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Original Research Paper

A Comparison of Conventional Blocks and Stabilized Earth Blocks as Building Materials in Uganda

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Abstract: In Uganda, the high cost of conventional cement and sand blocks has driven the widespread adoption of alternative building materials, such as wattle bricks, compressed earth blocks, and burnt bricks. Among these, compressed earth blocks have gained popularity due to their eco-friendly, energy-efficient, and biodegradable nature. Made by compressing damp soil at high pressure, these blocks offer an environmentally sustainable solution by minimizing deforestation and eliminating the need for firewood, which is often used in the production of traditional bricks. This study employed a case study methodology and utilized deliberate sampling to gather data, which was then analyzed using SPSS v20. The findings revealed that Stabilized Earth Materials (SEMs) have a stronger positive correlation with user satisfaction compared to conventional blocks, with a satisfaction rating of 0.651 for SEMs versus 0.602 for conventional blocks. Additionally, the study showed that SEMs had a notable impact on reducing construction costs, with a 4.8% cost difference in favor of SEMs. Based on these results, it is recommended that construction managers should consider increasing the use of stabilized earth materials. This shift could not only lead to significant cost reductions but also improve the overall quality of construction, making it a more sustainable and viable option for Uganda's building industry.

Keywords: Building Materials, Conventional Blocks, Eco-friendly Construction, Stabilized Earth Blocks, Stabilized Earth Materials.

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1. Introduction

BMI's report indicates Uganda's positive economic trajectory, with a 6.5% growth rate in 2023. The country's housing construction, which requires 300,000 units annually, is booming. The government has allocated 8.5% of its 2023/24 budget to transport and infrastructure, aiming to improve housing development and GDP through construction. Uganda's GDP in Construction rose to 2326.73 UGX Billion in Q2 2023 from 2205.56 UGX Billion in Q1 2023 [1]. The construction industry in Uganda, which contributes over 12% to the country's GDP, has experienced steady growth for the past 20 years. However, the country faces a significant housing deficit, with 2.4 million units in urban areas and 1.395 million in rural areas. With 7.3 million households and a national occupancy density of 1.1 households per unit, there is a total backlog of 710,000 units. The annual need for new housing is estimated at 200,000 units, with a national deficit of 140,000.

The high cost of conventional cement and sand blocks in Uganda has led to the widespread adoption of alternatives like wattle bricks, compressed earth blocks, and burnt bricks. Compressed earth blocks (CEB) are a biodegradable, energy-efficient, and eco-friendly building material made from damp soil compressed at high pressure. They reduce environmental hazards and deforestation without firewood. However, they shrink slightly as they dry, requiring curing and being 15-20 times less energy-efficient than fired bricks. SEB, a durable and cost-effective building material, is underutilized due to factors like production and construction costs, lack of skilled labor, design data availability, and government support.

Uganda is experiencing a shortage of building materials due to scarcity of raw materials and fuel prices. This has led to halting ongoing constructions, as site owners have different budgets before inflation. This has resulted in poor productivity and low profitability for construction site workers and clients. For example, a trip of sand costs 130000 UGX, an Elf truck of stones costs 200000 UGX in most developed areas, and clay bricks range from 150000-200000 UGX depending on the location and quality. Cement prices have also increased due to power blackouts in local factories. In 2023, a 25% increase in all construction materials was observed, with the COVID pandemic and Russian invasion of Ukraine contributing to the inflation. The rising cost of non-imported building materials like sand is primarily due to rising fuel prices, prompting the need to promote the use of local materials like stabilized earth blocks. Uganda's construction industry depends on professional services, construction services, and support services which materials content contributes heavily as opined by [2]. Figure 1 shows the Contribution of Construction Industries to Uganda's GDP from July 2020 to July 2023.

