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The Effect of Glass and Palm Fibers on the Mechanical and Thermal Properties of Compressed Earth Blocks (CEB) Stabilized with Cement

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ABSTRACT

Modern research is focused on the discovery of new compounds that meet the requirements of modern construction. An example of low energy consumption is that buildings consume between 20% and 40% of energy. In this research, the effect of fiber addition on the properties of compacted earth bricks composed of clay and sand and fixed with cement is studied. Fiberglass or palm are used in different proportions (0% and 0.4%). This is done by studying the change in mechanical and thermal properties. The study focuses on clarifying the role of fiber type and the amount of compressive force applied to the soil. To change the properties of bricks. This is studied using experimental methods and systematization criteria. The results showed a decrease in density by 9.1%, with a decrease in water absorption by 8%, an increase in brick hardness by 42.7%, and a decrease in thermal conductivity by 22.2%. These results show that the addition of fiber improves mechanical and thermal properties. Which reduces energy consumption. The results are important because they explain the changes that occur in the earth block when palm fibers and glass are added and how they are used to improve earthen buildings.

摘要

现代研究的重点是发现符合现代建筑要求的新化合物.低能耗的一个例子是建筑物消耗20%至40%的能源.在这项研究中，研究了纤维添加对由粘土和沙子组成并用水泥固定的压实土砖性能的影响. 玻璃纤维或棕榈纤维的使用比例不同（0%和0.4%）. 这是通过研究机械和热性能的变化来实现的.该研究侧重于阐明纤维类型和施加在土壤上的压缩力大小的作用.更改砖的属性.这是使用实验方法和系统化标准进行研究的.结果表明，密度降低了9.1%，吸水率降低了8%，砖硬度增加了42.7%，导热系数降低了22.2%.这些结果表明，纤维的加入提高了机械和热性能，这减少了能源消耗.这些结果很重要，因为它们解释了添加棕榈纤维和玻璃时土块中发生的变化，以及它们如何用于改善土建筑.

KEYWORDS
Compressed earth blocks (ceb); palm fibers; glass fibers; thermal properties; mechanical properties; strengthen; increase durability

关键词
压缩土块（CEB）; 棕榈纤维; 玻璃纤维; 热性能; 机械性能; 加强; 提高耐用性

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Introduction

Soil is a natural element that results from the disintegration of rocks. It consists of organic and mineral substances. In civil engineering, we care about the soil because it is the foundation for all structures and buildings, in some desert areas, earthen brick construction is widespread, such as Algeria, Mali and Morocco (Bredenoord and Kulshreshtha 2023; Chraibi et al. 2023; Hadji et al. 2020). Because the soil is an environmentally friendly material, as it lowers temperatures in summer. It is known that soil insulates heat better than concrete because its thermal conductivity is low (Nazira et al. 2019). Earth bricks are made by combining clay, sand and water. The mixture is placed in a metal figure and pressed with legs.This technique is considered traditional compared to the modern method (Hu et al. 2020). Recently, it has become essential to use a compression machine to manufacture pressed floor blocks. We apply pressure to the mixture using a press machine under a certain pressure. This technique is widespread in many countries, such as Iraq, India, and Burkina Faso (Daryah, Ameen, and Tokmachy 2019; Omar Sore et al. 2018; B. V. V. Reddy 2022). This technique is used to eliminate problems with earthen bricks, which consist of fragility and lack of water resistance. These problems made engineers in civil engineering, geotechnical and Soil Mechanics think about finding a solution to this problem. Moreover, links it to the field of energy use. In previous research, it was clear that the density of bricks and the number of pores had a negative effect from a mechanical point of view (Teixeira et al. 2020). In some research, stabilizers were added to the soil to improve its mechanical properties, such as cement, lime, and gypsum (Elahi, Shahriar, and Islam 2021; Malkanthi, Balthazaar, and Perera 2020; Zangana and Tokmachy 2019), where these stabilizers were added in specific proportions. Furthermore, the introduction of various types of fibers has proven to be an effective method for enhancing the soil's coefficient of elasticity, thereby improving its overall quality. As research progressed, the use of fiber in construction became widespread (Amin et al. 2022). Plant fibers such as palm, corn, and flax were used, for example (Chen et al. 2019; Haba et al. 2022; Morvan et al. 2003). And synthetic fibers, such as nylon, polyester, glass, and carbon (Ahmad et al. 2021, 2022; Seco et al. 2020). Natural fibers such as silk, wool, and cotton were sometimes used (Dénes, Florea, and Manea 2019; Kamble and Behera 2021; Shuang et al. 2022). What interests us in our study is the use of these fibers in construction. Some fibers were used with earthen bricks (Abdelkader et al. 2023, 2024).

This research is important because it links the improvement of the mechanical and thermal properties of the compressed earth block with the reduction of energy consumption. We use pressure to increase the hardness of the earthen bricks. We use fibers to increase thermal insulation. The use of pressure on bricks addresses the problem of fragility and the problem of high water absorption, and on the other hand. We study how to reduce the percentage of thermal conductivity. Since the thermal conductivity decreases, the thermal insulation ratio increases (Pásztory et al. 2018). Thermal insulation is associated with energy consumption (Lee et al. 2017). Whether for cooling or heating. Several studies have linked thermal insulation in buildings to reducing energy consumption. The researcher Zhang and others found reducing 0.6 degrees of heat reduces energy consumption by 7.6% annually (Zhang et al. 2024). And connect the Finder, Marouane Wakil, and others between the use of a compressed earth block and the improvement of thermal comfort and energy savings (Wakil et al. 2024), and discuss Reddy and others the relationship between housing and earthen structures, energy consumption and thermal performance (Samadianfard and Toufigh 2020). We use the previous studies to determine the quality of the soil (the ratio between Clay and sand), and help us to choose the stabilizer added to the soil (cement), and enable us to choose the type of fibers (artificial and natural).

In this study, we conduct experiments on soil composed of 30% clay and 70% sand. It is the optimal mixture according to previous research (Mkaouar et al. 2019). It is used cement of type CEM II/A-L 32.5 N. It is a Portland cement containing 80% clinker. The role of cement is to stabilize the soil and increase shear resistance (Sitton et al. 2018), and it is the best material that increases the hardness of the compressed earth block. It is better than lime and gypsum in the exact percentages and the same water content. It is used the proctor test to determine the cement and water ratio corresponding to the soil quality. This test is an experimental method aimed at experimentally determining the optimal water and moisture content in the soil. Where the optimal water rate corresponds to the most excellent density of dry mass (Luo et al. 2021). This test complies with ASTM d1557 standard (Mujtaba et al. 2020). We use two types of fibers. Palm fibers, which a natural fibers of plant source. Glass fibers, which are artificial fibers. The aim of using the two types is to understand their difference and each's effect on the mechanical and thermal properties. We add each type of fibers separately and do not merge the two types within the (CBE). We are asking for nine percentage points (0.05%. 0.1%, 0.15%, 0.2%, 0.25%, 0.3%, 0.35%, 0.4%) in addition to fibers-free samples. Mechanical pressure is applied of 2.5 MPa and 5 MPa to the resulting mixture by a particular machine, the aim of using two different pressure forces is to clarify the effect of pressure on the physical, mechanical and thermal properties of (CBE). Moreover, we leave the samples to dry for 28 days. A period of 28 days is a standard criterion for assessing the strength of the soil. The soil hardness increases progressively every seven days until it reaches 28 days, and then it becomes stable. Several researches in this field were conducted using 28 days for drying samples (Sekhar and Nayak 2018; Sturm, Ramos, and Lourenço 2015). The importance of research is to improve the properties of earthen bricks by reducing water permeability and increasing its hardness.

