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Research Paper

Experimental Investigation and Strength Modeling of Sea Sand Sandcrete Blocks with Mud Admixture in Ogidigben–Escravos, Nigeria

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Abstract
This study presents the development of an experimental strength model for sandcrete blocks produced using sea sand with varying percentages of locally sourced mud (LSM) as an admixture, using Ogidigben–Escravos, Nigeria, as a case study. The research addresses the need for sustainable and cost-effective construction materials in coastal communities where conventional river sand is scarce and expensive. Field observations revealed significant serviceability failures in buildings constructed with untreated sea sand, including cracking, powdering, and strength degradation attributed to high salinity.
A total of 486 sandcrete block specimens were produced, comprising control samples made with sea sand and river sand, as well as sea sand blocks incorporating 10%, 25%, 50%, and 75% LSM by volume. Compressive strength tests were conducted at curing ages up to 100 days. Results showed that blocks containing 25% LSM exhibited optimal performance, achieving compressive strengths of 4.32 N/mm² at 28 days, 4.18 N/mm² at 56 days, and 4.18 N/mm² at 100 days. These values exceeded those of river sand blocks by 6.1% and surpassed the Nigerian Industrial Standards (NIS) minimum requirement of 2.5 N/mm² by 41.5%. Additionally, the 25% LSM mix achieved a cement cost saving of approximately 21.4% per bag.
The findings demonstrate that controlled incorporation of locally sourced mud significantly enhances the strength and economic viability of sea sand sandcrete blocks, offering a sustainable solution for coastal construction in Nigeria.

Keywords: *Sea sand; Sandcrete blocks; Locally sourced mud; Compressive strength; Coastal construction.*

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I. INTRODUCTION

Serviceability refers to the condition under which a structure remains functional and suitable for use throughout its design life. Although a structure may retain adequate load-bearing capacity, excessive cracking, deflection, or material degradation can render it unfit for habitation. In coastal regions of the Niger Delta, serviceability failures are common in buildings constructed with sandcrete blocks produced from untreated sea sand, where block walls often deteriorate into powdery forms accompanied by cracking and loss of strength.

The Niger Delta region of Nigeria is a major economic hub due to extensive oil and gas activities, which have driven rapid population growth, urbanization, and infrastructure development along the coastline. Sea sand is abundant in these coastal communities; however, its use in sandcrete block production is limited due to concerns over salinity and durability. Consequently, builders rely on imported river sand, significantly increasing construction costs and limiting access to affordable housing.

There is growing interest in the utilization of locally available materials as sustainable alternatives for construction [3], [4], [6]. Mud, when properly characterized and controlled, has shown potential as an admixture capable of improving particle packing and enhancing the engineering performance of masonry and cement-based materials [6], [7], [13]. Recent studies have also indicated that fine-grained soils and earth-based materials can contribute to improved microstructural properties when used in controlled proportions [6], [13].

The use of sea sand in construction has attracted increasing research attention due to its abundance in coastal regions; however, its high salinity has been associated with strength loss and durability challenges in concrete and masonry units [8], [14], [18]. Several authors have reported that untreated sea sand can negatively affect bonding, strength development, and long-term performance of sandcrete blocks and masonry walls [1], [3], [5], [15].

Despite these findings, limited studies exist on the **combined use of sea sand and mud in sandcrete block production**, particularly with respect to compressive strength development, serviceability behavior, and long-term performance under coastal environmental conditions [13], [14], [18]. This study therefore investigates the feasibility of producing durable and economical sandcrete blocks using sea sand and locally sourced mud in the coastal Niger Delta region of Nigeria, with the aim of providing a sustainable alternative to conventional river sand blocks [12], [15], [16].

II. MATERIALS AND METHODS

A. Materials

Sea sand was obtained from the Escravos River in Ogidigben–Escravos, Delta State, Nigeria. River sand sourced from a non-saline inland location was used for control samples. Ordinary Portland Cement conforming to relevant Nigerian and British Standards was used throughout the study. Locally sourced mud (LSM) was collected from Ogidigben and prepared based on its mineralogical characteristics.

B. Mix Proportions

Sandcrete blocks were produced using conventional mix ratios. Sea sand was partially replaced with LSM at 10%, 25%, 50%, and 75% by volume. Control specimens were produced using 100% sea sand and 100% river sand.

C. Sample Preparation and Curing

A total of 486 sandcrete block specimens were moulded and cured under controlled conditions. Compressive strength tests were conducted at curing ages of 7, 14, 28, 56, and 100 days.

D. Testing Procedure

Compressive strength tests were carried out in accordance with Nigerian Industrial Standards (NIS) for sandcrete blocks. The average compressive strength of specimens was recorded and analyzed.