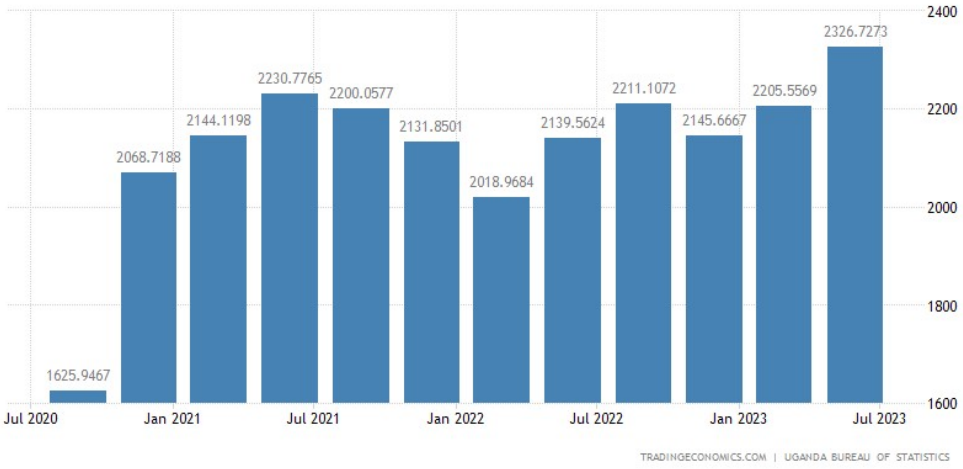

Figure 1. Contribution of the Construction Industry to Uganda's GDP [1]

2. Literature Review

2.1. Historical Concept of Bricks Usage in Uganda

Stabilized earth is a method for building foundations, floors, and walls using natural materials like earth, chalk, lime, or gravel [3]. The soil is compacted into building blocks, either in a box-shaped

mold or layer by layer [4]. The soil must be high in sand and low in clay, with cement and water sometimes added [5]. Stabilized earth houses are durable, lasting over 1000+ years [6]. Stabilized earth walls are ideal for high-humidity climates and moderate temperatures, like Uganda [7]. They are warm, dry, energy-efficient, sustainable, environmentally friendly, and non-toxic [8]. They require minimal energy to manufacture and construct and can be safely spread on-site [9]. Stabilized earth homes are low maintenance, offer excellent sound insulation, reduce pest problems, and are fire-resistant due to their solid nature [10]. They also require additional insulation in colder climates and locations with high rainfall [11].

Stabilized earth walls offer unique beauty and character, can be customized, and complement contemporary or rustic homes [12]. They also complement natural timber and stone building materials [7].

2.2. Cost Of Stabilized Earth

The cost of stabilized earth materials and final products varies from one locality to the other. Factors such as availability, awareness, and usability determine the cost of such products. The perception of the users and the durability, including aesthetics, also add to the choices of materials selection.

Examination of Andy Bynes reports carried out by [3] asserts that the prices of using earth materials for a building construction start at $75 (USH 267,500) per square foot which includes major elements such as foundation construction, building height, floor-to-ceiling height, and construction complexity.

2.3. Stabilized Earth materials in Uganda

Entebbe Children's Surgical Hospital, located near Lake Victoria, is one of the world's largest modern Stabilized earth projects, featuring Stabilized earth walls and monumental glass facades.

Figure 2. Renzo Piano Completes Uganda Children’s Hospital with Stabilized Earth walls [4]

Renzo Piano-designed a pro bono hospital using Italian firm Zintek, utilizing an ancient Stabilized earth wall construction method, which is environmentally friendly, strong, and aesthetically appealing as shown in Figure 2. Stabilized earth soil (STEB) is a cost-effective and environmentally friendly construction material that addresses housing needs in many communities [13]. Its affordability surpasses sandcrete block work in modern construction technology [14]. Assessing STEB strength and sandcrete block use can integrate STEB into the building industry, boosting government focuses on low-income housing [15].

A survey among building industry stakeholders revealed several reasons for preferring Sandcrete blocks over burnt bricks, including lack of design data, lack of experts, high initial construction costs, market availability, irregular shapes and colors, and flaky and algae formation [16]. Burnt bricks, on the other hand, have performance indicators such as durability, strength, sustainability, affordability,

and user satisfaction [17]. However, longevity depends on ingredient quality, climate, and artisans' skill [18]. Burnt bricks are permanent, weatherproof, age-proof, and non-combustible, making them ideal for bushfire-prone areas [19]. They require low maintenance but may deteriorate if not maintained regularly [20]. Sustainability is a key factor, as bricks have thrived over thousands of years due to their longevity, energy efficiency, and reduced environmental impact [21].

Sustainable construction efforts have focused on soil/earth construction, with the introduction of stabilized and enhanced soil blocks. Mixing stabilized earth with cement yields more blocks than sandcrete cement blocks, reducing housing construction costs. However, the high cost of cement and modern construction materials makes it difficult for low-income earners to own a house [6]

Brick-making involves shaping blocks using a steel plate mould, allowing them to dry and shrink. Three technologies are presented: ISSB, concrete blocks, and burnt bricks. Each method has its advantages and disadvantages, including specialized design, high wastage, deforestation, and construction time. Skilled workers and a long preparation time are required for successful brick-making. Blocks can be made using simple machines, wooden moulds, or steel moulds. The wooden mould is initially oiled overnight and doesn't need to be oiled each time filled. Concrete is placed in layers and compacted with a 3 kg rammer. Steel moulds are often used in large-scale production. Net steel plates can prevent damage during tamping and reduce wear on the mould.

