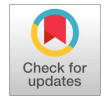


Effect of Adding Ash from the Combustion of Acacia Nilotica Wood on the Mechanical Properties of Clay Soils



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Abstract: To meet sustainable development goals, global policies are strongly oriented toward valorising local materials such as agricultural waste. In this context, the present study aims to evaluate the mechanical behaviour of compressed earth blocks (CEB) with wood ash. To this end, we used wood ash as a binder to reinforce the base materials. The experimental program included seven formulations (0%, 2%, 4%, 6%, 8%, 10%, and 12%) of wood ash as a percentage of the total soil mass. The results showed that 4% wood ash in 90% clay soil achieved the best compressive strength, with a compaction stress of 4.30 MPa.

Keywords: BTC, Clay, Stabilisation, Compressive Strength, Splitting Resistance.

Nomenclature:

CEB: Compressed Earth Blocks

CSEB: Compressed Stabilised Earth Blocks

I. INTRODUCTION

Global population growth, estimated to reach nearly 9.6 billion by 2050, will significantly increase demand for housing, infrastructure, and public facilities [1]. This development exacerbates the challenges facing the construction sector, one of the main consumers of energy and natural resources. Indeed, in 2021, construction and operation accounted for 34% of global energy consumption and 37% of CO₂ emissions [2].

Other studies indicate that the construction sector is responsible for more than 36% of total energy consumption and 39% of greenhouse gas emissions [3]. [4], this consumption reaches 50 to 70% in Sub-Saharan Africa [5], while the cement industry alone is responsible for 5 to 7% of global CO₂ emissions [1] [6] [7], [8], [9]. Moreover, cementitious materials negatively affect the environment [10] and the thermal comfort of buildings, particularly in tropical regions [11]. Moreover, buildings are still too often designed without sufficiently considering the climatic context or their environmental impact [12]. It is in this context that the search for new construction materials capable of simultaneously meeting economic, technical, and environmental requirements, with hygrothermal properties offering better thermal comfort for buildings, particularly in hot regions, while adhering to the principles of the circular economy and sustainable development [9], [10], [13]. Among these local materials, earth is one of the oldest construction materials used by humanity, requires low manufacturing energy, and remains easily recyclable at the end of its life [9]. Although often criticised for their sensitivity to water and limited durability, compressed earth blocks (CEB) offer numerous advantages for constructing sustainable, comfortable, and economical housing [14], [15]. Moreover, raw earth has intrinsic limitations, particularly low mechanical strength and high sensitivity to water [16]. To improve these properties, numerous studies have focused on stabilising CEBs with various additives to enhance their mechanical and hygroscopic performance. Several authors have studied the incorporation of synthetic, organic, or mineral reinforcements, while natural reinforcements now represent a particularly promising research avenue [15]. Moreover, several studies show that the compressive and flexural strengths of compressed stabilised earth blocks (CSEB) increase depending on the nature and rate of the stabilisers used [11].

Thus, in a context marked by the necessity to reduce greenhouse gas emissions, improve the energy performance of buildings, and promote economically accessible construction solutions, compressed earth blocks stabilised with local materials appear as a credible alternative to conventional materials. This work aims to evaluate the impact of wood ash on test bricks made from clay soil from the city of Abéché to validate their use in construction.

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II. MATERIALS AND METHODS

A. Location of Material Sampling Sites

The table below provides the geographical coordinates.

Table I: Different sites and their Geographical Coordinates

References of Soils	Sites	Geographical Coordinates
A1	Kamina 1	Latitude 13°50'52'' N Longitude 20°48' ,54''E
A2	Kamina 2	Latitude 13°50' , 52'' N Longitude 20°48' ,30''E

B. The Materials of the Study

i. The Clay

Article [17] provides the various physical and geotechnical properties of the clay from Abéché. These physical parameters helped classify the clays from three quarries in Abéché as "low plasticity clay."

ii. Wood Ash

Wood ash is collected from the grills of some meat barbecue restaurants in N'Djamena. The figure below illustrates images of wood ash.



