Original Research Article

Lengths and Content Variation of Oil Palm Broom Fibre (OPBF) and Lime on the Physico-Mechanical Properties of Compressed Earth Blocks

ABSTRACT

The use of oil palm broom fibre (OPBF) which is usually burnt as waste contributes to carbon dioxide (CO_2) emission in the atmosphere, as a sustainable reinforced construction material will provide both cost and environmental benefits. Combining OPBF and lime in compressed earth blocks as a construction material will further provide technical benefits in improving the mechanical properties of the blocks. This study investigates the physico-mechanical properties of compressed earth blocks stabilised with varying lengths and contents of OPBF and lime for housing provision. Laterite, 10% constant lime, and OPBF of 10, 20, and 30mm lengths, and 0.25, 0.5, and 0.75% by weight of laterite were used for preparing the blocks. The properties of the blocks were assessed between 7 and 28 days of curing. Compressive strength test, tensile strength test, water absorption test, and scanned electron microscopy (SEM) analysis were conducted on the OPBF and lime-stabilised compressed earth blocks. The 10mm and 0.5% OPBF and lime-stabilised compressed earth blocks achieved the lowest water absorption of 3.04% as compared to the highest water absorption of 9.78% recorded by the unstabilised blocks. The 20mm length with 0.5% content of OPBF achieved the optimum compressive strength of 6.641N/mm^2 as compared to the ustabilised specimens of 5.976N/mm^2, representing about 10% compressive strength increase. For the tensile strength, the 20mm length with 0.5% OPBF content specimens achieved the highest strength of 0.423N/mm^2 as compared to the ustabilised specimens of 0.326N/mm^2, representing about 23% increase in the tensile strength. The microstructural analysis of the specimen revealed micro-gaps at the periphery of the OPBF, and micro-cracks within the composite material. The study, therefore concludes that appropriate length and content of OPBF and lime enhance the physico-mechanical properties of compressed earth blocks. It is, therefore, recommended that 20mm length with 0.5% OPBF content should be used by practitioners to enhance the physico-mechanical properties of compressed earth blocks for use to provide housing accommodation.

Keywords: Earth blocks, lime, physical properties, oil palm broom fibre, mechanical properties, microstructure.

1. INTRODUCTION

The infrastructural needs of every developing society are inevitable and Ghana is of no exception. The housing deficit in Ghana currently stands at 2 million units from an earlier 1.7 million units as of 2019, hence the need to construct housing units between 190,000 and 200,000 each year to bridge the deficit gap [1]. This has made many low-income earners homeless even after they retire from active service and the hope of becoming house owners always remains a mirage. Danso, Obeng-Ahenkora and Manu [2] opined that there had been inconsistent pricing of selected building and construction materials such as sandcrete blocks, fine aggregates, felt, and aluminum roofing sheets and recommended that government and legislature enact laws to control the factors that create fluctuation of the selected material in the construction industry. For instance, a bag of Portland cement class 32.5R that was sold for GH¢38 in January 2021, is now being sold for GH¢98 in September 2024 due to importation challenges of clinker and currency depreciation. The challenge in the cement manufacturing industry is mainly the importation of clinker and gypsum, which makes a hopping foreign exchange exceeding $250 million annually since 2008 [3, 4].

Apart from the inconsistent price hype of cement in Ghana, the entire manufacturing process is not sustainable because of the harmful chemicals of cement production and the emission of carbon dioxide, methane, sulfur oxides, and nitrogen oxides that are harmful to the human respiratory system and contribute to climate change [5]. Again, cement production generates a high carbon footprint with harmful manufacturing processes. Sand for moulding sandcrete blocks also contributes to socio-economic challenges such as the degradation of arable land for sand-winning activities for the manufacturing of sandcrete blocks for housing purposes. The cost of cement has forced producers of sandcrete blocks to produce low-standard blocks that do not meet their expected strength [6-8]. To mitigate these challenges, there has been a growing concern about environmental factors, such as land degradation because of unregulated sand-winning activities and there is a need to re-direct attention to the use of local materials, which are environmentally friendly and sustainable [9]. The most abundant and available local building material in every country is soil/earth.

Earth building is faster and easier to construct, it requires less skilled labour, has good thermal properties and creates extremely low levels of waste, has no known environmental pollution in its life cycle, and can absorb atmospheric moisture thereby creating a healthy environment for its occupants within the building [10, 11]. However, the major drawback of using earth alone as a building material is its strength in relation to compaction because of its hygroscopic inherent property and lack of dimension stability and durability required for building construction [12]. Subsequently, studies have focused on techniques such as compressed earth blocks (CEBs) with stabilisers to improve the properties of earth blocks for the construction of buildings [12-14].

