International Journal of Advanced Research in Engineering and Related Sciences

OPEN ACCESS

Available online at: www.ijarers.com

VOL 1 ISSUE 7 (14-22)

Utilization of Mound Soil as a Partial Cement Substitute in Sandcrete Blocks: Implications for Strength and Sustainable Construction

Joshua Ozioko [1], Boluwade Segun [2], Oladepo Oladipupo [3], Olawumi Olatunji [4], David Ajayi [5], Uthman Ismail [6], Giwa Gazali [7]

[1] Department of Civil Engineering, Faculty of Engineering, University of Nigeria, Nsukka.
[2] Department of Project Management Technology, Federal University of Technology, Akure, Nigeria.
[3] Independent Researcher.
[4] Ladoke Akintola University of Technology, Nigeria.
[5] Department of Civil Engineering, Faculty of Engineering, Olabisi Onabanjo University, Nigeria.
[6] Department of Civil Engineering, Ladoke Akintola University of Technology, Nigeria.
[7] Department of Civil and Environmental Engineering, Federal University of Technology, Akure, Nigeria.

Abstract

This study investigates the potential of mound soil as a partial replacement for cement in the production of sandcrete blocks, with emphasis on compressive strength, water absorption, cost effectiveness, and sustainability. Sandcrete blocks are widely used in Nigeria and other developing nations due to their affordability and ease of production. However, the increasing cost of cement and its contribution to global carbon dioxide emissions have necessitated the search for alternative materials that can replace cement in part without reducing performance. In this research, mound soil, a locally available material, was incorporated into sandcrete mixes at substitution levels of 5 percent, 10 percent, 15 percent, and 20 percent by weight of cement. Standard tests were carried out to determine compressive strength at curing ages of 7, 14, and 28 days, as well as water absorption to evaluate durability.

The results revealed that blocks containing 5 percent and 10 percent mound soil achieved compressive strengths of 3.20 N/mm² and 3.05 N/mm² respectively at 28 days, which remain within the Nigerian Industrial Standards for non-load bearing and certain load bearing applications. At these levels, water absorption values also remained below the maximum allowable 12 percent, confirming adequate durability. In contrast, substitution levels of 15 percent and 20 percent produced lower strengths of 2.35 N/mm² and 1.24 N/mm² at 28 days, coupled with water absorption above standard limits, indicating a decline in structural reliability.

These findings suggest that mound soil can serve as a cost effective and sustainable partial cement substitute when used at low proportions of up to 10 percent. Its application reduces cement consumption, lowers construction costs, and mitigates environmental impacts. Further research is recommended on long term durability, resistance to environmental exposure, and the potential benefits of combining mound soil with admixtures to enhance performance.

Keywords: Sandcrete blocks; Mound soil; Cement replacement; Compressive strength; Water absorption; Sustainable construction; Cost effectiveness; Durability; Environmental impact; Building materials

INTRODUCTION

The increasing demand for affordable and durable building materials has made sandcrete blocks a key component in the construction industry. These blocks, which are primarily made from cement, sand, and water, are widely used for wall construction due to their cost-effectiveness, availability, and ease of production. However, the rising cost of cement and its negative environmental impact, particularly in terms of carbon dioxide (CO_2) emissions, have necessitated the search for alternative materials that can partially replace cement without compromising structural performance. Cement production is responsible for approximately 8% of global CO_2 emissions, making it one of the largest contributors to environmental pollution.

One way to address these challenges is by partially replacing cement with alternative materials. Various industrial and agricultural by-products, such as fly ash, rice husk ash (RHA), eggshell ash (ESA), Coconut shell ash (CSA), and Mound soil, have been explored as potential substitutes. These materials have been found to enhance certain properties of sandcrete blocks, reduce dependence on cement, and contribute to environmental sustainability (Afolayan et al., 2017). Additionally, using locally available alternatives can help lower the overall cost of block production, making housing projects more affordable. By integrating these substitutes into sandcrete block manufacturing, the construction industry can move towards more economical and environmentally friendly solutions (Owamah et al., 2024).

Various experimental studies have examined the effects of replacing cement with alternative materials in sandcrete block production. According to Christopher et al. (2018), a 10% replacement of cement with Coconut shell ash (CSA) resulted in increased compressive strength after 28 days of curing. Similarly, Agbede and Obam (2008) reported that incorporating up to 17.5% rice husk ash in sandcrete blocks produced blocks with adequate strength for non-load-bearing walls. These findings suggest that an optimal level of cement substitution can significantly enhance sustainability while maintaining structural integrity.