The authors divide the work into parts: The first part concerns the characterization of the materials used in the experiments. The second part deals with the study of the physical properties of compressed bricks. Emphasis is placed on the bulk density and water absorption rate. The third part is devoted to studying mechanical properties. Researchers are interested on calculating the compressive force used to break the samples. The fourth part is concerned with the study of thermal properties. Experimenters focus change in thermal conductivity. Then, The authors do analyze and discuss the results to determine the effect of compressive strength, type, and ratio of fibers on the mechanical and thermal properties of (CEB) and correlate them with energy consumption. The main points are summarized in knowing the effect of adding fibers to compressed earth bricks from a mechanical and thermal point of view.

Materials and methods

Materials

Clay

We use clay from the Adrar region of southern Algeria. This clay is available in all territories of the region. It is used in the field of traditional construction (Mohammed et al. 2018). We get it by digging 3 meters deep. Its red color characterizes it, and its density is 2.6 g/cm^3. It consists mainly of the element silica 63%. It adheres firmly to water because its composition is 54% silt, less than 0.02 mm. It absorbs water significantly, it uses the Atterberg limit test to determine the properties of clay (Polidori 2007). And is the measurement of water content in fine-grained clay. This test identifies three variables for us (liquid limit WL, plastic limit WP, and plastic index IP).The test shows WL = 81%, which means that the moisture content at which the clay changes from a liquid to a plastic state is 81%, and WP = 34%, which means that the moisture content at which the clay cannot be reconstituted without cracking is 34%. Therefore, it is suitable for use in the construction field because it is configurable. Table 1 shows the biotechnological, and chemical properties of the studied clay.

Sand

In the study, we used dunes found in most desert areas. It is a fine sand with a density of 1.46 g/cm^3. It is characterized by its freedom from organic substances and a high percentage of SiO_2 93.66%. The grain size is less than 2 mm. It uses sand to improve the properties of the compacted earth block (CEB). Where the percentage of its addition varies according to the type of clay and the percentage of cement.

Table 1. Clay properties.

Geotechnical properties			Chemical composition		
Sand (>0,02 mm)	9%	[23]	$SO4^{-2}$	0.41%	[24]
Silt(0,02-0,002 mm	54%	[23]	$CaCO_3$	3.6%	[24]
Clay (<0,002 mm)	37%	[23]	Cl-	0.14%	[24]
Liquid limit WL	81%	[23]	SiO_2	63%	[24]
Plastic limit WP	34%	[23]	Al_2O_3	16%	[24]
Plastic index IP	47%	[23]	Fe_2O_3	7%	[24]
VB	8	[23]	MgO	2.4%	[24]
Specific density γs	2.6 g/cm3	[23]	Other	7.46%	[24]

In a previous study used Muhwezi and another 5% of cement with clay, the proportion of sand was changed, and they noticed an increase in shear strength at 10% of sand and a decrease in water absorption rate at 20% sand (Muhwezi and Achanit 2019).

Table 2 represents the geotechnical properties and chemical composition of the sand used.

Figure 1 shows the granular analysis of clay and sand.

This curve is known as the particle size distribution curve.

Cement

It uses Portland cement of CPJ-CEMII/A 32.5 type. A high content of Cao elements characterizes it. 60.18%. Contains at least 80% Portland clinker, and limestone 20% at most, addition to gypsum. This cement is low alkalinity less than 0, 60%. It has been used in previous studies of soil compaction (Boulmaali and Belhamri 2023b).

The use of dry mass and density selects the appropriate ratio of cement with clay and sand. We change the cement percentage between 6%, 8%, 10%, 12%, 14% and 16%, change the percentage of water. It gets dry lumps of different weights. Our approach to determining the best cement ratio involves calculating the bulk density. The ratios that correspond to the highest density value are considered the most effective. This method has been used in several researches to determine the best cement ratio with the best water ratio (El-Emam and Al-Tamimi 2022, Nshimiyimana et al. 2020), Jannat et al. (2020). In our experiments, we found that 12% of the cement is the best. Details are in Methods.

Table 3 shows the physical properties and chemical composition of the cement used.

Palm fibres

Palm fibers are plant fibers that are widely used in the field of construction, especially in remote areas. It is widespread in the south of Algeria. In our experiment, we used palm fibers wrapped around the palm stem. It is characterized by a large percentage of hemicellulose 37% and a density of 1.25 g/cm^3. It has mechanical properties such as tensile strength 170–275 MPa.

It uses untreated natural palm fibers. The reason for choosing it is because the residents in the south of the Adrar region use palm fibers directly from the stem of the palm plant.

Table 2. Sand properties.

Geotechnical properties			Chemical composition		
Sand equivalent	36.49%	[24]	SiO_2	93.66%	[25]
Specific density	2.5 g/cm^3	[24]	Al_2O_3	1.52%	[25]
Apparent density	1.46 g/cm^3	[24]	Fe_2O_3	0.59%	[25]
Finesse Model	2.79	[24]	CaO	1.14%	[25]
			K_2O	0.43%	[25]
			Na_2O	0.13%	[25]
			MgO	00%	[24]
			SO_3	0.05%	[24]

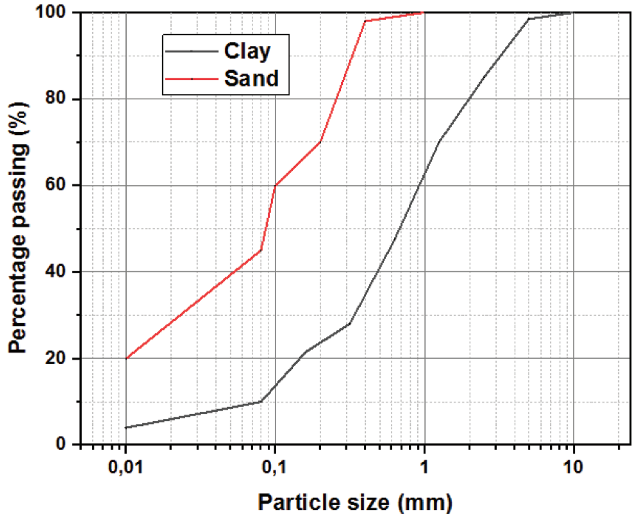

Figure 1. Granular analysis of used sand and clay.

Table 3. Cement properties (Mokhtari et al. 2015).

Chemical properties(%)								Physical properties			
So_2	CaO	AL_2O_3	Fe_2O_3	MgO	So_3	K_2O	Na_2O	Loss on ignition	Fineness (m2/kg)	Setting time(min)	σ_C
21.9	60.18	5.73	3.13	1.85	2.22	0.83	0.19	4.07	370	175	30

Table 4 shows the mechanical properties and chemical composition of palm fibers.

Glass fibres

In these experiments, it uses electronic glass fibers of Class E, which are characterized by resistance to corrosion and combustion and resistant to chemical agents.