A study by López-Rebollo et al [14] investigated the application of fibre and cementitious stabilisers in compressed earth blocks and found that CEB samples with 15, 20, and 25% cement obtained a strength of 2.02, 2.43, and 3.28 MPa, respectively. Shantanu et al. [15] examined the properties of compressed earth blocks enhanced with cement and rice husk ash and found 63–1190% in split tensile strength, 224–1515% compressive strength, and 112–732% flexural strength improvement. A study by Danso [16] assessed the characteristics of compressed earth blocks enhanced with a liquid chemical and found an over 200% increase in both compressive and tensile strength. Shantanu et al. [17] studied the properties of compressed earth blocks enhanced with *Chrysopogon zizanioides* (Vetiver) grass and found an increase in the strength and ductility properties.

This study is conducted as a result of the gap identified during the review of the relevant literature on the use of laterite, agricultural waste, and lime for producing compressed earth blocks. Previous studies have used rice husks as compressed earth blocks reinforcement [18-19]. Others used materials like raw rice coconut husk fibres, oil palm fibres, sugarcane bagasse fibres [20], husk and rice husk ash [21], waste and low energy material [22], rice husk ash and cement [23],oil palm empty fruit bunch fibres [24], sugarcane bagasse ash and lime [25-26], plantain pseudo-stem fibres [27], synthetic waste wig fiber [28], plantain pseudostem fibres and lime [29], coconut fibres and lime [30]. From the review of the previous studies, there is a lack of information on the use of laterite, oil palm broom fibre, and lime for producing compressed earth blocks for housing applications. There is a gap in the research on using oil palm broom fibre and lime as stabilisers for compressed earth blocks, which requires a study to explore the potential of using oil palm broom fibre and lime in building materials for construction applications.

As a contribution towards filling this gap, this study was conducted to investigate the physico-mechanical properties of compressed earth blocks stabilised with varying lengths and contents of oil palm broom fibre (OPBF), and lime for housing applications. The use of OPBF which is usually burnt as waste which contributes to carbon dioxide (CO_2) emission in the atmosphere, would rather be useful as a construction material. The use of laterite, OPBF, and lime as a construction material contributes to sustainable construction practices in terms of cost reduction and environmental impact. By investigating the properties of compressed earth blocks stabilised with OPBF and lime, this study aims to address the critical need for improved durability and strength in sustainable construction materials. The use of OPBF and lime in CEBs is expected to overcome the limitations such as water-induced erosion, and strength deficiencies in the use of natural fibres in compressed earth blocks. Through comprehensive laboratory procedure, the study specifically examines the water absorption, compressive and tensile strengths of compressed earth blocks stabilised with different lengths and content of OPBF and lime as well as microstructural properties. This study adopted an experimental research design that determined the properties of the compressed earth blocks manufactured with laterite, OPBF, and lime. Laterite, 10% constant lime, and OPBF of 10, 20, and 30mm lengths, and 0.25, 0.5, and 0.75% by weight of laterite were used for preparing the blocks, and their properties were assessed between 7 and 28 days of curing. Compressive strength test, tensile strength test, water absorption test, and scanned electron microscopy (SEM) analysis were conducted on the OPBF and lime-stabilised compressed earth blocks.

2. MATERIALS AND METHODS

2.1. Materials

Laterite, lime, oil palm broom fibre (OPBF), and water were the main materials employed in this experimental study. Laterite sample was obtained from Abuakwa in the Ashanti Region of Ghana. The laterite sample (Figure 1a) was manually excavated at a depth of 300mm below the ground surface of the earth to ensure that no organic contents were collected from the soil. It was bagged and transported to the laboratory, and any foreign material in the sample was removed. It was sun-dried for two weeks and the properties were determined before using it for manufacturing the blocks. The properties of the laterite sample are presented in Table 1. The particle size distribution curve of the laterite is shown in Figure 2. The particle size distribution has influence on the properties of the OPBF and lime-stabilized compressed earth blocks. It can be observed that the maximum dry density (MDD) of the laterite was 1.67 g/m^3 while the optimum moisture content was 12.5%. The hydrated lime (Figure 1b) used for the experimental work was bought at a shop at Kejetia market in Kumasi, Ghana. The oil palm broom fibre (Figure 1c) used was obtained from the Abuakwa market in the Ashanti region of Ghana. The average length of the oil palm broom was 600 mm and was cut to 10, 20, and 30mm lengths taking cognizance of earlier research on natural fibres [31]. The diameter of the oil palm broom fibres ranged from 0.20 to 0.35 mm while the tensile strength ranged from 42.35 to 73.74 when tested. Tap water from Ghana Water Company supplied to the construction laboratory at the Akenten Appiah Menka University of Skill Training and Entrepreneurial Development (AAMUSTED) was used for the study.