Stabilized earth block production is more economical in developing countries due to its low water consumption, low resource requirements, and low emissions [7]. Earth construction is easy to work with, fireproof, and load-bearing, reducing the need for structural supports and reducing building costs. It also offers good insulation properties. House construction in Uganda is shifting from traditional fired bricks to concrete blocks, which are a mixture of sand, gravel, cement, and water. These bricks are more environmentally friendly and superior to locally burned bricks. Industrially manufactured bricks, produced by factories using machinery, are preferred in urban centers and are fired in specialized kilns using biomass like coffee husks. Decorative concrete or sand/cement blocks offer light, security, ventilation, and aesthetic appeal. Some are designed to prevent rain or mosquitoes. Simple shapes can be created in wooden moulds, while more complex designs require a professionally made steel mold.

3. Methodology

This paper employed a case study methodology to investigate a phenomenon, utilizing both quantitative and qualitative methods. It uses deliberate sampling and semi-structured surveys sent by Google Surveys to government employees and building industry professionals in the study area. A five-point Likert scale and SPSS v20 analysis were used for reliability.

4. Finding and Discussion

Table 1 indicates that thermal comfort, stability, and cost are the main criteria for using stabilized earth in Uganda which is 100% in use in the eastern, and western regions.

Table 1. Determinants of Choice of Materials in Housing Construction

Criteria	Conventional Blocks		Stabilized Earth Blocks	
	N	%	N	%
Stability	45	37.5	75	62.5
Thermal comfort	35	29.1	85	70.9
Cost	39	32.5	81	67.5
Aesthetic	68	57.1	51	42.9
Class	78	65	42	35
Texture	67	56.7	51	43.3
Fire resistance	40	33.3	80	66.7
Security purpose	45	37.5	75	62.5
Average Determinant Sum		***43.59***		***56.41***

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Meanwhile, aesthetics, texture, and class are the main determinants of selecting conventional blocks as the main case in Uganda Central. In all, stabilized earth block has a higher average criteria value of 56.41% which makes it the most preferred.

The study was in line with a previous study of [5] that the strength of earth materials used for blocks in southern Nigeria increases with age and it is also in conformity with [6] of the thermal advantage of stabilized earth material over the conventional. This also aligns with a [8] stating that the experimental prototype school, built using compressed stabilized soil blocks, was cost-effective and strong by acceptable standards as also applicable in Sudan.

The location of the materials varies from one end user to the other. Figure 3 indicates that stabilized earth is preferred in the construction of the entire location except doors and windows.

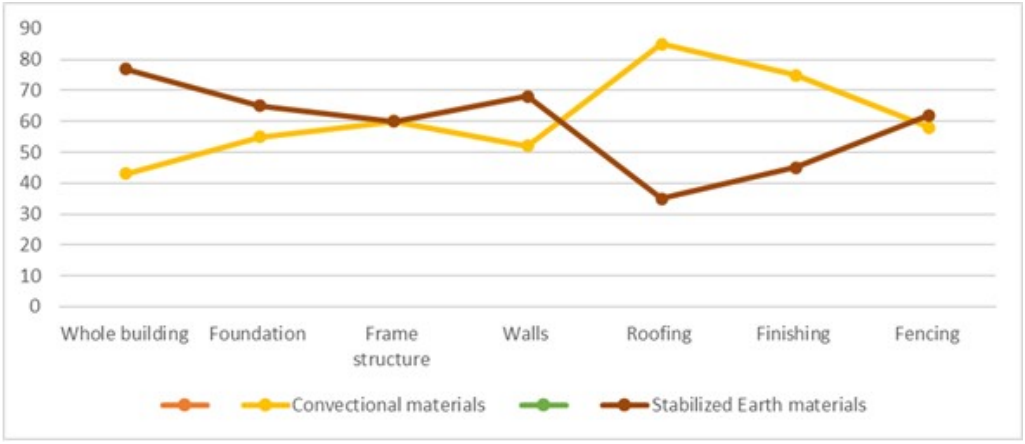

Figure 3. Preferred Location of Materials in a Building

It is mainly used in foundation (65%) and walls (68%) while convectional is mostly applied in the roofing (85%) and finishing (75%). Meanwhile, both conventional and earth materials have equal application in constructing frame structures (60%) each.