Experimenters use these fibers because they are durable and have a high intensity strength of 3500 MPa. In addition to the ease of obtaining them. The result of getting rid of fibers growths in Internet threads.

Table 5 Physical and mechanical properties of used glass fibers (Sujatha et al. 2021).

Figure 2a represents Palm fibers 2b glass fibers.

Cut the palm fibresand glass with a fixed diameter. We use a length of 1 cm, to ensure that the fibers mix well with the soil.

In previous research, researchers have shown the effect of changing the length of fibers on the flexion force and compression (Donkor et al. 2014; Laibi et al. 2018; Lejano 2018). So we prove these variables and focus on the type of fibers and compression force.

Water

Researchers use ordinary tap water at a temperature of 30 ^{0}C in the laboratory. The chemical analysis of the water was carried out at the water treatment laboratory.

Table 4. Properties of palm fibers.

Chemical properties [27]				Mechanical properties[27]		
Cellulose (%)	Hemicellulose (%)	Lignin (%)	Fats (%)	Tensile strength	Young's modulus	Elongation
27	37	28	7	170 - 275 MPa	5 - 12 GPa	5 -10%

Table 5. Properties of glass fibers.

Physical and mechanical properties [28]					
Density (g/cm^3)	Filament diameter (mm)	Diameter (μm)	Tensile strength (MPa)	Lengthen at break (%)	Modulus of elasticity (Mpa)
2.57	12	19	3500	4.8	73500

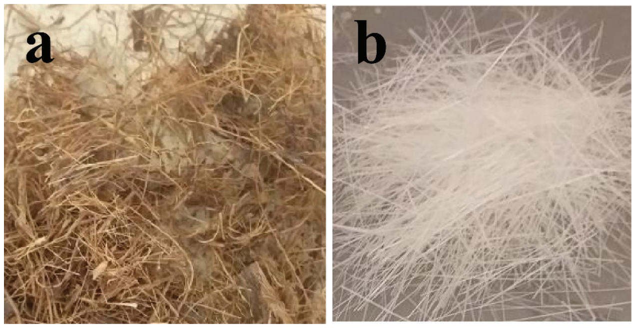

Figure 2. ¨Palm fibers and glass fibers.

Table 6. Chemical composition of water.

Element	Na++	Ca++	Cl-	So_4–	Mg++	Ka+
Concentrations(**mg/L**)	200	200	500	400	150	12

Table 6 shows the chemical composition of the used water (Chaib, Kriker, and Mekhermeche 2015).

Methods

From a previous study, we determined the ratio of clay and sand (Mkaouar et al. 2019).

To obtain a homogeneous mixture, we sift clay and sand with a diameter of less than 2 mm. The goal of choosing this small diameter is to get the maximum durability between the particles, and this is with little friction between the particles.

The size of particles in the soil is essential because it is related to the size of the pores between these particles.

This affects the extent of water absorption in the soil.

We chose 30% clay and 70% sand, representing the soil (SO) (Mkaouar et al. 2019).

Determine the ratio of cement and water

It uses the proctor test. This test is based on the selection of the best percentage of water that corresponds to the highest value of the bulk density of the samples.

According to ASTM D698–12 standard (Spagnoli and Shimobe 2020).

We prepare the weight of 2000 g of soil (SO) and then change the cement ratio from 6% to 16%, because percentages less than 6% do not affect the properties and composition of the soil, and percentages more significant than 16%, the soil loses the property of reconstitution after drought. Recycling and reuse are essential characteristics of the soil.

The percentage of water changes every time we change the percentage of cement.

Researchers obtain samples with different proportions of cement and water.

Its apparent density is calculated after 28 days. The results obtained are shown in Figure 3.

Figure 3 shows that the best water content and cement ratio corresponds to the highest apparent density value, which is 14% water with 12% cement with a density of 1.76 g/cm3

This method corresponds to the modern method of calculating the water content in cement-reinforced soils (Wang, Li, and Liu 2022).

Sample preparation

The composition with which we make pressed earth bricks is soil (70% sand + 30% Clay) + 12% cement + 14% water.

Experimenters choose a dry mass of 2000 g to correspond to the dimensions of the mold used $20 \times 10 \times 10\ cm^3$.

It gets the soil by mixing clay with sand inside an electric mixer for 2 minutes, then add cement, then mix for 2 minutes.

Add the palm fibers or glass fibers, depending and the composition, mix for 2 minutes.

Then, gradually add water, mixing. So, we get a homogeneous mass.

We put this homogeneous mass inside a metal mold and use a hydraulic press machine equipped with a screen to control the pressure force.

The choice of compressive strength of 2.5 MPa corresponds to the average weight of the walls on the first floor, and 5 MPa is the weight of the walls on the first and second floor.

It uses a compressive strength of 2.5 MPa, equivalent to a force of 25,493 kg/cm^2. Knowing that the area exposed to the force is $(10 \times 20)\ cm^2$ is equivalent to 200 cm^2

The samples obtained are shown in Table 7. They include:

Samples 1 (clay + sand + cement +water + palm fibers. Percentages (0% to 0.4%)).

Samples 2 (clay + sand + cement + water + glass fibers. Percentages (0% to 0.4%)).

It uses a pressure force of 5 MPa, which is equivalent to 50,983 kg/cm^2.

Samples 3 (clay + sand + cement + palm fibers. Percentages (0% to 0.4%)).

Samples 4 (clay + sand + cement + glass fibers. Percentages (0% to 0.4%)).

Liquidity limits (WL) of 80% are determined by the us according to the Standard ASTM D4318.

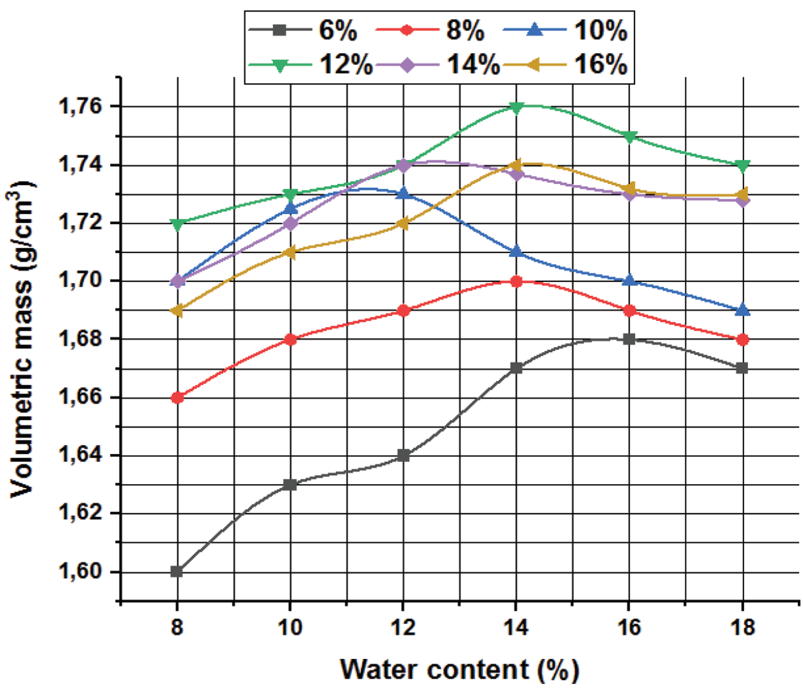

Figure 3. Water content 14% (12% cement).