This study aims to assess the compressive strength of sandcrete blocks produced with mound soil as a partial replacement of cement by evaluating different replacement percentages (5%, 10%, 15%, and 20%) and testing their mechanical properties over 7, 14, and 28 days. The results provide valuable insights into cost-effective and environmentally friendly alternatives for sandcrete block production, promoting sustainable building practices in the construction industry.

MATERIALS AND METHOD

A. MATERIALS

The materials used include: Mound soil, fine aggregate, cement, and water.

Mound Soil

The mound soil was gotten from opposite the Civil/Structural Engineering laboratory. The collected samples were air dried under ambient conditions to reduce the moisture content to an acceptable level. The air-dried soil was crushed and sieved through a 150mm sieve to remove coarse particles and obtain a finer fraction. The sieved soil was stored in airtight containers to prevent moisture reabsorption and contamination.

Fine Aggregate

Fine sand was utilized for this study, specifically sand obtained from riverbed, which should be free of trash and dirt. The particle should be a maximum of 2mm in size.

Cement

The cement utilized was Ordinary Portland Cement (OPC) of grade 42.5, purchased from a retail plant at Ugbowo, Benin City, Edo State.

Water

Water to be used for the concrete mix and curing would be free from contaminants and anything that will slow down hydration. Water will be obtained from the civil/structural laboratory, University of Benin, Benin City, Edo State.

B. EXPERIMENTAL DESIGN

Sieve Analysis

Mound soil was broken, crushed and placed in a 150mm sieve, the sieve was shaken for a set time, allowing finer particles to pass through. After sieving, the finer particles that passed through was weighed. Upon reaching the needed calculated weight it will be used to replace cement.

Mix Proportions

A control mix with 100% cement was prepared with a cement-sand ratio of 1:8 and various mixes were designed by partially replacing cement with mound soil and different percentage intervals of 5%, 10%, 15% and 20% by weight of cement. The water-cement ratio of the mixes was kept constant at 0.5.

Mixing Procedure

1. Batching: Materials were measured by weight using a digital weighing scale for accuracy.

2. Dry mixing: Cement, Mound soil, and sand were thoroughly mixed in a dry state until a uniform color was achieved.
3. Water Addition: Water was gradually added while continuously mixing until a homogeneous and workable paste was obtained.

Block Molding

Standard sandcrete blocks mold of size 450mmx225mmx150mm were used. The sandcrete mix was thoroughly mixed manually until a uniform consistency was achieved. The mixed sandcrete was then filled into the molds and compacted by means of hand tamping and left to dry and solidify. It was then cured by means of sprinkling for the periods of 7, 14, and 28 days.

C. COMPRESSIVE TEST

The compressive strength of the sandcrete blocks was tested using a universal testing machine (UTM), as shown in Fig 1.

Fig 1: Universal Testing Machine (UTM)

Testing Procedure

1. Preparation: Blocks were weighed before testing.
2. Placement: Each block was positioned centrally on the compression testing machine.
3. Load Application: A gradual compressive force was applied at a steady rate until failure of each block.
4. Recording Results: The maximum load at failure was recorded.

RESULTS

A. COMPRESSIVE STRENGTH TEST

This study aimed to investigate the compressive strength of sandcrete blocks produced by substituting varying proportions of cement with mound soil. The substitution levels of mound soil used were 5%, 10%, 15%, and 20%. The compressive strength of the blocks was measured at different curing times—7, 14, and 28 days. Compressive strength was determined using a universal testing machine, which applied a compressive load to the blocks and recorded the maximum force the blocks could withstand before failure. The results are presented below;

Table 1 Compressive strength obtained after 7 days of curing with 0%, 5%, 10%, 15%, and 20% of mound soil.

MOUND SOIL SUBSTITUTION (%)	WEIGHT(KG)	FAILURE LOAD(KN)	COMPRESSIVE STRENGTH (/)	AVERAGE COMPRESSIVE STRENGTH (/)

0%	17.90	85.16	1.80	1.82
	16.65	86.80	1.84	
5%	16.80	80.25	1.70	1.69
	16.20	76.80	1.68	
10%	15.75	60.20	1.28	1.23
	16.25	55.75	1.18	
15%	17.65	46.24	0.98	0.96
	17.45	44.33	0.94	
20%	18.50	27.29	0.58	0.59
	17.45	28.47	0.60	

Table 2 Compressive strength obtained after 14 days of curing with 0%, 5%, 10%, 15%, and 20% of mound soil.