The study aimed to assess the satisfaction levels of brick houses by asking respondents to rate their satisfaction levels in various aspects of the house and the data is presented in Table 2.

Table 2. Housing Satisfaction Levels

S/N	Section	Conventional materials (%)	Stabilized Earth materials (%)
1	General satisfaction	30	70
2	Brick value for money	49	51
3	Interior comfort	28	72
4	Wall quality	48	52
5	Maintenance and sustainability	47	53
6	Durability of materials	36	64
7	Affordability	32	68

The results in Figure 4 showed that 30% and 70% of respondents were very satisfied with the general construction quality of the housing units, indicating that bricks have value for their money compared to other building materials. 51% of respondents were satisfied with the interior comfort of earth bricks as a building material, as bricks absorb and release heat slowly, reducing stress load and keeping the house cool during the daytime and warm at night. 72% of respondents were satisfied with the wall quality of Earth bricks. 49% and 36% of respondents were very satisfied with the

maintenance and sustainability of burnt bricks as a building material, as little or no maintenance work has been done on the brick wall itself.

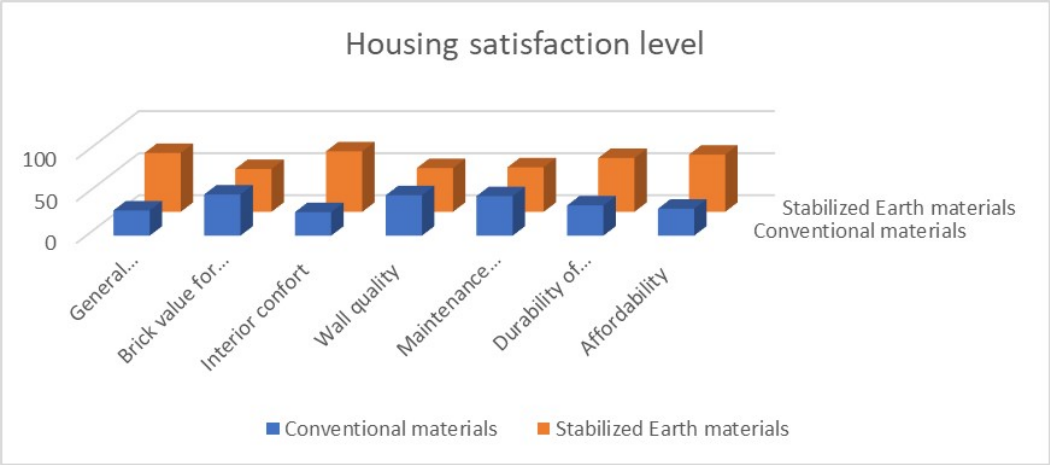

Figure 4. Housing Satisfaction Level

53% of respondents were satisfied with the durability of the building material, and 49% and 36% of respondents were very satisfied with affordability as a building material. Overall, brick houses were rated as attractive and well-valued compared to other building materials.

- Cost value of different materials

The comparison of the cost of production of blocks and laying; then the usage of materials for plastering were considered for conventional materials (CM) and stabilized earth materials (SEM). The results are shown in Table 3.

The study provides quantitative cost data affirming that earth blocks are more cost-efficient with an average value of 4.8% reduction per unit cost of production. Meanwhile, it has production savings of 86% which is in agreement with [9] where cost analysis carried out on the convectional blocks and stabilized earth blocks affirmed that earth blocks are cheaper alternatives to convectional blocks, giving a 46% reduction in the total production cost. Findings revealed that it has 60% economic stability. That is, has a lesser fluctuation effect. Previous authors, [10, 11, 12] have shown that the blocks from Earth or adobe are cost-effective, viable, and more sustainable alternatives to the widely used conventional sandcrete blocks.

- Relationship between the determinants and level of satisfaction

From the result of the correlation analysis in Table 4 and Table 5, Stabilized Earth Materials have a positive relationship with satisfaction such that it causes 0.651 satisfaction against Conventional Blocks which is 0.602.

The result of the descriptive statistics shown in Table 4 is that the mean coefficient of conventional blocks is 48.125. More so, the result indicates that the mean value of stabilized earth materials is 51.250.

Based on table 5, One-Sample Test of the Hypotheses Ho: There is no significant impact of Stabilized Earth Materials on cost.