Table 7. Components of laboratory samples.

Soil (%)	Cement (%)	Palm fibers (%)	Glass fibers (%)	Water (%)	Code
74	12	0	-	14	P.G.F
		0.05	-		PF1
		0.1	-		PF2
		0.15	-		PF3
		0.2	-		PF4
		0.25	-		PF5
		0.3	-		PF6
		0.35	-		PF7
		0.4	-		PF8
		-	0.05		GF1
		-	0.1		GF2
		-	0.15		GF3
		-	0.2		GF4
		-	0.25		GF5
		-	0.3		GF6
		-	0.35		GF7
		-	0.4		GF8

The plastic limit (WP) is 36% according to ASTM d4318 standard.

$$IP = WL - WP \tag{1}$$

Plasticity index (IP) 44%.

IP ˃ 40 The soil is very plastic.

ASTM D4318 standard specifies the water content at which the behavior of clay soils changes from plastic to liquid.

The dimensions of the obtained brick are $20 \times 10 \times 5\ \mathrm{cm}^3$.

The authors make six samples of each percentage for fibers.

It studies changes in bulk density, water absorption rate, the value of stresses and the change in thermal conductivity.

Laboratory experiments

Density

The bulk density is measured by placing the samples on the scale and then measuring their dimensions. According to the law of volumetric mass (2):

$$\rho = \frac{\mathrm{m}}{\mathrm{v}} \tag{2}$$

According to Standard ASTM D1557. We dry the samples well to avoid moisture and then accurately determine the dimensions.

The goal of measuring bulk density is to clarify the effect of fiber type and compressive strength on bricks.

In search of Mostafa and others. The effect of adding banana fibers on density has been studied. And they linked it to the compressive strength and flexure of (CEB) (Mostafa and Uddin 2016). Where it was concluded that the decrease in density does not affect the increase in tensile strength in the samples.

In another study. The effect of adding palm fibers to compacted soil has been studied.

He got up Bachir and Others studied the reduction of cracking and improved tensile strength and the role of fibers in reducing the size of samples and concluded that density has a fundamental role in determining mechanical properties (Taallah et al. 2014).

Water absorption rate

The experimenters calculate the water absorption rate by placing the samples in an aquarium. According to the ASTM D570 standard.

Samples are insulated with plastic, and the contact area with water is determined ($100 \times 50\ mm^2$). Samples are weighed before and after immersion in water for 120 minutes.

The experiment configuration is shown in Figure 4.

This test links the percentage of water absorption to the number of pores present in the bricks. The difference between wet and dry blocks is the percentage of water absorption, and we link this to the amount of fibers and the compressive strength.

We use relationship 3 to calculate the difference between the mass before water immersion (m1) and after immersion (m2):

$$\mathrm{w}(\%) = \frac{m2 - m1}{m2} \tag{3}$$

In previous research, the relationship between the rate of water absorption and its relationship to the number of pores and moisture content in the CEB was studied. In search of Miccoli, L. and Others have studied the reaction of the ground to which wooden pieces are added when saturated with water.

They concluded that the content of water and moisture affects the cohesion of the earth (Miccoli, Müller, and Fontana 2014).

In search Danso and Others have linked the amount of fibers and the rate of water absorption to the change in the physical and mechanical properties of the (CEB).

She explains to them that the water absorption rates vary according to the type of fibers (Danso et al. 2015).

Change in thermal conductivity

It uses a thermal sensor that specializes in measuring soil thermal conductivity (Hukseflux n.d.).

It consists of a thermal sensor needle inserted into the samples at a distance of 15 cm.

We make a hole inside the samples to insert the thermal needle and get the value of the thermal conductivity directly from the display screen every 20 minutes.

This device was used in several previous researches (Bertermann et al. 2024; Morais, Sousa, and Tsuha 2019; Nikiforova et al. 2013).

Figure 4. Water absorption experiment.

In search of Millogo and others. The effect of adding hibiscus hemp fibers to (CEB) has been studied. The researchers observed a decrease in thermal conductivity with an increase in the percentage of fibers (Millogo et al. 2014).

Thermal conductivity is associated with thermal insulation in buildings. The effect of adding straw and sawdust to the soil was studied. Moreover, it turns out Ashour, T and others that the thermal conductivity decreases as the percentage of fibers increases (Ashour et al. 2010).

Mechanical compressive strength

The samples are placed in a hydraulic press device with a display for reading the pressure value. We apply vertical pressure on the samples according to the following conditions:

- Application area (200 × 100) mm^2.
- The initial force is 10 KN. We use this force because the machine is intended for experiments on concrete samples, and we noticed that the initial force to destroy these samples was 20 KN. So we chose a lower-power.
- Application speed force 0.4 MPa/s.

We use relation 4 to calculate the applied pressures (σ) on the area (A):

$$\sigma = \frac{\mathrm{F}}{\mathrm{A}} \tag{4}$$

The compressive strength of the (CEB) has been studied when we add fiber to it.

Where the compressive strength connects the density of the brick and the fiber ratio

That is what got Zak, P and others when soil, cement, gypsum, used hemp fibers and flax (Zak et al. 2016).

In previous research for Millogo and others use kenaffibres with (CEB). Moreover, studied the change in the value of the pressure force. It was concluded that these fibers increase in compressive strength, and the best ratio is 0.8% with a length of 30 mm (Millogo et al. 2015).

Results and discussion

Change in the density value

The density is related to the mass and volume of the studied brick. We obtain the bulk density values by knowing the difference between weight and volume in three directions.

Figure 5(c1) represents the change in the density value when we add palm fibers and Figure 5(c2), when the glass fibers are added, at compressive strength 2.5MPa and 5 MPa.

It turns out that the density decreases when the percentage of fibers increases.

Palm fibres ratio effect

The density decreases when the palm fibers ratio is added (1768–1606) kg/m^3.

In comparison with the fibers-free sample (P.G.F), the density decreases by between 0.7.% To 9.1% at a pressure of 2.5 MPa and decreases between 0.33% to 7.3% at a pressure of 5 MPa.

The density decreases as the sample size increases. This is related to the increase in pores resulting from adding palm fibers. When the samples dry, gaps remain inside the earthen bricks. This causes an increase in size, although the mass is stable. This results in decreasing density according to relation 2. These results are consistent with previous research (Khoudja et al. 2021).

Effect of glass fibers ratio

Like palm fibers, the density decreases when the glass fibers ratio is added (1793 – 1646) kg/m^3.