Table 1: Laterite properties

Properties	Value
Particle size distribution	
Silt & clay (<0.063) %	0.13
Sand (2 - 0.063) %	37.45
Gravel (>2) %	62.42
Proctor test	
Maximum dry density (mg/m^3)	1.67
Optimum moisture content (%)	12.50

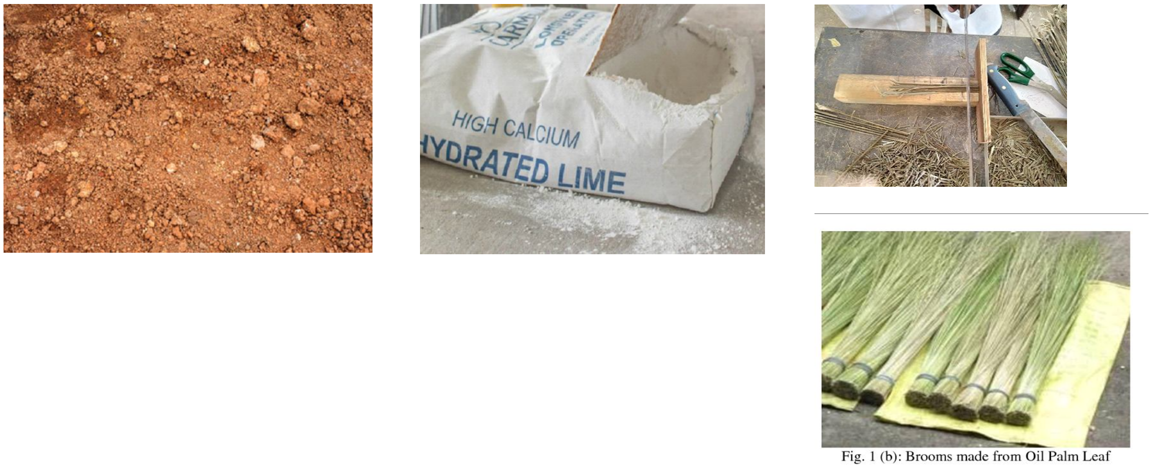

Figure 1: Materials for experiment: (a) laterite, (b) hydrated lime, (c) oil palm broom fibres

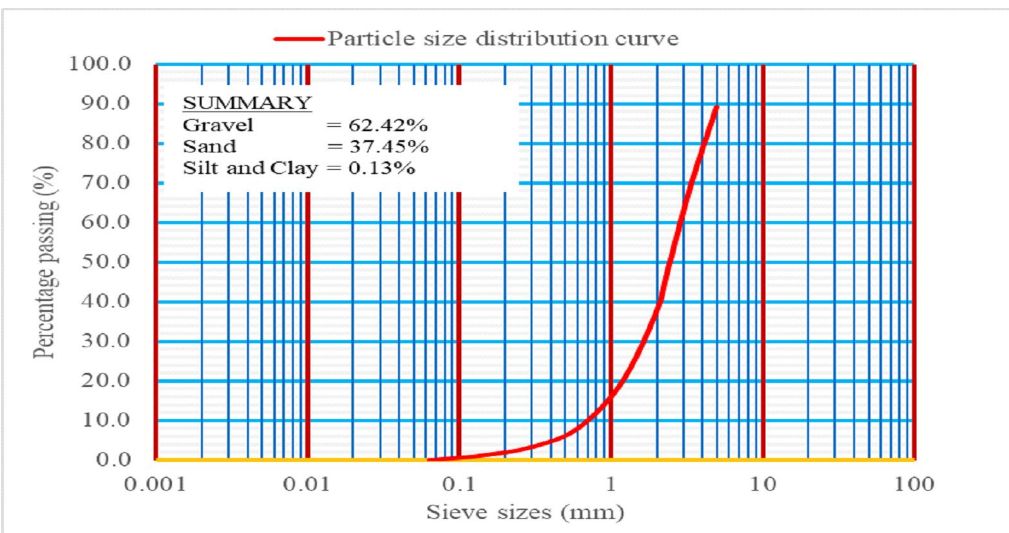

Figure 2: Particle size distribution curve of laterite

2.2 Sample Specimens preparation

The compressed earth block specimens were prepared with laterite, 10% constant hydrated lime, three different lengths (10, 20, and 30mm) of OPBF with 0.25, 0.5, and 0.75% contents, and 12.5% water as per the OMC of the laterite by weight. Studies have shown that using higher fibre content in earth blocks beyond 0.75% weakens the strength properties of the compressed earth blocks [11, 12, 19, 29]. The control specimens were prepared with only laterite and water without OPBF and lime. The mortar was manually prepared on a platform. The required quantity of the laterite was batched and spread on the platform, the required quantity of lime was also batched and spread on the laterites, and mixed thoroughly with spade until uniform mix was attained. The required quantity of each OPBF content was batched, and added and mixed thoroughly and the required water was batched, sprinkled on the mixture, and mixed until a uniform mortar mixture was attained. The mortar was used to fill the compressed earth block machine to press and mould the blocks of sizes 140 x 100 x 100mm. 270 blocks were prepared and cured by sprinkling water on them daily and tested at 7, 14, 21, and 28 days.

2.3 Testing of Specimens

Three replicates of each of the compressed earth blocks (Figure 3a) were tested for density, water absorption, compressive strength, split tensile strength, and microstructural analysis.