[Fig.1: Illustrates Images of Wood Ash]

C. Loss on Ignition

To determine the loss on ignition, first dry the sample to a mass M2 at 105°C, then place it in a furnace (SYBRON type 6000 Furnace) set to 1000°C for 2 hours. After cooling, we record a new mass M3. It is expressed as a percentage, representing the weight loss of a soil after calcination at 1000°C, relative to the initial weight. During heating, various reactions occur that modify the soil (dehydration and/or dehydroxylation of iron and aluminium hydroxides, oxy-hydroxides, clay minerals with loss of hydration and/or structural water; decomposition of carbonates and organic matter) [18]. To measure this, we heated a soil mass M2, previously dried at 105 °C for 24 hours, at 1000 °C in a Ceradel furnace. M3 is the mass obtained after calcination and cooling. The loss on ignition is calculated using the relationship:

$$PF(\%) = \frac{M2-M3}{M3} * 100 \quad (1)$$



[Fig.2: Muffle Furnace for Determining Loss on Ignition]

D. Soil Preparation

For sample preparation, we prepared the mixture as follows: We first collected the material passing through the 5 mm sieve for the clay and the material passing through the 2 mm sieve for the wood ash. First, we weighed the clay dry and mixed it with different percentages of wood ash. We kneaded the mixture (clay + wood ash), then added water and kneaded again to achieve a homogeneous blend. The Standard Proctor method determines water content by compacting the clay in a standardised mould using a standardised tamper, then measuring its natural water content and bulk density after compaction according to the standard [19]. The device used during this test is shown in the following figure.



[Fig.3: Compaction Device]

The test is repeated several times in succession on samples brought to different moisture contents, and the normal Proctor curve is plotted. It shows the maximum dry bulk density, with water content on the abscissa and optimal dry bulk density on the ordinate. Cylindrical samples (10/11 cm²) are used for mechanical tests (bending and compression). Table II presents the different formulations.

Table II: Formulation of 10/11 cm² Test Specimens of Different Materials with Acacia Ash

Soils	Clay (%)	%GA	D (cm)	h (cm)	Number
A1	100	0	10	11	6
	98	2	10	11	6
	96	4	10	11	6
	94	6	10	11	6
	92	8	10	11	6
	90	10	10	11	6
A2	88	12	10	11	6
	100	0	10	11	6
	98	2	10	11	6
	96	4	10	11	6
	94	6	10	11	6
	92	8	10	11	6
Sol	90	10	10	11	6
	88	12	10	11	6

E. Fabrication of Specimens for Mechanical Testing

To fabricate these samples, we used a metal mould (10 cm diameter, 11 cm height) and a 12-ton hydraulic compaction press. However, for sample preparation, we determined the water content for each formulation. First, we mixed the clay with wood ash, then added water and kneaded thoroughly to achieve homogeneity. We followed the NF P 94-093 standard for compaction. We initially dried these samples at ambient temperature in the Laboratory of the National School of Public Works for one week, then oven-dried them at 105 °C for 3 days. The samples are arranged for mechanical characterisation (experimental setup below).





[Fig.4: Preparation and Fabrication of Cylindrical Specimens]

For each formulation, 6 samples were manufactured: two (2) for bending and 3 for compression.

F. Mechanical Characterisation of Specimens a) Compression Strength

The manufactured samples are first dried to achieve a stable mass before being subjected to the crushing operation. This crushing operation is carried out with a CBR press, shown in the diagram below. First, the specimen is placed on a compression plate composed of two pistons. A fixed upper piston, on which a 30 kN force sensor is installed to record the pressures exerted on the specimen, and a lower mobile piston operated by a handwheel, which allows the sample to remain in contact with the upper piston. We use two steel discs, one above and one below the specimen, to distribute pressure evenly across the specimen. The upper piston has a displacement gauge to measure the sample's deformation during crushing. After placing the sample on the test platform, the device's start button is pressed, and the sample rises with the lower piston until it comes into contact with the upper piston, allowing the force sensor and the displacement gauge to record the effort exerted by the frame on the sample until it breaks and deforms. This press is designed to evaluate the CBR value of subgrades and subbases in the laboratory and to determine material strength. The force F is then applied at a speed of 1.27mm/min until the specimen breaks abruptly. After the rupture of the latter, the rupture force and the deformation value are recorded. The compressive strength is determined according to the following formula:

$$R_c = \frac{F_r}{S} \quad (2)$$

Where R_c is the compressive strength (MPa), F_r is the breaking force (N), and S (mm²) is the specimen cross-section.