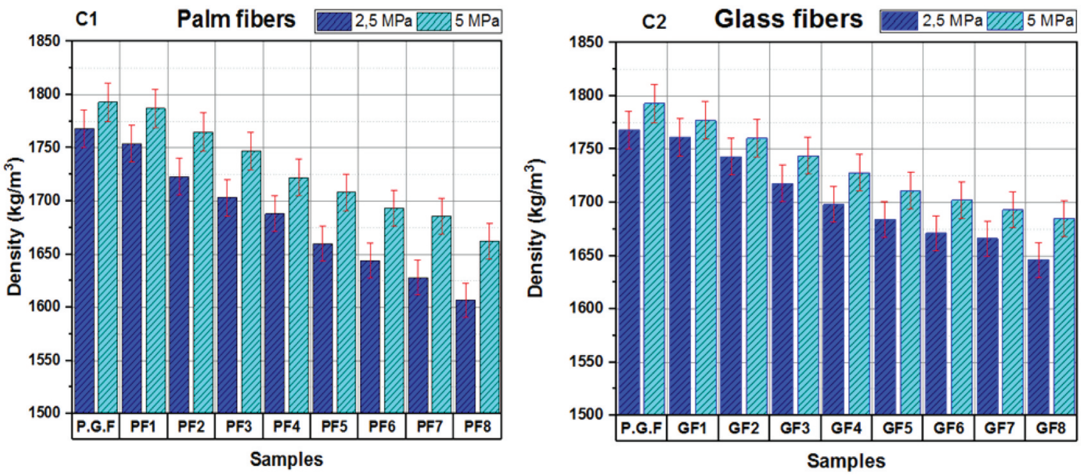

Figure 5. Density change with the addition of palm fibers and glass at a pressure of 2.5MPa and 5 MPa.

In comparison with the fibers-free sample (P.G.F), the density decreases between 0.39% and 6.9% at a pressure of 2.5 MPa and between 0.86% and 6.03% at a pressure of 5 MPa.

The density of palm fiber and glass fibers are inherently lower than that of soil. When these fibers are introduced into the soil, they induce a significant decrease in soil density. This finding, as per the research conducted by Danso and Adu (2019), holds immense relevance in the field of soil science.

The decrease in density of samples containing glass fibers is less than in samples containing palm fibers. This is explained by the palm fibers absorbing part of the water used to mix the ingredients. This corresponds to the results of a previous research (Idder et al. 2020). In addition, glass fibers are thinner than palm fibers (Velmurugan and Manikandan 2007), which reduces the pore size, this makes the difference in the percentage of low density between the glass fibers and the palm.

Effect of compressive strength

From the analysis of curves (c1, c2) shown in Figure 5, it becomes clear to us that when the compressive strength increases, the density increases.

The compressed earth technique is based on the collection of the largest amount of matter in a given space (Kropotin, Penkov, and Marchuk 2023).

The greater the pressure, the greater the density.

When comparing the two pressures (2.5 and 5MPa), the percentage of density increases in samples containing palm fibers between 1.39% and 3.3% and increases with glass fibers between 0.9% and 2.3%.

According to relation 5, when the pressure force increases over a specified quantity, its density increases because the length and width of the samples are constant. The thickness changes.

$$\sigma = \frac{2.F}{(\pi.l.d)4} \tag{5}$$

σ is stresses, F is Compressive force, l is length, d is width.

When the compressive strength value is increased from 2.5 MPa to 5 MPa, the density value increases from 1768 kg/m^3 to 1793 kg/m^3 by 1.4% in fibers-free samples

When adding fibers to bricks in samples under 5 MPa, we notice that the decrease in density is less. Comparison with samples under 2.5 MPa pressure

The greater the pressure force, the more positive the effect on the CEB in terms of density.

The density value changes as the pressure force used to stack the CEB changes.

High pressure reduces the number and size of gaps between the soil grains and between the used fibers.

Water absorption rate

After weighing the samples before and after water immersion.

It calculates the water absorption rate in each sample using the relation 3.

Figure 6 represents the percentage of water absorption in the samples for 120 minutes.

It is clear from the analysis of Figure 6 that the percentage of water absorption increases when the percentage of fibers increases, these results coincide with previous results (Atiki et al. 2022).

Influence of fibres types

Figure 6(c1), represents the change in the percentage of water absorption when adding palm fibers.

From the analysis of this figure, we observe an increase in the rate of water absorption in samples containing palm fibers between 11% to 13% with a pressure of 2.5 MPa and between 9% to 11% with a pressure of 5 MPa.

While Figure 6(c2), represents the change in the percentage of water absorption when adding glass fibers.

We observe an increased rate of water absorption in samples containing glass fibers between 10% To 12% with a pressure of 2.5 MPa and between 8% to 10% with a pressure of 5 MPa.

Based on the analysis of the two figures, it becomes clear to us that the percentage of water absorption increases as the percentage of fibers increases (Taallah and Guettala 2016).

The absorption ratio increases with increasing immersion time in water.

The percentage of water absorption in samples containing palm fibers is greater than in samples containing glass fibers.

According to previous studies, the reason for this is due to:

- Palm fibers thickness is larger than glass fibers thickness.
- Different water absorption rates due to the distribution of palm fibers and unregulated glass. This allows them to create larger pores when mixed in the soil and makes them absorb a lot of water. These results are consistent with a previous study of Boukhattem L and others (Boukhattem et al. 2017).
- The increase in the percentage of water absorption due to the increase in the number of pores resulting from the addition of fibers.

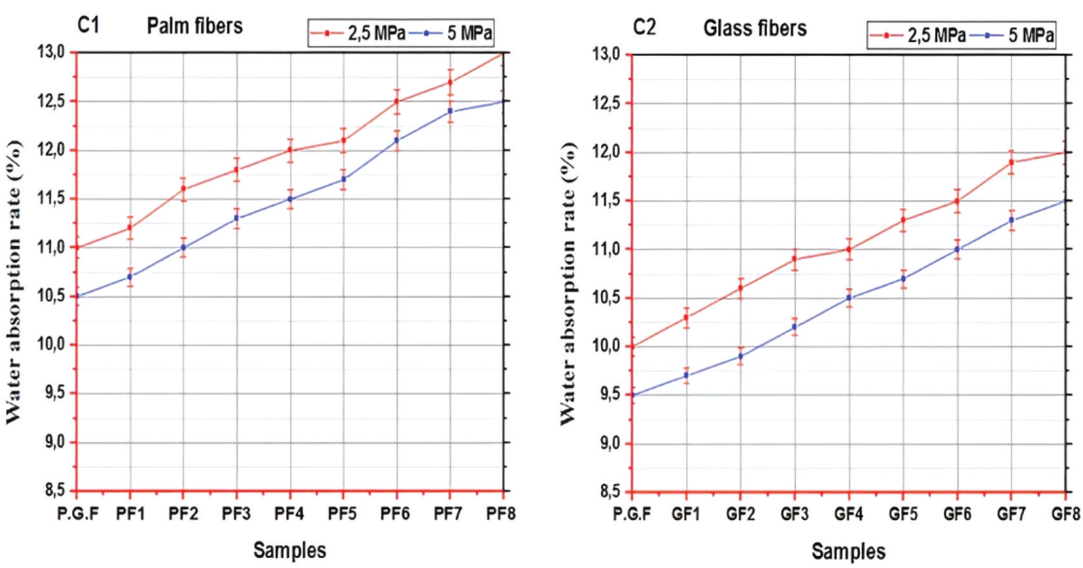

Figure 6. The rate of water absorption changes when palm fibers and glass are added with a pressure of 2.5 MPa and 5 MPa.

Fibre type is essential in determining the permeability of bricks to water.

Building upon the work of Millogo, Y., and others, we have discovered a unique correlation between the ratio of lignin and water permeability resistance (Millogo et al. 2014).

The palm fibers used in our experiments consist of 27% cellulose, 37% hemicellulose, 28% lignin, and 4% lipids.

This percentage of lignin resists water by a small percentage; it allows to increase in the rate of water absorption between 8% to 12%.