Figure 3: specimen and testing, (a) specimen, (b) compressive strength test, (c) tensile strength test

The density of the OPBF and lime-stabilised compressed earth block specimens were assessed following the BS EN 771-1 [32] procedure. The specimens were oven-dried at a temperature of 105°C and allowed to cool, after which the three dimensions of the specimens were measured and used for calculating the volume of the specimens. The weight of each specimen was measured using an electronic weighing balance. The density of the OPBF and lime-stabilised compressed earth block specimens was calculated using Equation 1, where ***ρ*** is the dry density, ***m*** is the weight of the OPBF and lime stabilised compressed earth block specimens, and ***v*** is the volume of the OPBF and lime stabilised compressed earth block specimens.

$$\rho = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

The water absorption rate of the OPBF and lime-stabilised compressed earth block specimens were assessed following the BS EN 772-11 [33] procedure. The specimens were oven-dried after 28 days of curing at a temperature of 105°C and allowed to cool, after which the weight of each specimen was measured using electronic weighing balance as the dry weight specimen (***Wd***). The bed-side of the specimens was immersed in a constant head-water bath to a depth of 10mm and allowed to absorb water through capillary action for 10 minutes as the wet weight specimen (***Ww***). The water absorption (***WA***) percentage was calculated using Equation 2.

$$WA = \; x\,100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

The compressive strength of the OPBF and lime-stabilised compressed earth block specimens were assessed following the BS EN 772-1 [34] procedure. The specimens were placed in the compressive testing machine (Figure 3b) with a capacity of 1000 KN and were crushed at the rate of 0.25 N/mm^2/s. The maximum load at which the specimen raptured (***P***) and the cross-sectional area (***A***) of the specimen at which the load was applied were used to calculate the compressive strength (***fc***) of the specimen using Equation 3.

$$fc = x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

The tensile strength of the OPBF and lime-stabilised compressed earth block specimens were assessed following the BS EN 12390-6 [35] procedure. The specimens were placed in the testing machine (Figure 3c) with metal jigs placed above and below the specimen and were split at the rate of 0.25 N/mm^2/s. The maximum force at which the specimen split (***F***), the length of the specimen (***L***), and the diameter of the specimen (***d***) of the specimen were used to calculate the tensile strength (***ft***) of the specimen using Equation 4.

$$ft = \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

The microstructural analysis of the OPBF and lime-stabilised compressed earth block specimens was assessed with scanning electron microscopy (SEM) using the Phenom-World ProX desktop scanning electron microscope. The specimen was prepared to withstand vacuum conditions and high energy beam electrons by impregnating it with Canada balsam and trimmed to fit the specimen. The test was conducted following the principles of ASTM E766 [36] using Optical images captured at the magnification of 500 ×.

3. RESULTS AND DISCUSSION

3.1. Physical properties of OPBF and lime-stabilised compressed earth block

Dry density and water absorption tests were used to characterise the physical properties of the OPBF and lime-stabilised compressed earth blocks. The results obtained from the density and water absorption tests are presented below.

The result of the average dry density of compressed earth block specimens with 10, 20, and 30mm lengths of OPBF and 0.25, 0.5, and 0.75wt.% content of OPBF and lime at 28-

days curing periods is presented in 4. It is worth noting that the unstabilised compressed earth blocks (control) had the highest dry density of 1947.73 kg/m^3. This was followed by 10mm and 0.5% OPBF and lime stabilised compressed earth blocks' dry density of 1885.87 kg/m^3, and the least 30mm and 0.75% OPBF and lime stabilised compressed earth blocks' dry density of 1790.40 kg/m^3. There was a reduction in the density of the OPBF and lime-stabilised compressed earth blocks. This result is in line with the results of previous studies [12, 20, 27, 29, 30]. The reduction in the density of the OPBF compressed earth blocks as compared with the control can be attributed to the less weight of the OPBF as compared with the laterite. It was also observed that, generally shorter OPBF compressed earth blocks recorded slightly higher density than the longer OPBF compressed earth blocks. This might be due to the shorter OPBF better cohesion with the laterite creating less pores in the composite materials.

Figure 4: Average dry density of OPBF and lime-stabilised compressed earth block

The result of the average water absorption of the compressed earth block specimens with 10, 20, and 30mm lengths of OPBF and 0.25, 0.5, and 0.75% content of OPBF and lime at 28 days curing periods is presented in 5. The results of the average water absorption of specimens followed a similar trend with the dry density of OPBF and lime-stabilised compressed earth blocks. The control specimens had the highest water absorption of 9.78% as compared with the lowest water absorption of 3.04% achieved by 10mm and 0.5% OPBF and lime-stabilised compressed earth blocks. This represents a 223% reduction in water uptake of the OPBF and lime-stabilised compressed earth blocks. Similar results were found in the studies [29] with plantain pseudo stem fibre and lime, and [30] coconut fibre and lime. This can be attributed to the lime functioning as a binder and the OPBF blocking the passage of the water by protecting the particles of the laterite from being washed away. It can further be observed that the OPBF with a longer length (20 and 30mm) recorded a slight increase in water absorption as compared with the shorter length OPBF length (10mm). This might be due to the longer OPBF length crossing each other which results in the formation of voids in the composite material.