MOUND SOIL	**WEIGHT(KG)**	**FAILURE**	**COMPRESSIVE**	**AVERAGE**
0%	18.00	99.10	2.10	2.34
	18.40	121.49	2.57	
5%	17.50	97.20	2.06	2.02
	17.00	93.59	1.98	
10%	17.90	81.46	1.73	1.67
	17.60	75.56	1.60	
15%	17.90	69.98	1.48	1.49
	18.30	70.93	1.50	
20%	18.00	43.99	0.93	0.97
	17.65	47.22	1.00	

Table 3 Compressive strength obtained after 7 days of curing with 0%, 5%, 10%, 15%, and 20% of mound soil.

MOUND SOIL SUBSTITUTION	**WEIGHT(KG)**	**FAILURE LOAD(KN)**	**COMPRESSIVE STRENGTH**	**AVERAGE COMPRESSIVE**

(%)			(/)	STRENGTH (/)
0%	17.60	172.32	3.65	3.59
	17.70	166.18	3.52	
5%	17.30	146.30	3.10	3.20
	17.10	155.31	3.30	
10%	17.50	144.40	3.06	3.05
	18.25	143.71	3.04	
15%	16.55	100.32	2.13	2.35
	17.75	121.28	2.57	
20%	17.65	50.13	1.06	1.24
	17.70	66.71	1.41	

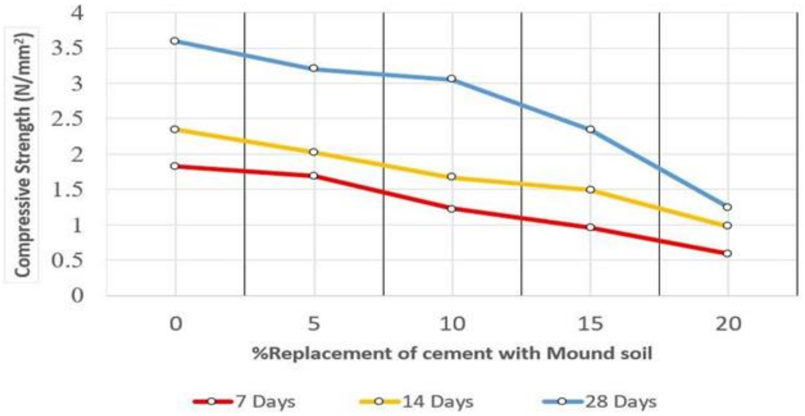

Figure 2: Graph showing comparison between average compressive strength and mound soil replacement

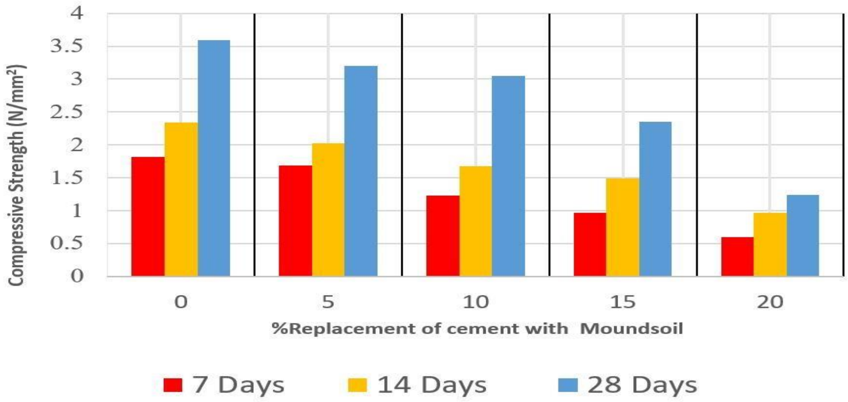

Figure 3: Chart showing comparison between average compressive strength and Mound soil replacements

Discussion Of Result from Compressive Strength Test

From the result of the compressive test, the strength of the sandcrete blocks decreases as the mound soil replacement increases from 5% to 20%. At 5% and 10% replacement, the reduction in strength is minimal, and the block still meets standard requirements for non-load bearing applications (2.77N/^{2}**)**. At 15%, a noticeable decline occurs, at 20%, the reduction becomes significant, affecting structural integrity and the compressive falls below acceptable limits for load bearing use as seen in table 4.3 above. If the strength remains within standard limits, the block can be used for non-structural applications, but higher replacement levels of 15% and above may not be suitable for structural purposes unless enhanced with additives or improved curing methods.

B. WATER ABSORPTION TEST

The water absorption rate is determined by measuring the decrease in mass of the saturated block and surface dry sample. It is gotten by measuring the weight of the dry block denoted as (M1), also measuring the weight of the saturated block immersed in water for 24 hours denoted as (M2). The difference in weight between M1 and M2 is calculated by subtracting the dry weight from the saturated weight i.e., M2 - M1.

