Thermomechanical characterization of Grewia bicolor bark mucilage reinforced mud bricks

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ABSTRACT

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| In the current context characterised by global warming, the use of local materials in construction is becoming an imperative to save the planet. The aim of this research is to study the effect of the mucilage in the bark of Grewia bicolor on the properties of mud bricks. Specifically, the aim is to verify the compressive and flexural strengths, as well as the thermal conductivity, resistance and effusivity of these bricks. To this end, the mucilage from GB bark was used to stabilise raw earth bricks. Two types of samples were used: the first is with 100% soil, without mucilage, and the second one stabilised with mucilage at three different viscosities (25.30s, 20s and 10s). The results show an increase in compressive strength when the viscosity of the mucilage is increased. An increase in flexural strength when the viscosity of the mucilage was increased. A decrease in thermal conductivity when the viscosity of the mucilage is increased. An increase in thermal resistance when the viscosity of the mucilage is increased. Effusivity decreased with increasing mucilage viscosity. These results show that the mucilage of Grewia bicolor can significantly improve the characteristics of mud bricks and this may have potential for eco-construction. |

*Keywords: Grewia bicolor, mud brick, compressive strength, flexural strength, thermal conductivity, thermal resistance and thermal effusivity*

1. INTRODUCTION

Construction using energy-intensive industrial materials and the near-increasing cost of energy [1] have prompted researchers to take up the issue of building heating. According to Houben et al [2], earth can be used as a building material without expending energy. Earth, a locally abundant natural material, can be used to build passive houses. In Chad, a Sahelian country with temperatures sometimes reaching 50°C in March, researchers are showing renewed interest in this material [3], [4], [5], [6], [7], [8], [9] as an alternative to expensive fossil fuels such as cement. The results of their work showed that earth, used as a matrix for composite materials with plant fibers as reinforcements, offers very interesting advantages in thermomechanical terms. They highlighted the good thermal inertia of raw earth bricks.

However, because of its vulnerability to bad weather, soil continues to be a concern for researchers, particularly in terms of its mechanical and thermal performance. Hence the interest shown in the Fianga soil in the East Mayo Kebbi region and a shrub, the Grewia Bicolor, in this research work.

1. **Materials et Methods**

**1.1. Materials**

**1.1.1. Le soil**

The soil used comes from Fianga, precisely from the village of Lengoua; it was chosen on the basis of its availability and proximity. The coordinates of the site are (9°56'1.06‘’ N, 15°7'59.99‘’ E). It is taken from its natural state at a depth of around 90 cm.

* **Granular composition**

The granulometric curve of Fianga soil is presented in Figure 1. jf



Figure 1 : Granulometric curve of Fianga soil

* ***Geotechnical classification***

The table 1 presents the Granulometric composition of the soil.

**Table 1: Granulometric composition of the soil**:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **N°** | **Sample** | **Sand (%)** | **Loam (%)** | **Clay (%)** | **Nature of soil** |
| 1 | Fianga Lengoua1 | 48 | 16 | 36 | Sandy-clay-silty |

* + - 1. ***Water***

To prepare the test tubes, we used water from the Chadian Water Society (STE) available at Building and Civil Engineering Laboratory.

* + - 1. ***Grewia bicolor bark mucilage***

Grewia bicolor (GB) shrubs were collected at Fianga in the Mont Illi Department, in the village of Lagna (9°.56‘.43.7’‘N, 15°.6’.13.85‘’E).

|  |  |
| --- | --- |
| C:\Users\Temoua Habmon\Downloads\IMG-20250123-WA0001.jpg | **C:\Users\Temoua Habmon\Desktop\TOFO\1738782748567.jpg** |
| a) GB bark fibers | b) Mucilage and fibers of GB barks |
| Figure 2 : Mucilage of GB bark |

**1.2. Methods**

**1.2.1. Preparation of adobe specimens**

To obtain the best conditions for mixing, the soil used is ground and dried. The soil is oven-dried for 24 hours at a temperature of 65°C. Material mixes (soil + fibers) are first made dry, then mixed with water using an electric mixer. The dry mixes are homogenized with the fibers for a few minutes. Mixing with water lasts three minutes. The composite material is placed in the mold directly after mixing and homogenization. A block of 3 molds measuring 4x4x16cm3 found at LBTP was used to make the adobes for the mechanical tests, and another measuring 4x5x8cm3 for the thermal tests. They are made of hardened steel. Specimens are densified using a LBTP vibrating table.

* **Coding of formulations**

Table 2: Coding of different formulations

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Formulation** | **Sol (%)** | **Mucilage (Viscosity)** | **Codes** | **Meaning** |
| 1 | 100 | 0 | NSO | 100% soil, without mucilage |
| 2 | 100 | 25,30s | SMv1 | Mixing with a v1 viscosity of 25.30s |
| 3 | 100 | 20s | SMv2 | Mixing with a v2 viscosity of 20s |
| 4 | 100 | 10s | SMv3 | Mixing with a v3 viscosity of 10s |

**1.2.2. Thermomechanical tests**

The 3-point bending and compression tests were carried out in accordance with standards (NF EN 12390 - 5, 2001) [10] and (NF EN 12390 - 3, 2003) [11] respectively, at 28 days curing. Each test was carried out on three specimens of the same formulation.

3. RESULTS AND DISCUSSION

The results observed from experiment are presented in this section.