Figure 5: Average water absorption of OPBF and lime-stabilised compressed earth blocks

3.2. Mechanical properties of OPBF and lime-stabilised compressed earth block

Compressive strength and tensile strength tests were used to characterise the mechanical properties of the OPBF and lime-stabilised compressed earth blocks. The results obtained from the density and water absorption tests are presented below.

The compressive strength of the OPBF and lime-stabilised compressed earth blocks is illustrated in Figure 6. It can be observed as expected that at each OPBF content, there was increased strength from curing day 7 to curing day 28, implying that as the curing days increased the compressive strength of the OPBF and lime-stabilised compressed earth blocks increased. At 10mm length of OPBF specimens (Figure 6a), the 0.5% fibre content specimens achieved the highest compressive strength of 5.865N/mm^2 as compared to the lowest which is the control specimens of 5.393N/mm^2 at 28 days of curing representing an 8% increase in the compressive strength. At 20mm length of OPBF specimens (Figure 6b), the 0.5% fibre content specimens achieved the highest compressive strength of 6.641N/mm^2 as compared to the lowest which is the control specimens of 5.976N/mm^2 at 28 days of curing, representing a 10% increase in the compressive strength. At 30mm length of OPBF specimens (Figure 6c), the 0.5% fibre content specimens again achieved the highest compressive strength of 6.542N/mm^2 as compared to the lowest which is the control specimens of 5.862N/mm^2 at 28 days of curing, representing about 10% increase in the compressive strength. It was further found that among the three OPBF lengths and contents, the 20mm with 0.5% had the highest strength of 6.641N/mm^2 as can be seen in Figure 6d. This implies that the 0.5% fibre content with 20mm OPBF length achieved the optimum compressive strength. The increased strength recorded was between 8 and 10% of the OPBF and lime stabilised compressed earth blocks over the ustabilised compressed earth blocks. A similar trend was found in previous studies with plantain pseudo stem fibre and lime [29], and coconut fibre and lime [30] which obtained optimum compressive strengths of fibre content at 0.25 and 0.20, respectively. The previous study [30] achieved the highest compressive strength of the specimens with 20mm coconut fibre length. This supports the findings of the current study.

Figure 6: Average compressive strength of OPBF and lime-stabilised compressed earth blocks: (a) 10mm length of OPBF specimens, (b) 20mm length of OPBF specimens, (c)

30mm length of OPBF specimens, (d) comparison of 0.5% OPBF content for 10mm, 20mm, and 30mm specimens

The tensile strength of the OPBF and lime-stabilised compressed earth blocks is presented in Figure 5. As expected and in the case of the compressive strength, the tensile strength of the OPBF and lime-stabilised compressed earth blocks increased with increased curing age. It must be noted that at curing day 7, the tensile strength test did not yield any appreciable values, therefore, the test result obtained was from curing days 14 to 28. At 10mm length of OPBF specimens (Figure 7a), the 0.5% fibre content specimens achieved the highest tensile strength of 0.397N/mm^2 as compared to the lowest which is the control specimens of 0.326N/mm^2 at 28 days of curing representing about 18% increase in the tensile strength. At 20mm length of OPBF specimens (Figure 7b), the 0.5% fibre content specimens achieved the highest tensile strength of 0.423N/mm^2 as compared to the lowest which is the control specimens of 0.326N/mm^2 at 28 days of curing, representing about 23% increase in the tensile strength. At 30mm length of OPBF specimens (Figure 7c), the 0.5% fibre content specimens again achieved the highest tensile strength of 0.446N/mm^2 as compared to the lowest which is the control specimens of 0.326N/mm^2 at 28 days of curing, representing about 27% increase in the tensile strength. It was further found that among the three OPBF lengths and contents, the 20mm with 0.5% had the highest strength of 0.446N/mm^2 as can be seen in Figure 7d. This implies that the 0.5% fibre content with 20mm OPBF length achieved the optimum compressive strength as was also in the case of the compressive strength. The increased tensile strength recorded was between 18 and 27% of the OPBF and lime-stabilised compressed earth blocks over the ustabilised compressed earth blocks. The percentage increase in the tensile strength was higher than the compressive strength. A similar study [37] carried out by reinforcing plain concrete with OPBF revealed an increase in splitting tensile strength of 1.2% at 28 days of curing. Again, another study [20] conducted by reinforcing earth blocks with oil palm fruit fibre revealed a 5% increase in tensile strength.

Figure 7: Average tensile strength of OPBF and lime-stabilised compressed earth blocks: (a) 10mm length of OPBF specimens, (b) 20mm length of OPBF specimens, (c) 30mm length of OPBF specimens, (d) comparison of 0.5% OPBF content for 10mm, 20mm, and 30mm specimens

The results indicate that the mechanical properties of the OPBF and lime-stabilised compressed earth blocks were enhanced. Both the compressive and tensile strengths of the blocks obtained an optimum strength at 0.5% fibre content with 20mm OPBF length. This suggests a correlation between compressive strength and tensile strength at 28-day curing period for the highest-performing OPBF and lime-stabilised compressed earth blocks. A 2-tailed Pearson correlation test was run between the results of the 28 days compressive and tensile strengths and the result is presented in Table 2. A strong positive correlation (r= 0.692) was observed between compressive strength and tensile strength.