Table 4 Result from water absorption test for hollow sandcrete block

MOUND SOIL REPLACEMENT (%)	SAMPLE ID	DRY MASS (KG)	SATURATED MASS (KN)	WATER ABSORPTION (%)
0%	A	17.60	18.66	6.02
	B	17.70	18.77	6.04
5%	A	17.30	18.80	8.60
	B	17.10	18.55	8.48
10%	A	17.50	19.50	11.43
	B	18.25	20.35	11.51
15%	A	16.55	18.75	13.30

	B	17.75	20.40	14.93
20%	A	17.65	20.45	15.86
	B	17.70	20.50	15.82

Discussion of Result from Water Absorption Test

From the result gotten as shown in table 4.4 above, it shows that the water absorption value of the 5% and 10% replacements is below the maximum water absorption specified by the Nigerian standard which is 12%, while the 15% and 20% are above which potentially reduces durability and affects the load bearing capacity.

CONCLUSION

This study has provided valuable insights into the structural and sustainability implications of incorporating mound soil as a partial substitute for cement in sandcrete block production. The experimental results demonstrated that while the compressive strength of blocks generally decreases as the percentage of mound soil increases, the reduction remains moderate at lower substitution levels of 5% and 10%. At these levels, compressive strength values at 28 days (3.20 N/mm² and 3.05 N/mm² respectively) were within the Nigerian Industrial Standards for non-load-bearing and, in certain cases, load-bearing applications. These findings indicate that mound soil, when carefully proportioned, does not significantly compromise the performance of sandcrete blocks and can thus serve as a practical material for reducing dependence on cement. However, substitution levels of 15% and 20% resulted in a marked decline in strength (2.35 N/mm² and 1.24 N/mm²), with the latter falling below acceptable limits. This suggests that excessive incorporation of mound soil undermines structural reliability, restricting its application in load-bearing construction. The water absorption test further reinforced these trends. Blocks with 5% and 10% mound soil replacement maintained absorption levels within the Nigerian standard of 12%, while those at 15% and 20% exceeded this limit, raising concerns about long-term durability, susceptibility to moisture ingress, and potential deterioration under aggressive environmental conditions. This indicates that beyond strength considerations, water resistance becomes another critical factor limiting the viable substitution threshold. Beyond technical performance, the study highlights the economic and environmental benefits of partial cement replacement. By reducing cement consumption, even at modest substitution levels, construction costs can be lowered, making housing projects more affordable in developing economies. Additionally, the approach contributes to global sustainability goals by mitigating the environmental impact of cement production, a process responsible for significant carbon dioxide emissions. The localized availability of mound soil further enhances its attractiveness, reducing transportation costs and supporting the use of indigenous resources in construction.

In summary, the research confirms that mound soil can be a viable supplementary material for sandcrete block production when used in carefully controlled proportions of up to 10%. At these levels, it achieves a balance between strength, durability, affordability, and sustainability. However, higher replacement levels compromise both compressive strength and water resistance, restricting their applicability for structural purposes. The study therefore provides an important foundation for advancing sustainable construction practices through material substitution. For widespread adoption, further investigations are necessary, particularly in the areas of long-term durability, performance under varying climatic conditions, and the potential synergy between mound soil and chemical or mineral admixtures. Such research will determine the full scope of mound soil's role in promoting a more sustainable and resilient built environment.

Conflicts of Interest: All authors declare that they have no conflict of interest associated with this research work.
Funding: No special funding was received for this research work.