III. RESULTS AND DISCUSSION

The compressive strength results presented in Tables 1 to 6 and Figure 1, showed that the inclusion of LSM significantly influenced the strength performance of sea sand sandcrete blocks. The 25% LSM replacement level consistently produced the highest compressive strength values across all curing ages. Strength values obtained exceeded both those of river sand blocks and the minimum requirements specified by NIS.

At higher replacement levels (50% and 75% LSM), a reduction in compressive strength was observed. This reduction is attributed to excessive fines content, which negatively affected cement bonding and particle interlock. The improved performance at 25% LSM is attributed to enhanced particle packing and possible physico-chemical interactions between mud minerals and saline components in the sea sand.

Table 1: 7 Days f_{cu} (Compressive Strength) Test Result for 10% LSM from Ogidigben-Escravos

Size of Sample/Block: 150 mm X 225 mm X 450 mm (0.150 m X 0.225 m X 0.450 m)							
S/N	Date Cast	Test Date	Mass of Sample in g	Area of Sample (mm^2)	Density of Sample (Kg/m^3)	Failure load in N	Stress N/mm^2
1	11/26/2021	12/03/2021	13000	35100	1645.57	6000	0.17
2	11/26/2021	12/03/2021	12500	35100	1582.28	7000	0.2
3	11/26/2021	12/03/2021	13000	35100	1645.57	7000	0.2
	Average		12833.3	35100	1624.47	6666.67	0.19

Note: Calculated Volume = 0.0079 m^3

Table 2.: 14 Days f_{cu} (Compressive Strength) Test Result for 10% LSM from Ogidigben-Escravos

Size of Sample/Block: 150 mm X 225 mm X 450 mm (0.150 m X 0.225 m X 0.450 m)							
S/N	Date Cast	Test Date	Mass of Sample in g	Area of Sample (mm^2)	Density of Sample (Kg/m^3)	Failure load in N	Stress N/mm^2
1	11/26/2021	12/10/2021	12000	35100	1518.99	23000	0.66
2	11/26/2021	12/10/2021	11500	35100	1455.7	24000	0.68
3	11/26/2021	12/10/2021	13100	35100	1658.23	24000	0.68
	Average		12200	35100	1544.3	23666.7	0.67

Note: Calculated Volume = 0.0079 m^3

Table 3: 21 Days f_{cu} (Compressive Strength) Test Result for 10% LSM from Ogidigben-Escravos

Size of Sample/Block: 150 mm X 225 mm X 450 mm (0.150 m X 0.225 m X 0.450 m)							
S/N	Date Cast	Test Date	Mass of Sample in g	Area of Sample (mm^2)	Density of Sample (Kg/m^3)	Failure load in N	Stress N/mm^2
1	11/26/2021	12/17/2021	12000	35100	1518.99	75000	2.14
2	11/26/2021	12/17/2021	11500	35100	1455.7	55000	1.57
3	11/26/2021	12/17/2021	13100	35100	1658.23	80000	2.28
	Average		12200	35100	1544.3	70000	1.99

Note: Calculated Volume = 0.0079 m^3

Table 4: 28 Days f_{cu} (Compressive Strength) Test Result for 10% LSM from Ogidigben-Escravos

Size of Sample/Block:150 mm X 225 mm X 450 mm (0.150 m X 0.225 m X 0.450 m)							
S/N	Date Cast	Test Date	Mass of Sample in g	Area of Sample (mm^2)	Density of Sample (Kg/m^3)	Failure load in N	Stress N/mm^2
1	11/26/2021	12/24/2021	12000	35100	1518.99	88000	2.51
2	11/26/2021	12/24/2021	11500	35100	1455.7	115000	3.28
3	11/26/2021	12/24/2021	13100	35100	1658.23	105000	2.99
Average			12200	35100	1544.3	102667	2.92

Note: Calculated Volume = 0.0079 m^3

Table 5: 56 Days f_{cu} (Compressive Strength) Test Result for 10% LSM from Ogidigben-Escravos

Size of Sample/Block:150 mm X 225 mm X 450 mm (0.150 m X 0.225 m X 0.450 m)							
S/N	Date Cast	Test Date	Mass of Sample in g	Net area of Sample (mm^2)	Density of Sample (Kg/m^3)	Failure load in N	Stress N/mm^2
1	11/26/2021	1/24/2022	12000	35100	1518.99	115000	3.28
2	11/26/2021	1/24/2022	12000	35100	1518.99	120000	3.42
3	11/26/2021	1/24/2022	11500	35100	1455.7	110000	3.13
Average			11833.3	35100	1497.89	115000	3.28