[Fig.5: a) CBR Press, b) Compression Device, Tensile Strength (Brazilian Test)]

The determination of tensile strength is carried out with the same CBR press. Generally, materials have low tensile

strength during a tensile test. Earth constructions are designed to function exclusively under compressive stress. This measurement is rare, but under particular circumstances, it is obtained through indirect tests such as three-point bending on prismatic specimens and the Brazilian (or splitting) test on curved specimens. In this study, we use the Brazilian test to evaluate tensile strength. The tensile strength measurement system is identical to that of the compressive strength. The test is performed on a sample with a circular cross-section, compressed between two opposing plates. The centre of the specimen is the movable lower piston. After pressing the start button, the test tube rises until it contacts the upper piston. After the rupture of the latter, the needle of the force comparator returns to zero, the value is recorded, and the 0 button is pressed so that the lower piston descends to start another test. The tensile strength is determined according to the following expression :

$$R_t = \frac{2*F}{\pi DH} \quad (3)$$

Where R_t is the rupture strength (MPa), F is the rupture load (N), D is the specimen diameter (mm), and H is the specimen height (mm).



[Fig.6: a) CBR Press, b) Bending Device]

III. RESULTS AND DISCUSSIONS

The following table shows the fire losses for both soils.

Table III: Results of Fire Loss Analysis

Soils	Loss on Ignition (%)
A1	8,48
A2	8,17

The loss on ignition corresponds to the percentage of volatile matter, at 8.48% and 8.17% for A1 and A2, respectively. This loss on ignition would correspond to the dehydroxylation of the clay minerals present in the sample and their decarboxylation. The high loss-on-ignition values of the two soils indicate a higher fine-particle content.

A. Results of Mechanical Tests of Cylindrical Specimens

i. Case of Compressive Strength

The results of the compression of the cylindrical specimens (11/10) are given in the following table.



Table IV: Values of Compressive Strengths

Soils	Compressive Strength (MPa), 11/10 Clay + Wood Ash Specimens (%)						
	0%	2%	4%	6%	8%	10%	12%
A1	4,04	4,08	3,73	2,62	2,10	1,61	1,49
A2	3,85	3,88	3,36	3,02	2,65	2,17	1,73



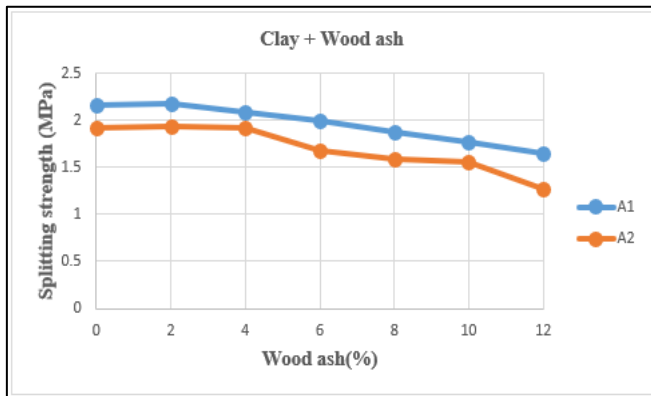
[Fig.7: Evolution of Wood Ash]

It is observed that the compressive strength decreases with the increase in the percentage of wood ash, except in the case of 0% wood ash. Thus, wood ash in the mixture does not improve the specimens' flexural strength [20]. However, starting at 2% wood ash, we observe a descending linear curve, reaching an average value of 4.01 MPa for both soils. Beyond 2%, wood ash no longer acts as a binder because there is less matrix to ensure this bond; consequently, strength decreases [21].

ii. Case of Splitting Resistance

Table VI: Values of Splitting Resistances

Soils	Splitting Tensile Strength (MPa), Clay + Wood ash Specimens (10/11) (%)						
	0%	2%	4%	6%	8%	10%	12%
A1	2,16	2,18	2,08	2,00	1,88	1,77	1,65
A2	1,92	1,94	1,92	1,67	1,58	1,55	1,27



[Fig.8: Splitting Resistance]

In Figure 8, the increase in resistance for samples with 2% wood ash addition is not significant compared with samples with 0%; this result is observed in the work [22]. However, a significant progressive decrease is observed beyond 2% wood ash addition. However, the average strength of 1.74 MPa for samples with 2% wood ash remains higher than that of samples without wood ash; these results are consistent with studies [23]. Indeed, both soils show a strength loss of more than 30% between 2% and 12% wood ash addition. Therefore, adding wood ash significantly reduces the material's compressive performance. The compressive

strength values for samples incorporating more than 4% wood ash decrease compared with the control samples without wood ash. Moreover, these results are supported by the inability to characterise samples with more than 10% ash, as they break during handling. We conclude that adding more than 2% wood ash offers no compression benefit. However, they can be used as a filling element in construction even though their strengths are lower than those of the traditional reference material. This would help reduce environmental pressures, given the depletion of available natural resources.