Here it becomes clear to us the role of pressure applied to the earthen blocks.

High pressure reduces water absorption and transport. As for the glass fibers, they are not affected by moisture and no soil components.

Therefore, the rate of water absorption is related to the percentage of fibers how that are distributed inside the samples and the amount of pressure force applied.

In addition, the amount of cellulosic material determines the rate of water absorption and density decrease (Ugwuishiwu, Mama, and Okoye 2013).

Impact force compression

From the analysis of figures (c1, c2), we note that the pressure force of the mixture affects the water absorption ratio.

When the compressive strength of the mixture increases, the percentage of water absorption decreases.

Water absorption in samples containing palm fibers decreases between 15.4% and 18% (11–9 and 13–11)% when the pressure is increased from 2.5 MPa to 5 MPa.

Water absorption in glass fibers samples decreases when the pressure is increased from 2.5 MPa to 5 MPa between 16.7% and 20%.

Water absorption rates are considered low compared to samples that do contain lime (Taallah and Guettala 2016).

Therefore, cement is considered the best stabilizer for clay soils, reducing water absorption and increasing cohesion between soil parts (Edris et al. 2021).

Soil absorbs water gradually and the size of soil grains has a role in determining the percentage of water absorption (Kasinikota and Tripura 2021).

Bulk density can be related to the rate of water absorption.

The samples with the highest density are the least water-absorbing and vice versa, and this corresponds to the research of Ugwuishiwu, Mama, and Okoye (2013).

So, the high pressure on the CEB causes an increase in density and, consequently, a decrease in water absorption.

In our experience, some variables contribute to reducing the percentage of water absorption in the samples: the percentage of fibers, the percentage of cement, and the type of soil.

When comparing theoretical results with experimental results.

It turns out that there is some difference in the measurements

We use relation 6 to determine the coefficient of water absorption according to the norm XP standard 13–901.

$$C = \frac{M \times 100}{A \times \sqrt{t}} \tag{6}$$

M is mass of water (g) absorbed by the brick since the beginning of immersion.

A is surface area of the submerged face expressed in cm^2.

t is time in minutes elapsed since the start of the immersion.

The relationship does not take into account the temperature of the water and the temperature of the external ocean, nor the amount of bonding between the grains.

In the southern Algerian state of Adrar, the summer temperature reaches 49 C^0.

When conducting experiments, the water temperature of 35 C^0 , and the laboratory temperature of 37 C^0, were measured and determined.

Several factors influence the rate of water absorption in soil bricks. Maybe the subject of future studies, such as the temperature of the samples and the type of additives for soil (lime, gypsum, or cement. . .), The degree of cohesion of the granule's compressive strength and the type of clay soil.

The rate of water absorption increases with increasing fibers content in the soil. It turns out that plant-based fibers absorb more water than synthetic fibers because they are hydrophilic fibers (Charai et al. 2022).

However, it's important to note that a high percentage of fibers can lead to an increased rate of water absorption, which could be seen as a drawback from a physical standpoint in the context of earthen brick construction.

In our research, although the water absorption rate is lower than in adobe bricks (13% < 22%), it is greater than the water absorption rate in concrete (13% ˃ 4.3%) (Machaka et al. 2019).

Therefore, ground buildings should be insulated from water or add materials that reduce water absorption. Future research will focus on improving this aspect.

Calculation of thermal conductivity

The goal of calculating the thermal conductivity is to find out how much the brick insulates to heat (Hung Anh and Pásztory 2021).

We measure the thermal conductivity according to ASTM D 5334–00 standard for measuring soil and soft rocks.

This method is based on inserting a probe into the hole of a pre-made brick.

A heat sensor and a heating wire are connected.

The Wire is heated for 20 minutes and is inside the samples.

The vector values are obtained from reading the screen directly.

The temperature of the laboratory room is 30C^0.

The results are shown in Figure 7.

The results showed that the thermal conductivity changes depending on the type of fibers and the compressive strength.

Effect of compressive strength

From the analysis of Equation 7 (c1) and 7(c2).

At a compressive strength of 2.5MPa, the thermal conductivity decreases from 0.31 to 0.25 W/m.k, (19.35%) with palm fibers and from 0.36 to 0.28 W/m.k (22.22%) with glass fibers.

At a compressive strength of 5 MPa, the thermal conductivity decreases from 0.34 to 0.27 W/m.k, (20.58%) with palm fibers and from 0.38 to 0.302 W/m.k, (20.52%) with glass fibers.

It has been observed that high pressure increases the thermal conductivity value regardless of the fibers type.

This is explained by the high compressive strength increasing the contact between the soil grains. This allows for easy heat transfer between the molecules.

Bulk density is related to thermal conductivity.

When the density of samples increases, the value of thermal conductivity increases with it, and vice versa, this corresponds to the research of researcher Kheltent and others (Kheltent, 2024).

Increasing the pressure causes a decrease in the number of pores and, consequently, a decrease in heat transfer.

These results are consistent with the research. Mansour et al. (2016).

When exerting great pressure, the pores inside the samples decrease, which increases the value of the bulk density and an increase in the value of the thermal conductivity, this is what the researcher found. Lahbabi et al. (2023).

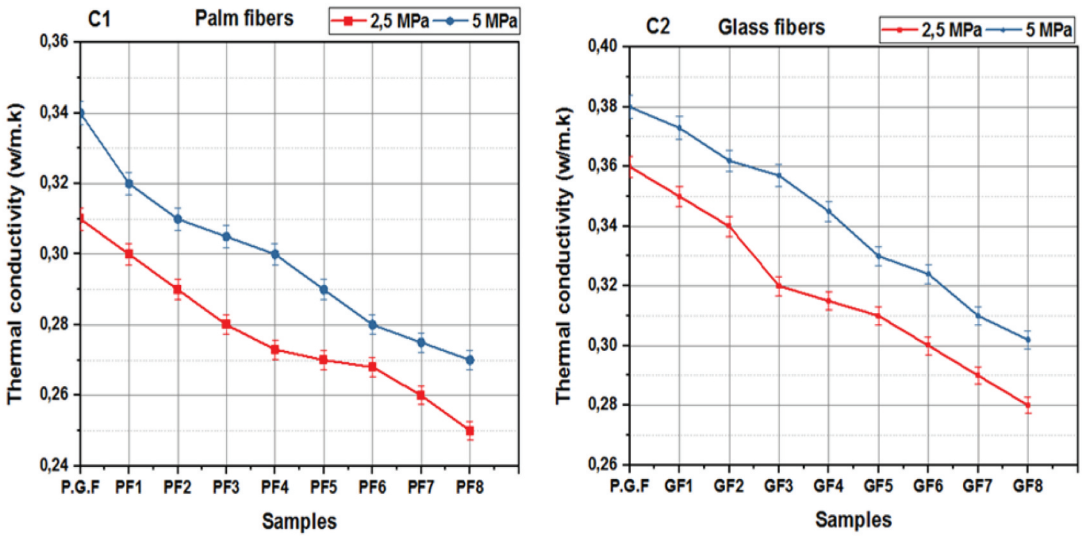

Figure 7. The thermal conductivity changes when palm fibers and glass are added with a pressure of 2.5 MPa and 5 MPa.

