture content had

minimal impact on block performance due to controlled hydration during casting. Overall, the study demonstrates that locally available erosion sand, when properly processed, can serve as an effective and sustainable material for sandcrete block production, reducing reliance on riverbed sand and associated environmental impacts.

#### 4.2 Recommendations

1. **Adoption of Grading and Strengthening Techniques:** Locally sourced poorly graded sand should undergo sieving and particle size adjustment before block production to achieve optimal density and compressive strength.
2. **Promotion of Local Materials:** Government and construction stakeholders should encourage the use of locally sourced erosion sand to reduce construction costs and dependence on riverbed sand.
3. **Quality Control in Production:** Regular laboratory testing for particle size distribution, moisture content, and compressive strength should be implemented to ensure consistent block quality.
4. **Curing Practices:** Adequate curing, either through rainfall or controlled covering, is essential to ensure sufficient hydration and strength development of blocks.
5. **Sustainability Considerations:** Exploitation of local erosion sand reduces environmental degradation associated with riverbed sand mining while supporting sustainable construction practices.
6. **Further Research:** Future studies could explore the use of additives, such as cement replacements or natural fibers, to enhance block durability and reduce material costs further.

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