IV. CONCLUSION

In this work, we determined the physico-mechanical properties of a BTC produced from clay collected from the city of Abéché (Seidou). The experimental study focused on incorporating wood ash to produce an environmentally friendly (green) material. However, the study focused on using wood ash from plant waste as a soil reinforcement and cement as a stabilising agent. The researchers added wood ash to the clay soil at 0, 2, 4, 6, 8, 10, and 12% relative to the total mass of the BTC. The results show that adding wood ash affects the mechanical properties of the manufactured specimens. Furthermore, samples made solely from soil exhibit higher mechanical strength than those with wood ash.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of interest:** Based on my understanding, this article has no conflicts of interest.
- **Funding/Grants/Financial Support:** This article has not been sponsored or funded by any organisation or agency.
- **Ethical Approval and Consent to Participate:** The data provided in this article are exempt from ethical approval or participant consent requirements.
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REFERENCES

1. ECOMAT-AFRICA, "Proceedings of the 3rd Conference on Eco-Materials in Africa," in ECOMAT-AFRICA, Gabon: ECOMAT AFRICA, 2025, p. 311.
https://books.google.com/books/about/The_3rd_Eco_Materials_Conference_in_Afri.html?id=o0nOEQAQBAJ
2. Teddy Gresse, "Development and validation of a three-dimensional and dynamic thermo-aerodynamic model of the building for the study of complex indoor thermal environments," INSA de Lyon, Lyon, France, 2023.
https://hal.science/tel-04193207v2/file/Manuscrit_these_VFfinale.pdf
3. J. Tchiotso, N. Issaadi, P. Poullain, S. Bonnet, and R. Belarbi, "Assessment of the natural variability of cob buildings hygric and thermal properties at material scale: Influence of plants add-ons," Constr. Build. Mater., vol. 342, p. 127922, August 2022, DOI: [10.1016/j.conbuildmat.2022.127922](https://doi.org/10.1016/j.conbuildmat.2022.127922).
4. N. Fezzioui, M. Benyamine, N. Tadj, B. Draoui, and S. Larbi, "Energy Performance of a Patio House in the Maghreb Context (Algeria, Morocco, Tunisia, and Libya)," J. Renew. Energ., vol. 15, no. 3, pp. 399-405, Oct. 2023, DOI: [10.54966/jreen.v15i3.330](https://doi.org/10.54966/jreen.v15i3.330).
5. E. Ouedraogo, O. Coulibaly, A. Ouedraogo, and A. Messan,





"Mechanical and Thermophysical Properties of Cement and/or Paper (Cellulose) Stabilised Compressed Clay Bricks." https://www.researchgate.net/publication/290606570_Mechanical_and_Thermophysical_Properties_of_Cement_andor_Paper_Cellulose_Stabilized_Compressed_Clay_Bricks