Table 2: Relationship between compressive and tensile strengths results at 28 days of curing

Correlations		Compressive strength	Tensile strength
Compressive strength	Pearson Correlation	1	.692*
	Sig. (2-tailed)		.039
	N	9	9
Tensile strength	Pearson Correlation	.692*	1
	Sig. (2-tailed)	.039	
	N	9	9

*Correlation is significant at the 0.05 level (2-tailed).

3.3 Microstructural analysis of OPBF and lime-stabilised compressed earth block

The microstructural analysis of the compressed earth block satbilised with OPBF and lime was conducted on the randomly selected specimen and the typical image of the surface texture of OPBF is shown in Figure 8a, and the image of the composite material is shown in Figure 8b. It can be observed in Figure 8a that the surface image of the OPBF is rough, and therefore can ensure good adhesion between the OPBF and laterite-lime matrix [38]. The scanning electron microscopy (SEM) optical image captured at 500× magnification as can be seen in Figure 8b shows the cross-section of the OPBF with micro-gaps at the peripheral of the OPBF, the laterite-lime matrix, and micro-cracks within the composite material. This result supports the findings of a study [38] that established that micro-gaps are found between the fibres and soil matrix because of shrinkage of the fibre as a result of drying of the blocks. It can further be observed that the OPBF bridging the crack and holding the cracked sections together acts like dowels preventing the spread of the cracks. It is an indication that the use of the appropriate size (length and diameter) of OPBF, the better the tensile strength to support the assertion that fibres help to restrain the propagation of cracks in compressed earth blocks [31]. The mechanism between the fibres and the laterite-lime matrix contributed to the improved mechanical properties of the compressed earth block [38].

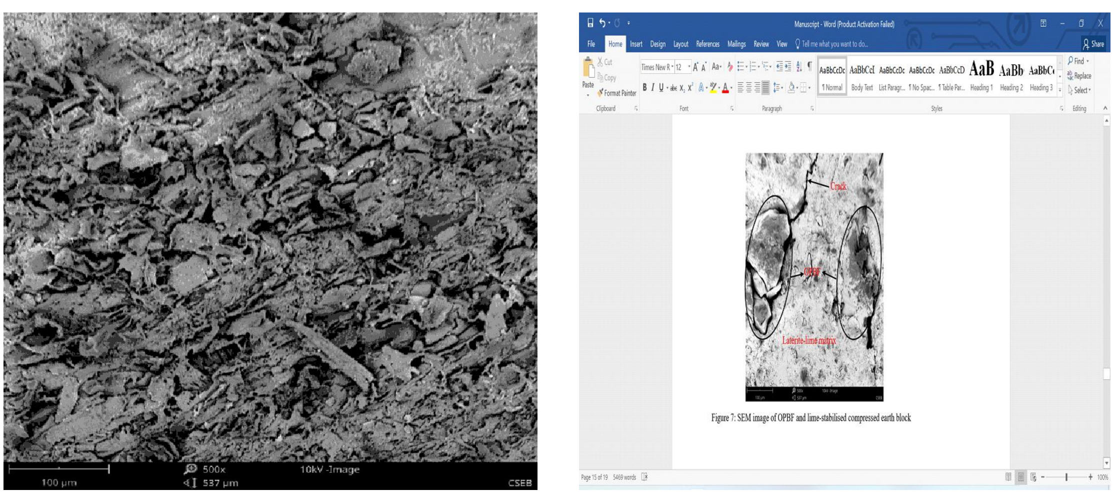

Figure 8: SEM images: (a) surface texture of OPBF, (b) OPBF and lime-stabilised

compressed earth block

4. SUMMARY AND CONCLUSION

The study investigated the physico-mechanical properties of compressed earth blocks stabilised with varying lengths and contents of oil palm broom fibre (OPBF), and lime for housing provision. The findings of the investigation are summarised below:

- There was a reduction in the density of the OPBF and lime-stabilised compressed earth blocks as compared to the unstabilised compressed earth blocks. The unstabilised blocks recorded a dry density of 1947.73kg/m^3. This was followed by 10mm and 0.5% OPBF and lime-stabilised blocks' dry density of 1885.87 kg/m^3, and the least of 1790.40 kg/m^3 recorded by 30mm and 0.75% OPBF and lime-stabilised blocks.

- The compressed earth blocks stabilised with OPBF and lime provided better water resistance than the unstabilised blocks. The 10mm and 0.5% OPBF and lime-stabilised compressed earth blocks achieved the lowest water absorption of 3.04% as compared to the highest water absorption of 9.78% recorded by the unstabilised blocks. This represents a 223% reduction in water uptake of the OPBF and lime-stabilised compressed earth blocks.

- The 20mm length with 0.5% content of OPBF achieved the optimum compressive strength of 6.641N/mm^2 as compared to the ustabilised specimens of 5.976N/mm^2, representing about 10% compressive strength increase.