**3.1. Effect of GB mucilage on the compressive strength of adobes**

Figure 3 shows the effect of varying the viscosity of Grewia bicolor on compressive strength.

Figure 3: Effect of varying the viscosity of GB mucilage on the compressive strength of adobe specimens.

The results in the figure show an improvement in compressive strengths with mucilage compared with the formulation with 100% soil without binder. The maximum is reached with a viscosity of 25.30s (5.74MPa). There was an increase in compressive strength with increasing mucilage viscosity. This result is in agreement with the results of work ([3], [4], [5]) carried out with fibers as stabilisers.

**3.2. Effect of GB mucilage on the flexural strength of adobes**

Figure 4 shows the effect of varying mucilage viscosity on the flexural strength of adobe specimens.

Figure 4 : Effect of varying the viscosity of mucilage on the flexural strength of adobe specimens

As with compressive strength, the results in the figure show an improvement in flexural strength with mucilage compared with the formulation with 100% soil without binder. The maximum is reached with a viscosity of 25.30s (2.88 MPa) ([6], [7], [8], [9]).

An increase in flexural strength is observed as a function of increasing mucilage viscosity. The same trend was obtained from work carried out on adobes stabilised with plant fibers.

**3.3. Effect of WB mucilage on the thermal conductivity of adobes**

Figure 5 shows the effect of varying mucilage viscosity on the thermal conductivity of adobe specimens.

Figure 5 : Effect of varying mucilage viscosity on the thermal conductivity of adobe specimens.

The results in the figure show a decrease in thermal conductivity with mucilage as the viscosity of the mucilage increases. The thermal conductivity varies from 0.69 to 0.60 W/mK. This result shows the same trend with adobes made from GB bark fibers. The same decrease was obtained from work carried out on raw earth bricks stabilised with plant fibers [3], [4], [5], [6], [7], [8], [9].

**3.4. Effect of GB mucilage on the thermal resistance of adobes**

Figure 6 shows the effect of varying the viscosity of GB mucilage on the thermal resistance of adobe specimens.

Figure 6 : Effect of varying the viscosity of GB mucilage on the thermal resistance of adobe specimens

The results in the figure show an increase in thermal resistance as the viscosity of the mucilage increases. This increase ranges from 0.058 to 0.066 m2°C/W.

This result shows the same trend for adobes made from GB bark fibers. Authors [3], [4], [5], [6], [7] obtained similar results with plant fibers and other biobased aggregates.

**3.5. Effect of GB mucilage on the thermal effusivity of adobes**

Figure 7 presents the effect of varying mucilage viscosity on thermal effusivity of adobe specimens.

Figure 7 : Effect of varying mucilage viscosity on thermal effusivity of adobe specimens

The results in the figure show a higher thermal effusivity obtained with the soil formulation without binder (100% soil). The formulations using mucilage have lower thermal effusivities than the soil without binder. Adobes with viscosities of 20s and 10s have the lowest thermal effusivities (0.60 W/S1/2m2/K) [3], [4], [5], [7], [8].

**CONCLUSION**

The aim of this study was to investigate the effects of the viscosity of Grewia bicolor bark mucilage on the thermomechanical properties of mud bricks. In view of the results obtained from this work, the following can be concluded:

There is an improvement in the thermomechanical performance of mud bricks reinforced with GB mucilage. As viscosity increases, so does thermomechanical performance:

* The flexural strength of fiber-reinforced specimens increases as the viscosity of the GB mucilage increases.
* The compressive strength of fiber-reinforced specimens increases with increasing viscosity of GB mucilage.
* Thermal conductivity decreases with increasing viscosity of GB mucilage.
* Thermal resistance increases with increasing viscosity of WBC mucilage.
* Thermal effusivity decreases with increasing viscosity of WBC mucilage. Specimens made with mucilage viscosities of 20s and 10s have the lowest effusivities (0.60 W/S1/2m2/K).

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

**REFERENCES**

[1] Senicat C.A., “Energy Efficiency in the Residential Sector: An Analysis of Policies in Southern and Eastern Mediterranean Countries,” Ideas for the Climate Change Debate, No. 14, pp. 1-67, 2008.

[2] Houben H., “For a New Architecture,” Eco Decision, Autonome, 1997

[3] Mbairangone, S., Ntamack, G. E., Bianzeube, T., Bozabe, R. K. and O. Kinet, O. (2022). Effect of Rice Husk on Adobes in Clay Soils. Research Journal of Engineering Sciences, 11(3), 12-21.

[4] Togdjim Jonas. Influence of Diatomite on the Physicomechanical Properties of Compressed Earth Blocks. Physical Science International Journal. 2023. [5] Mahamat Saleh Abdel-khadir et al., 2024. Thermomechanical characterization of Abéché soils in Chad. Scientific Research and Academic Publisher.

[6] Abdallah Ban-nah et al., Thermophysical and mechanical characterizations of Gaiui clay stabilized by gum arabic. International Conference on Circuit, Systems and Communication (ICCSC), 1-6, 2024.

[8] Abderahman Adoum Oumar et al., 2024. Thermophysical characterization of local works in a Chadian town for use in eco-construction. Scientific Research and Academic Publisher.

[9] Abakar Ali et al., Mechanical characteristics of compressed earth blocks (CEB) stabilized by gum arabic. Afrique science. 15(1) (2019) 348 – 360.

[10] NF EN 12390 - 5, 2001. Three-point bending test.

[11] NF EN 12390 - 3, 2003. Compression test]