The value of the t-statistics as shown in Table 6 is (0.037), which is below 0.05 (the critical value), so we reject the null hypothesis and come to the conclusion that there is a significant impact of Stabilized Earth Materials on cost. This is based on the decision rule that states, accept the null hypothesis if the value of the t-statistics is greater than 0.05.

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Table 3. Cost Implications

Work Process	Qty CM	Qty SEM	Unit	Rate	Amount CM	Amount SEM
Production	**(a)**					
Cement	0.05	-	bag	45,000.00	2,250.00	
Sand	0.004		trip	130,000.00	520	
Earth		0.086	trip	2,500.00	-	215.78
Water	0.304	0.442	litre	25	7.61	11.05
Labor including bonding				1,500.00	85	150
Materials cost					**2,862.61**	**376.83**
Cost Difference					2,485.78	
% Difference					86.84	
Laying	**(b)**					
Cement	0.167	0.18	bag	45,000.00	7,515.00	8,078.63
Sand	0.012	0.009	trip	130,000.00	1,560.00	1,170.00
Water	0.013	0.013	liter	25	0.33	0.33
Materials cost					**9,075.33**	**9,248.95**
Cost Difference					173.63	
% Difference					1.88	
Plastering	**(c)**					
Cement	0.083	0.125	bag	45,000.00	3,735.00	5,602.50
Sand	0.012	0.009	trip	130,000.00	1,560.00	1,170.00
Water	0.013	0.016	litre	25	0.33	0.41
Materials cost					**5,295.33**	**6,772.91**
Cost Difference					**1,477.58**	
% Difference					**21.82**	
CM Total Cost = a+b+c			17,233.30			
SEM Total Cost = a+b+c			16,398.70	834.57	**4.80%**	

Table 4. Analyses of the Descriptive Statistics

	Mean	N
Conventional Blocks	48.125	8
Stabilized Earth Materials	51.25	8

Table 5. Correlation Analyses

		Conventional Blocks	Stabilized Earth Materials
Conventional Blocks	Pearson Correlation	1	0.031
	Sig. (2-tailed)	0	0.602
	N	8	8
Stabilized Earth Materials	Pearson Correlation	1	0.038
	Sig. (2-tailed)	0	0.651
	N	8	8

Table 6. One-Sample Test

	Test Value = 0					
	T	**Df**	**Sig. (2-tailed)**	**Cost Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
There is no significant impact of Stabilized Earth Materials on the cost	0.037	9	0.011	**834.57**	102.805	126.46

5. Conclusion

Uganda is experiencing a shortage of building materials due to scarcity of raw materials and fuel prices. This has led to halting ongoing constructions, as site owners have different budgets before inflation. This has resulted in poor productivity and low profitability for construction site workers and clients. Stabilized earth is a method for building foundations, floors, and walls using natural materials like earth, chalk, lime, or gravel. Sustainable construction efforts have focused on soil/earth construction, with the introduction of stabilized and enhanced soil blocks. Mixing stabilized earth with cement yields more blocks than sandcrete cement blocks, reducing housing construction costs. It is therefore noted that earth block production and usage can be achieved both in the urban and rural areas.

Based on the research then we recommended that construction managers should make more use of stabilized earth materials to reduce ccostsand improve quality. The government should reduce the tax levy on local manufacturers in order to improve more productivity of stabilized earth materials products like bricks, tiles, etc.

References

[1] K. Muhakanizi, "The Public Financial Management Reform Strategy (2018-2022)," Ministry Of Finance, Planning And Economic Development, pp. 1-115, 2010.

[2] P. D. Rwelamila and A. R. Abdul-Aziz, *Improving the Performance of Construction Industries for Developing Countries: Programmes, Initiatives, Achievements and Challenges*, 1st ed. Routledge, 2020.

[3] R. Muloodi, "Construction material: Building using rammed earth materials," 2021. [Online]. Available: https://realmuloodi.co.ug/construction-materials-building-using-rammed-earth/. [Accessed: March, 2024].

[4] Design Boom, "Renzo Piano completes Uganda Children's Hospital with Stabilized Earth Walls," 2019. [Online]. Available: www.designboom.com. [Accessed: March, 2024].