- For the tensile strength, the 20mm length with 0.5% OPBF content specimens achieved the highest tensile strength of 0.423N/mm^2 as compared to the ustabilised specimens of 0.326N/mm^2, representing about 23% increase in the tensile strength.

- The microstructural analysis of the compressed earth block satbilised with OPBF and lime revealed micro-gaps at the peripheral of the OPBF, and micro-cracks within the composite material.

The study, therefore concludes that varying lengths and contents of OPBF and lime impact the physico- mechanical properties of compressed earth blocks. It is, therefore, recommended that 20mm length with 0.5% OPBF content should be used by practitioners to enhance the physico-mechanical properties of compressed earth brick for use as eco-friendly materials to provide housing accommodation. Further studies can consider investigating the thermal and long-term durability properties of OPBF and lime-stabilise compressed earth blocks. Cost benefit analysis and environmental impact assessment on OPBF and lime-stabilise compressed earth blocks are also recommended for future studies. In terms of scalability, manufacturers would have to use appropriate sizes of OPBF lime-stabilised compressed earth blocks as pertains to their locality and adequate OPBF in their locality for large-scale production.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

References

[1] Amegayibor. S. (2020). Here's how many homes gov't needs to build to bridge housing deficit gap. Ghana Web. https://www.ghanaweb.com/GhanaHomePage/business/Here-s-how-many-homes-gov-t-needs-to-build-to-bridge-housing-deficit-gap-1024477#google_vignette (Accessed 25 September 2024).

[2] Danso, H., Obeng-Ahenkora N. K. & Manu D. (2021). Prices trend of selected building construction materials on Ghanaian construction market: 2011 – 2016, International journal of Construction Management, 21:3, 284-291, D01:10.1080/156235.2018.1531809.

[3] CBI Ghana, (2021). CBI Ghana relies on Clinker importation during shortage. Ghana News Agency, 05 March, 2021.

[4] Bediako, M and Frimpong, A.O (2013). Alternative Binders for increased sustainability construction in Ghana. A guide for Building Professionals.

[5] Saeed, M. (2017). Cement production Effects on Human with Respect to Cement

Lifecycle Assessment. Gazi University, Faculty of Applied Science, Department of Environmental Science, Ankara, Turkey.

[6] Anosike M.N, Oyobade A.A. (2012). Sandrete blocks and quality management in Nigeria building Industry. Journal of Engineering Project and production management 2-37-46.

[7] Baiden B, Tuuli M, (2004). Impact of Quality Control Practices in Sandcrete Blocks Production, Journal of Architectural Engineering. 10 (2): 53-60.

[8] Korankye, P., Danso, H. (2024). Properties of Sandcrete Blocks Stabilized with Cashew Apple Ash as a Partial Replacement for Cement. Scientific Reports, 14, 6804, 1-11, https://doi.org/10.1038/s41598-024-55031-7

[9] Danso, H. (2013). Building Houses with Locally Available Materials in Ghana: Benefits and Problems. *International Journal of Science and Technology*, 2(2), 225-231.

[10] Xinlei, Y, Hailiang W. (2019). Strength of Hollow Compressed Stabilized Earth-Block Masonry Prisms. School of civil Engineering, Tianjin Chengjian University, No. 26 Jinjing Road, Xiqing District, Tiangin 300384, China.

[11] Turkson, A.T., Danso, H. & Appiah-Kubi E. (2024). Enhancing Compressed Earth Blocks with Eggshell and Lime: Effects on Mechanical and Physical Properties. London Journal of Engineering Research, 24(7):19-37. https://journalspress.com/investigating-the-effect-of-eggshell-and-lime-on-the-properties-of-compressed-earth-blocks/

[12] Danso H, Martinson D. B., Ali M., Williams J. B. (2015). Physical, Mechanical and Durability Properties of Soil Building Blocks Reinforced with Natural Fibres.

[13] Brown, E. & Danso, H. (2024). The Use of Waste Synthetic Hair Fibre in Cement Mortar. Journal of Engineering Research and Reports, 26(10):217-27. https://doi.org/10.9734/jerr/2024/v26i101300

[14] López-Rebollo J, Cárdenas-Haro X, Parra-Vargas JP, Narváez-Berrezueta K, Pino J. Improvement of Mechanical Properties of Compressed Earth Blocks with Stabilising Additives for Self-Build of Sustainable Housing. Buildings. 2024; 14 (3):664. https://doi.org/10.3390/buildings14030664

[15] Shantanu P., Mohammad S. I, Tausif E. E. Potential of waste rice husk ash and cement in making compressed stabilized earth blocks: Strength, durability and life cycle assessment. Journal of Building Engineering, 73, 2023, 106727, https://doi.org/10.1016/j.jobe.2023.106727.

[16] Danso, H. (2017). Experimental Investigation on the Properties of Compressed Earth Blocks Stabilised with a Liquid Chemical. Advances in Materials 6(6), 122–128, doi:10.11648/j.am.20170606.13

[17] Shantanu P., Mohammad S. I., Mohammad I. H. Suitability of Vetiver straw fibers in improving the engineering characteristics of compressed earth blocks. Construction and Building Materials, 409, 2023, 134224, https://doi.org/10.1016/j.conbuildmat.2023.134224.