REFERENCES

1. Adeniran K.A., Mijinyawa, Y., Akpenpan T.D., and Oseni T.O. (2014). *Engineering Properties of Termite Mound Bricks as a Construction Material for Agricultural Buildings*. Journal of Agricultural Engineering and Technology, 22(4).
2. Adesola, A., Fadugba, O.G., Hafiz, A.A., and Jeffrey, M. (2023). *Analysis of Soldier Ant Mound for Concrete Application*. Proceedings of International Structural Engineering and Construction, 10(1).
3. Akinyemi, B., Akpenpan, and Timothy, D. (2018). *Development of Moisture Resistant Termite Mound Clay Bricks for Rural Structures*. International Journal of Civil Engineering, 9(11), 1425-1429.
4. Akinyemi, B.A., Omoniyi, T.E., and Ademoyemo, M.O. (2016). *Prospects of Corn Fiber as Reinforcement in Termite Mound Clay Bricks*. Acta Technologica Agriculturae, 19(3), 57-62.
5. Akinyemi, B.A., Orogbade, B.O., Ogheneyome, A., Abeer, M.A., Khan, A., Mahmoud, A.H., and Asiri, A. (2022). *Influence of Alkali Activators on Thermo-physical Properties of Ecofriendly Unfired Clay Bricks from Anthill Mounds*. European Journal of Environmental and Civil Engineering, 26(11), 5167-5179.
6. Alabadan, B.A., Adekola, K.A., and Esumobi, T.J. (2016). *Compressive Strength of Rice Husk Stabilized Termite Hill Soil*. CIGR Journal, 18(1).
7. Assia, A.M. and Salifa, T.A. (2018). *Mechanical Properties of Termite Soil as a Partial Replacement to Cement for Different Applications*. Journal of Advanced Composite Materials, 2(2).
8. Ayobami, A.B., Orogbade, B.O., and Chukwunonyen, O.W. (2020). *The Potential of Calcium Carbide Waste and Termite Mound Soil as Materials in the Production of Unfired Clay Bricks*. Journal of Cleaner Production, 279.
9. Elinwa, A.U. (2006). *Experimental Characterization of Portland Cement, Calcined Soldier Ant Mound Clay Cement Mortar and Concrete*. Construction and Building Materials, 20(9), 754-760.
10. Elvis, M.M. and Osadebe, N.W. (2014). *Effect of Mound Soil on Concrete Produced with River Sand*. Journal of Advances in Biotechnology, 2(1), 75-82.
11. Felix, U.F., Cassidy, A.O., and Jajere, S. (2000). *Mound Soil as Construction Material*. Journal of Material in Civil Engineering, 12(3), 205-211.
12. Ifetayo, O., Aigbavboa, C.O., Pretorius, J.H.C., and Joshua, A. (2018). *A Study of Engineering Properties of Cement Modified Termitanium Soil Found within Ado Ekiti Metropolis for Bricks Production*. Proceedings of the International Conference on Industrial Engineering and Operations Management, 567-577.
13. Kamau, J., Ahmed, A., and Kangwu, J. (2020). *Potential of Anthill Soil as a Pozzolan in Concrete*. International Journal of Material Science and Engineering, 8(3), 58-73.
14. Mahamat, A.A., Obianyo, I.I., Ngayakamo, B., Bih, N.L., Ayeni, O., Azeko, S.T., and Sayastano, H. (2021). *Alkali Activation of Compacted Termite Mound Soil for Ecofriendly Construction Materials*. Heliyon, 7(3).
15. Manuwa, S.I. (2004). *Properties and Shear Strength of In situ and Compacted Mound Soil in Akure, Nigeria*. Journal of Agricultural Machinery Science, 5(4), 415-421.
16. Mijinyawa, Y. and Omobowale, O. (2013). *Determination of Some Physical and Mechanical Properties of Termite Mound Clay Relevant to Silo Construction*. International Journal of Materials Engineering, 3(5), 103-107.
17. Ofreno, M.O., Kabubo, C.K., and Gariy, Z.A. (2015). *A Study of Uncalcined Termite Clay Soil as Partial Replacement in Cement for Roofing Tiles in Low Cost Housing Schemes in Kenya*. International Journal of Engineering and Advanced Technology (IJEAT), 4(3).
18. Olusola, K.O., Olanipekun, E.A., Ata, O., and Olateju, O.T. (2006). *Studies on Termite Hill and Lime as Partial Replacement for Cement in Plastering*. Building and Environment, 41(3), 302-306.
19. Omofunmi, O.E. and Oladipo, O.I. (2018). *Assessment of Termite Mound Additive on Soil Physical Characteristics*. Agricultural Engineering International: CIGR Journal, 20(1), 40-46.
20. Orie, O.U. and Eze, E.O. (2013). *Some Flexural Behavior of Rectangular Concrete Beams with Mound Soil as Partial Substitute for Ordinary Portland Cement*. Trends in Engineering and Applied Sciences, 4(4), 618-622.
21. Shettima, U.A., Gana, A., Amina, S.G., and Mohammed, U. (2023). *Development of Termite Mound Clay Bricks for Rural Housing*. Engineering Research Journal, 3(4).

22. Owamah, H.I., Uguru, H., Umukoro, L.O., Akpokodje, O.I., Mahmoud, H., Rokayya, S., et al. (2024). *Mechanical and Physiochemical Characteristics of Sandcrete Blocks Produced with Sustainable Biomaterials*. Science of Advanced Materials, 16(4), 518-531.