[5] E. A. Nnamdi, N. E. O. Ejiofor, and O. D. V. Ugoyibo, "Assessment of Stabilized Earth Blocks (STEB) Strength to Sandcrete Blocks Used in Housing Construction," *American Journal of Civil Engineering*, vol. 10, no. 2, pp. 70-78, 2022. doi: 10.11648/j.ajce.20221002.16

[6] V. U. Okwu-Delunzu, E. O. Nnadi, and A. N. Ezemerihe, "Evaluation of Stabilised-Earth Block (STEB) As Alternative to Sandcrete Blocks for Housing Provision and Construction in South East Nigeria," *Iconic Research and Engineering Journals*, vol. 5, no. 9, pp. 366-373, 2022.

[7] M. Dabaieh, "Building Rammed Earth Technical Report," 2014. [Online]. Available: https://www.researchgate.net/publication/269763371_Building_with_Rammed_Earth#fullTextFileContent. [Accessed: March, 2024].

[8] I. I. Akinwumi, "Earth building construction processes in Benin City, Nigeria and engineering classification of earth materials used," *Indian Journal of Traditional Knowledge*, vol. 13, no. 4, pp. 686-690, 2014.

[9] P. Nwamgbowo, E. Nnadi, V. H. U. Eze, and N. Kibwami, "Quantification of Earth Material for Sustainable Road Works in Southeast Nigeria," *Journal of Engineering, Technology, and Applied Science*, vol. 5, no. 3, pp. 99-109, 2023.

[10] W. B. Kareem, R. O. Okwori, A. M. Hassan, B. M. Mohammed, H. O. Abubakar, and J. A. Dada, "Use of Bamboo and Earth Materials in Construction for the Provision of Affordable Building Structures for Sustainable Development at Kuje Area Council, Abuja," *Journal of Engineering and Sustainable Development*, vol. 1, no. 2, 2018.

[11] E. A. Nnamdi, "Additional insulation for colder climates in earth buildings," *Sustainable Building Practices Journal*, vol. 8, no. 1, pp. 56-65, 2022.

[12] V. U. Okwu-Delunzu, "Aesthetic benefits of stabilized earth walls," *Journal of Architectural Design*, vol. 9, no. 2, pp. 89-102, 2023.

[13] Design Boom, "Renzo Piano completes Uganda Children's Hospital with Stabilized Earth Walls," 2019. [Online]. Available: www.designboom.com. [Accessed: March, 2024].

[14] R. Muloodi, "Construction material: Building using rammed earth materials," 2021. [Online]. Available: https://realmuloodi.co.ug/construction-materials-building-using-rammed-earth/. [Accessed: March, 2024].

[15] E. A. Nnamdi, N. E. O. Ejiofor, and O. D. V. Ugoyibo, "Assessment of Stabilized Earth Blocks (STEB) Strength to Sandcrete Blocks Used in Housing Construction," *American Journal of Civil Engineering*, vol. 10, no. 2, pp. 70-78, 2022. doi: 10.11648/j.ajce.20221002.16

[16] V. U. Okwu-Delunzu, E. O. Nnadi, and A. N. Ezemerihe, "Evaluation of Stabilised-Earth Block (STEB) As Alternative to Sandcrete Blocks for Housing Provision and Construction in South East Nigeria," *Iconic Research and Engineering Journals*, vol. 5, no. 9, pp. 366-373, 2022.

[17] M. Dabaieh, "Building Rammed Earth Technical Report," 2014. [Online]. Available: https://www.researchgate.net/publication/269763371_Building_with_Rammed_Earth#fullTextFileContent. [Accessed: March, 2024].

[18] I. I. Akinwumi, "Earth building construction processes in Benin City, Nigeria and engineering classification of earth materials used," *Indian Journal of Traditional Knowledge*, vol. 13, no. 4, pp. 686-690, 2014.

[19] P. Nwamgbowo, E. Nnadi, V. H. U. Eze, and N. Kibwami, "Quantification of Earth Material for Sustainable Road Works in Southeast Nigeria," *Journal of Engineering, Technology, and Applied Science*, vol. 5, no. 3, pp. 99-109, 2023.

[20] W. B. Kareem, R. O. Okwori, A. M. Hassan, B. M. Mohammed, H. O. Abubakar, and J. A. Dada, "Use of Bamboo and Earth Materials in Construction for the Provision of Affordable Building Structures for Sustainable Development at Kuje Area Council, Abuja," *Journal of Engineering and Sustainable Development*, vol. 1, no. 2, 2018.

[21] E. A. Nnamdi, "Additional insulation for colder climates in earth buildings," *Sustainable Building Practices Journal*, vol. 8, no. 1, pp. 56-65, 2022.