[18] Akinyele J. O., Olateju O.T., Oikelome O.K., "Rice husk as filler in the production of bricks using Gboko clay," Nigerian Journal of Technology, 34(4), 672-678 (2015), https://www.ajol.info/index.php/njt/article/view/124029

[19] Ige O., Danso H., "Experimental Characterization of adobe bricks stabilized with rice husk and lime for sustainable construction," Journal of materials in civil Engineering, 34(2) (2022).

[20] Danso H., "Use of Agricultural Waste Fibres as Enhancement of Soil Blocks for Low-Cost Housing in Ghana," PhD thesis, University of Portsmouth, London. (2016).

[21] Sasui S., Jinwuth W., Hengrasmee S., "The effects of raw rice husk and rice husk ash on the strength and durability of adobe bricks," Civil Engineering Journal, 4 (4), 732-742 (2018).

[22] Yalley P.P.K., Kwan A.S.K., "Use of waste and low energy material in building block construction," International Refereed Journal of Engineering and Science (IRJES), 2(11) 01-05 (2013).

[23] Suthar P., Rathor A., Jha A., Singh J., "Effect of Rice Husk Ash on Cement Stabilized Laterite," International Journal of Engineering Research & Technology, 4(23), 1-3 (2016).

[24] Ismail S., Yaacob Z., "Properties of laterite bricks reinforced with oil palm empty fruit bunch fibres," Pertanika Journal of Science & Technology, 19(1): 22–43 (2011).

[25] Alavez-Ramirez R., Montes-Garcia P., Martinez-Reyes J., Altamirano-Juazez D.C., Gochi-Ponce Y., "The use of sugarcane bagasse ash and lime to improve the durability of mechanical properties of compacted soil blocks," Construction and Building Materials, 34, 296-305 (2012).

[26] Lima S.A., Varum H., Sales A., Neto V.F., "Analysis of the mechanical properties of compressed earth blocks masonry using the sugarcane bagasse ash," Construction and Building Materials, 35, 829-837 (2012).

[27] Ige O., Danso H., "Physico-mechanical and thermal gravimetric analysis of adobe masonry units reinforced with plantain pseudo-stem fibres for sustainable construction," Construction and Building Materials, 273, 1-10 (2021), https://doi.org/10.1016/j.conbuildmat.2020.121686

[28] Akinwande A.A., Balogun O.A., Romanovski V., Danso H., Ademati A.O., Adetula Y.V, "Recycling of synthetic waste wig fiber in the production of cement-adobe for building envelope: physio-hydric properties," Environmental Science and Pollution Research, 29, 34075-34091, (2022). https://link.springer.com/article/10.1007/s11356-022-18649-6

[29] Danso H., "Influence of Plantain Pseudostem Fibres and Lime on the Properties of Cement Mortar," *Advances in Materials Science and Engineering*, 2020, 1-9, (2020), https://www.hindawi.com/journals/amse/2020/4698603/

[30] Danso H., Manu D., "Influence of Coconut Fibres and Lime on the Properties of Soil-Cement Mortar," Case Studies in Construction Materials, 12, 1-12 (2020),

https://doi.org/10.1016/j.cscm.2019.e00316

[31] Danso H., Martinson D.B., Ali M., Williams J.B. “Effect of fibre aspect ratio on mechanical properties of soil building blocks.” Construction and Building Materials, 83, 314-319, (2015), doi:10.1016/j.conbuildmat.2015.03.039

[32] BS EN 771-1, Specification for masonry units. Clay masonry units. European Standard adopted by British Standards Institution, 2003. http://shop.bsigroup.com/ProductDetail/?pid=000000000030142472.

[33] BS EN 772-11, Methods of Test for Masonry Units, European Standards adopted by British Standards Institution: http://shop.bsigroup.com/ProductDetail/?pid= 000000000030215381, 2011.

[34] BS EN 772-1. Methods of Test for Masonry Units. Determination of Compressive Strength, (2011) European Standard adopted by British Standards Institution: http://shop.bsigroup.com/ProductDetail/?pid=000000000030215378.

[35] BS EN 12390-6, Testing hardened concrete, Tensile Splitting Strength of Test Specimens, European Standard adopted by British Standards Institution: https://www.document-center.com/standards/show/BS-EN-12390-6, 2009.

[36] ASTM E766 (2019): Standard practice for calibrating the Magnification of a Scanning Electrons Microscopy.

[37] Momoh E.O., Osofero A.I. “Behaviour of oil palm broom fibers (OPBF) reinforced concrete.” Construction and Building Materials. 221: 745–761 (2019). https://doi.org/10.1016/j.conbuildmat.2019.06.118.

[38] Danso H., Martinson D.B., Ali M., Williams J.B. Mechanisms by which the inclusion of natural fibres enhance the properties of soil blocks for construction. Journal of Composite Materials, 51(27), 3835–3845 (2017), DOI: 10.1177/0021998317693293