6. Abdelhadi Serbouti, "Optimisation of energy resources for the design of high energy efficiency buildings," Hassan I University, Laroc, 2021. DOI: [10.14419/ijet.v7i4.13280](https://doi.org/10.14419/ijet.v7i4.13280)
7. G. E. Boukili, M. Lechheb, M. Ouakrouh, A. Dekayir, F. Kifani-Sahban, and A. Khaldoun, "Mineralogical, physico-chemical and technological characterisation of clay from Bensmim (Morocco): Suitability for building application," Constr. Build. Mater., vol. 280, p. 122300, April 2021, DOI: [10.1016/j.conbuildmat.2021.122300](https://doi.org/10.1016/j.conbuildmat.2021.122300)
8. K. A. J. Ouedraogo, J.-E. Aubert, C. Tribout, and G. Escadeillas, "Is stabilisation of earth bricks using low cement or lime content relevant?", Constr. Build. Mater., vol. 236, p. 117578, March 2020, DOI: [10.1016/j.conbuildmat.2019.117578](https://doi.org/10.1016/j.conbuildmat.2019.117578)
9. Sarah Nassar, "Design and Optimisation of Compressed Blocks Based on Dredging Sediments," vol. 42, no. 1, p. 10, 2024. <https://www.researchgate.net/publication/>
10. Louleide Madi and Khadim Ndiaye, "Comparative Study of the Mechanical Properties of Stabilised Compressed Earth Blocks Made with Mauritanian Clays," Ruge 2025, vol. 43, no. 1, 2025.
11. S. Kabre, F. Ouedraogo, B. Naon, A. Messan, and J. C. Benet, "Evaluation of the thermo-hydro-mechanical properties of compressed earth blocks (CEB) from the Matourkou quarry in Burkina Faso." <https://www.scirp.org/reference/referencespapers?referenceid=4062934>
12. A. E. Hammouti, "Study of the hygro-thermomechanical and energy performance of a bio-based and local eco-material for sustainable construction," Université Paris-Est Créteil Val-de-Marne - Paris 12, France, 2025. https://glass-lyon2026.sciencesconf.org/data/pages/BOOK_ABSTRACT_GLASS_LYON_website.pdf
13. M. Charai, "Design and characterisation of new bio-based eco-materials for sustainable building construction." M. Charai, "Design and characterisation of new bio-based eco-materials for sustainable building construction."
14. Israël MAMAH, Higinio Menendez MILANES, Mohamed Abdallah Naguib EL-REEDY, and Abbas Abbaszadeh SHAHRI, "Formulation and Mechanical Characterisation of an Eco-Geo-Material Based on Lateritic Gravel Incorporating Blue Molinia Fibres for the Durability of Compressed Earth Block (CEB) Constructions in Togo," August 2025, DOI: [10.5281/ZENODO.16779650](https://doi.org/10.5281/ZENODO.16779650)
15. L. I. N. Nkotto, G. D. Kamgang, J. Tiewa, J. S. Kanda, and S. S. Loweh, "Characterisation of blocks produced by adding coconut fibres and laterite-cement-based construction materials." <https://www.scirp.org/reference/referencespapers?referenceid=2931362>
16. D. Abessolo, A. B. Biwole, D. Fokwa, and B. M. G. Koungang, "Effects of bamboo fibre length and content on the physico-mechanical and hygroscopic properties of compressed earth blocks used in construction." <https://www.researchgate.net/publication/357083827>
17. National Institute of Higher Sciences and Techniques in Abeche Et Al., "Geotechnical Study and Physico-Chemical Characterisation of Soils of Three Quarries in the City of Abeche in Chad," Int. J. Adv. Res., vol. 11, no. 05, pp. 318-326, May 2023, DOI: [10.21474/IJAR01/16883](https://doi.org/10.21474/IJAR01/16883)
18. P. Pialy, "Study of some clay materials from the Lembo site (Cameroon): mineralogy, sintering behaviour, and analysis of elasticity properties," thesis, Limoges, 2009. Consulted on: March 14, 2024. [Online]. Available at: <http://www.theses.fr/2009LIMO4002>
19. K. A. J. Ouedraogo, "Stabilisation of sustainable and ecological construction materials based on raw earth using organic and/or mineral binders with low environmental impacts," University of Toulouse, Toulouse, 2019. <https://www.scirp.org/reference/referencespapers?referenceid=3806091>
20. S. A. Djomo, H. C. Kouakou, and O. A. H. Konan, "Stabilisation of clay blocks with a natural base, potash." <https://www.scirp.net/journal/paperinformation?paperid=142457>
21. Augias Anagonou, Thierry Godjo, and Victor Songmene, "Study of the physico-mechanical properties of a hydraulic concrete containing cashew nut shell ash of micrometric and nanometric sizes partially substituting cement," p. 10, 2020. https://espace.etsmtl.ca/id/eprint/2609/1/ANAGONOU_Augias_Laurens_Louison_T.pdf
22. Schlupp Florian, "Valorisation of biomass bottom ash: an alternative to natural aggregates in concrete," p. 8, 2023. DOI: [10.1016/j.jobte.2023.106927](https://doi.org/10.1016/j.jobte.2023.106927)
23. S. Bajji, Y. Naimi, and A. Saba, "Study of the mechanical properties of clay bricks from the Tiznit region stabilised with natural waste." <https://www.scirp.org/reference/referencespapers?referenceid=3806093>

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