The effect of fibres types

Figure 7 (c1), represents the change in thermal conductivity when palm fibres are added, when palm fibers are added, We notice a change in the value of the thermal conductivity.

Comparison with the fibers-free sample:

The thermal conductivity decreases between 3.22% and 19.35% (0.3–0.25)W/m.k at a pressure of 2.5 MPa and between 5.8% and 20% (0.34–0.27) W/m.k at a pressure of 5 MPa.

When adding glass fibers Figure 7(c2).

The thermal conductivity decreases between 2.78% and 22.2% (0.36–0.28)W/m.k at a pressure of 2.5 MPa and between 1.18% and 21.05% (0.38–0.3) W/m.k at a pressure of 5 MPa.

The thermal conductivity values with palm fibers are lower than with glass fibers.

This is explained by the fact that the source of palm fibers is vegetable, as it contains cellulose (K. O. Reddy et al. 2016) and its thermal conductivity is similar to wood 0.21 W/m.k glass fibers are synthetic composites combined with a plastic matrix whose thermal conductivity is estimated at 0.36 W/m.k.

The increase in the ratio of glass fibers and palm affects the value of thermal conductivity within the earthen blocks.

This makes palm fibers better in thermal insulation than glass fibers, especially in clay compounds.

These results are consistent with the research of Raut and Gomez (2020).

In general, when other materials are added to the earthen bricks, they affect the value of the thermal conductivity.

In this context, the research will be interesting in this area because each element added to the earthen brick will affect the value of the thermal conductivity.

When analyzing Fourier's law for calculating the thermal conductivity shown in relation 7, we found that the difference between the temperatures is significant whenever the thermal conductivity is low.

$$\lambda = \frac{Q \times d}{A \times (T2 - T1)} \tag{7}$$

λ is tthe thermal conductivity (W/m.k), Q is Heat transfer (W), d is Wall thickness (m), A is the area through which heat is transferred, (T2-T1) is the difference between external and internal temperature.

Significant temperature differences between the internal and external environment indicate that a material is impeding heat transfer. This, in turn, enhances thermal insulation.

Cooling devices play a crucial role in regulating the temperature within a room, ensuring it remains within a comfortable range.

The temperature reaches 48 degrees in the outer Center in the south of Algeria.

The temperature of the internal rooms varies depending on the type of material used in the construction, the walls' thickness, and the insulators' quality.

Most of the cooling energy is consumed by the walls. A study estimated that 50% of the energy of buildings goes to the walls (Venkatesan et al. 2022).

Can be connected to the percentage of fibers, the number of pores inside the brick, and the difference in internal and external temperature. Brick walls with a high percentage of fibers contain several pores inside. They serve to resist external heat. Moreover, this is thanks to the air gaps (Venkatesan et al. 2022).

Calculation of stresses

Figure 8 represents the compressive force that the earthen samples with stand before the crash.

It is noted that the value of stresses increases with the addition of palm fibers and glass.

Influence of fibers types

Figure 8(c1), represents the value of stresses when adding palm fibers.

The value of mechanical stresses increases when the percentage of palm fibers increases to 0.2% and then decreases.

Comparison with a fibers-free dirt block:

The amount of increase in the value of stresses is between 6.9% and 24.4% (3.33–3.1 and 4.1–3.1) MPa at a pressure of 2.5 MPa and between 15.45% and 34.93% at a pressure of 5 MPa.

Figure 8(c2), represents the value of stresses when adding glass fibers.

It is noted that when adding glass fibers, the value of mechanical stresses increases to 0.15% and then decreases.

Compared with the fibers-free earthen blocks.

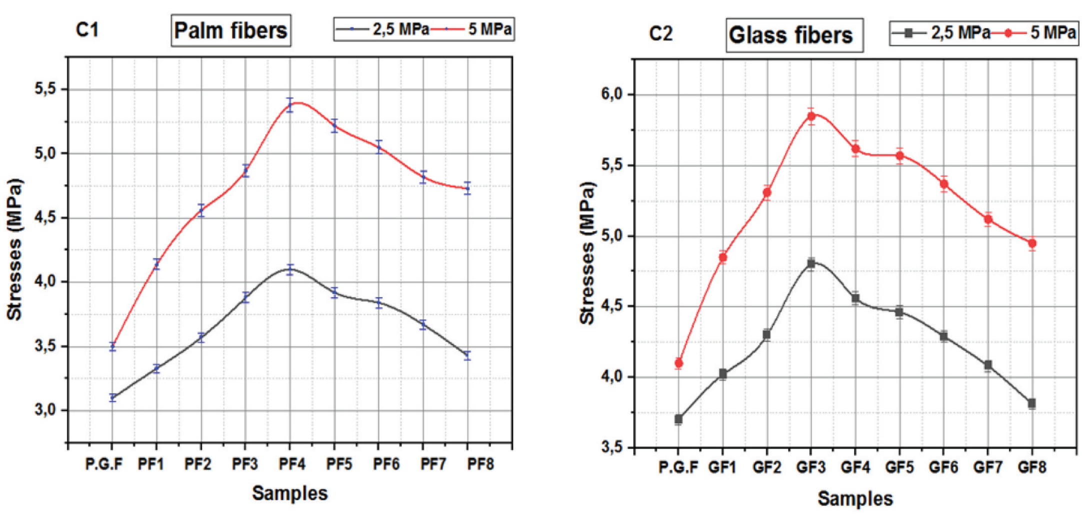

Figure 8. The value of stresses changes when adding palm fibers and glass with a pressure of 2.5 MPa and 5 MP.

The value of stresses increases by 8.7% and 28.2% at a pressure of 2.5 MPa and between 18.5% to 42.7% at a pressure of 5 MPa.

Palm fibers and glass increase durability in specific proportions and have the opposite effect in larger proportions. These results are consistent with several previous studies (Kabiraj and Mandal 2012; Kinuthia 2015; Sharma, Vinayak, and Marwaha 2015).

In general, glass fibers are better than palm fibers in terms of increasing the durability of compacted earthen blocks. This is explained by the fact that the glass fibers has greater tensile strength compared to palm fibers (3500 ˃ 275) MPa see mechanical properties of palm fibers and glass Tables 4 and 5.

Effect of compressive strength

When analyzing Figure 8, we notice that the value of stresses increases when the compressive force increases.

In samples containing palm fibers, the stress value increases between 11.42.% and 27.48% (3.5-3.1 and 4.73–3.43) MPa when we increase the compressive strength from 2.5 MPa to 5 MPa Figure 8(c1).

It observes an increase in the value of stresses between 9.75% and 23% when we increase the compressive strength from 2.5 MPa to 5 MPa in samples containing glass fibers. Figure 8(c2).

The stress values remain greater than the values after 0.15% with glass fibers and 0.2% with palm fibers, and this explains that the fibers have limits to increase the durability of earthen blocks.

Increasing the pressure force on the Earth's blocks leads to an increase in its cohesion and, consequently, an increase in the stresses necessary to break it.

Identical results were obtained with the results in a search. Bouchefra et al. (2022).

The high pressure on the breeding block reduces the number of pores and voids and thereby increases the bulk density, this is consistent with the results of the experiments when we changed the pressure from 2.5 MPa to 5 MPa see bulk density values. See Figure 5.

These results are consistent with the research. Talibi et al. (2023).