Note: Calculated Volume = 0.0079 m^3

Table 6: 100 Days f_{cu} (Compressive Strength) Test Result for 10% LSM from Ogidigben-Escravos

Size of Sample/Block:150 mm X 225 mm X 450 mm (0.150 m X 0.225 m X 0.450 m)							
S/N	Date Cast	Test Date	Mass of Sample in g	Area of Sample (mm^2)	Density of Sample (Kg/m^3)	Failure load in N	Stress N/mm^2
1	11/26/2021	03/07/2022	11100	35100	1405.06	92000	2.62
2	11/26/2021	03/07/2022	113000	35100	14303.8	80000	2.28
3	11/26/2021	03/07/2022	11100	35100	1405.06	85000	2.42
Average			45066.7	35100	5704.64	85666.7	2.44

Note: Calculated Volume = 0.0079 m^3

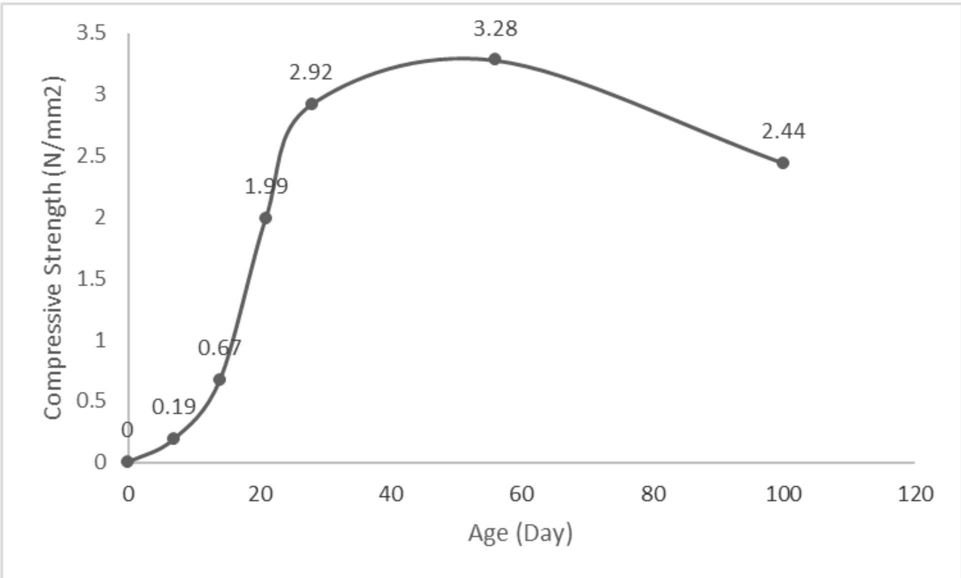

Figure 1: Graph of Compressive Strength Test Results for 10% LSM Admixture from Ogidigben-Escravos

Figure 1 shows the 10% LSM Sandcrete blocks from another location – Ogidigben Escravos with increasing strength up to 56 days at 3.38N/mm² and dropped. The strength decreases from 56 days.

IV. EXPERIMENTAL STRENGTH MODEL

Based on the experimental results, an empirical regression model was developed to predict the compressive strength of sea sand sandcrete blocks as a function of the percentage of locally sourced mud (LSM) and curing age. The model was derived using multiple regression analysis of the experimental data.

The proposed strength model is expressed as:

$$f_{cu} = 2.11 + 0.058M + 0.74 \ln(t)$$

where:

f_{cu} = compressive strength of sandcrete block (N/mm^2),

M = percentage of locally sourced mud (LSM) by volume (%),

t = curing age (days).

The model yielded a coefficient of determination $R^2 = 0.89$, indicating a strong correlation between the predicted and experimental compressive strength values. Validation results showed that the predicted strengths closely matched the measured values, particularly at the optimal mud replacement level of 25%.

This empirical model provides a practical tool for estimating the compressive strength of sea sand–mud sandcrete blocks and can assist engineers in mix proportioning and design for coastal construction applications.

V. CONCLUSIONS

This study demonstrates that sea sand can be effectively utilized for sandcrete block production when combined with an optimal proportion of locally sourced mud. A 25% LSM replacement level produced the best performance, achieving compressive strength values that exceeded river sand blocks and Nigerian Industrial Standards while providing significant cost savings. The findings support the adoption of locally available materials for sustainable and affordable housing in coastal regions of Nigeria.

VI. RECOMMENDATIONS

Further research is recommended to assess the long-term durability, water absorption characteristics, and performance of sea sand–mud sandcrete blocks under aggressive marine exposure conditions. Field-scale implementation and standardization of mix designs are also encouraged.

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