In the field of construction, our research is concerned with two fundamental variables:

- The first is to increase the durability of compressed earthen blocks, and this is what improves the mechanical endurance properties of structures.
- The second is to increase the thermal insulation of buildings made of these bricks, and this helps us reduce the cooling and air conditioning energy.

To understand the correlation between the effect of compressive strength and the type of fibers used and variables, we use the experimental results shown in Tables 8 and 9.

Table 8 represents the experimental results of the variables when adding palm fibers under pressure 2.5 MPa and 5 MPa.

Table 9 represents the experimental results of the variables when adding glass fibers under pressure 2.5 MPa and 5 MPa.

Correlation between density and water absorption ratio

Based on the analysis of Figure 9, it noted that when adding palm and glass fibers (at the same applied compressive strength), the density decreases and the water absorption rate increases. This is explained by the fact that the fibers increase the number of pores in the compacted soil, this reduces its density and, consequently, increases the number of gaps into which water moves.

That's what he proved Bachir Taallah and others in their research (Taallah et al. 2014).

Table 8. The experimental results of the variables when adding palm fibers under pressure 2.5 MPa and 5 MPa.

	Density (kg/m^3)		Water absorption rate (%)		Thermal conductivity (w/m.k)		Stresses (MPa)	
Fibres (%)	2.5MPa	5MPa	2.5MPa	5MPa	2.5MPa	5MPa	2.5MPa	5MPa
0	1768	1768	11	9	0,31	0,34	3,1	3,5
0.05	1754	1787	11.2	9.2	0,3	0,32	3,33	4,14
0.1	1723	1765	11.6	9.5	0,29	0,31	3,57	4,56
0.15	1703	1747	11.8	9.8	0,28	0,305	3,88	4,87
0.2	1688	1722	12	10	0,273	0,3	4,1	5,38
0.25	1660	1708	12.1	10.2	0,27	0,29	3,92	5.22
0.3	1644	1693	12.5	10.6	0,268	0,28	3,84	5,05
0.35	1628	1686	12.7	10.9	0,26	0,275	3,67	4,82
0.4	1607	1662	13	11	0,25	0,34	3,43	4,73

Table 9. The experimental results of the variables when adding glass fibers under pressure 2.5 MPa and 5 MPa.

	Density (kg/m^3)		Water absorption rate (%)		Thermal conductivity (w/m.k)		Stresses (MPa)	
Fibres (%)	2.5MPa	5MPa	2.5MPa	5MPa	2.5MPa	5MPa	2.5MPa	5MPa
0	1768	1768	10	8	0,36	0,38	3.7	4.1
0.05	1761	1754	10.3	8.2	0,35	0,373	4.02	4,85
0.1	1743	1723	10.6	8.4	0,34	0,362	4,3	5,31
0.15	1718	1703	10.9	8.7	0,32	0,357	4,8	5,85
0.2	1698	1688	11	9	0,315	0,345	4,56	5,62
0.25	1684	1660	11.3	9.2	0,31	0,33	4,46	5,57
0.3	1671	1644	11.5	9.5	0,3	0,324	4,29	5,37
0.35	1666	1628	11.9	9.8	0,29	0,31	4,08	5,12
0.4	1646	1607	12	10	0,28	0,302	3,81	4,95

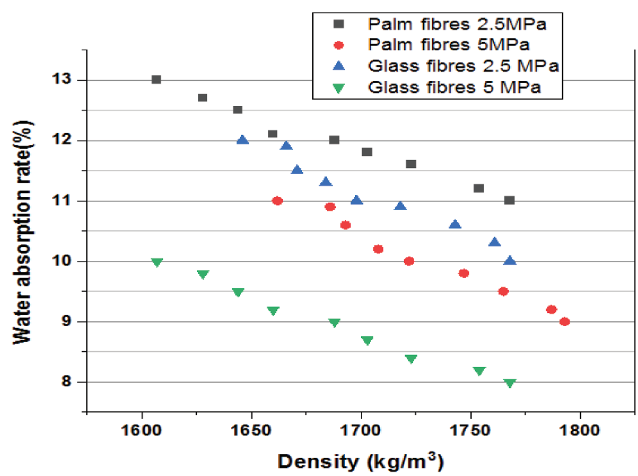

Figure 9. The effect of density on the water absorption rate.

Correlation between density and the value of thermal conductivity

Figure 10 shows the relationship between the density change and the change in the values of the thermal conductivity. It observed a decrease in the thermal conductivity values coinciding with a decrease in the bulk density values.

As the percentage of palm fibers and glass increases, it triggers a fascinating chain of events. The density values and thermal conductivity values, in turn, decrease, sparking curiosity about the underlying mechanisms at play.

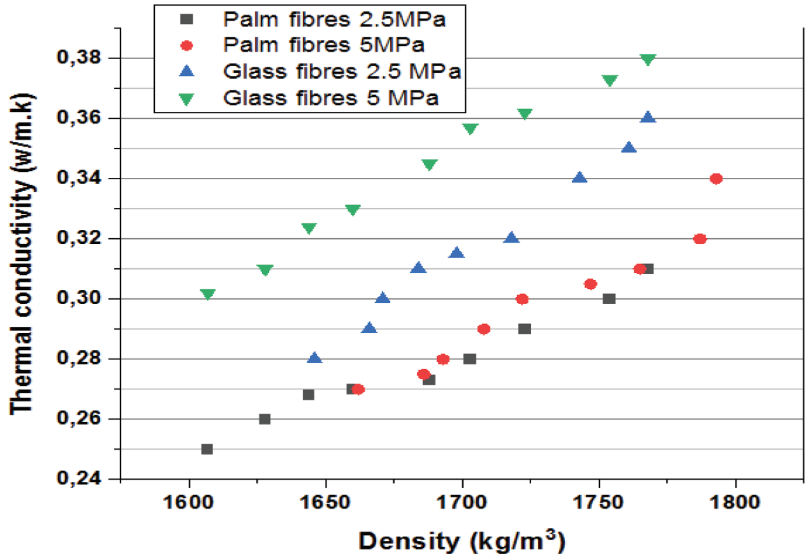

Figure 10. The effect of density on the value of thermal conductivity.

Despite the different values of the pressure of the Earth blocks, the value of the thermal conductivity decreases in the same type of fibers and the same pressure.

When the density of the Earth blocks decreases, the number of pores increases due to increasing the proportions of fibers in the Earth blocks, leading to a decrease in thermal conductivity. This finding is consistent with L's research by Ajouguim et al. 2021.

Correlation between the density and the value of stresses

The value of stresses is related to the degree of hardness of the compacted earthen blocks (CEB). It analyzed Figure 11, which represents the change in the values of bulk density and the value of stresses when we add palm fibers and glass. It noted that the palm fibers and glass increase the hardness of the dirt blocks in specific percentages – 0.15% glass fibers and 0.2% palm fibers-which gives us the most significant values of stresses at 0.15%. 4.8 MPa at a compressive strength of 2.5 MPa and 5.8 MPa at a compressive strength of 5 MPa with glass fibers.

The palm fibers give us the most significant values of stresses at 0.2%, 4.1 MPa at a compressive strength of 2.5 MPa, and 5.38 MPa at a compressive strength of 5 MPa.

Our findings indicate that glass fibers outperform palm fibers in enhancing the percentage hardness of the Earth's blocks. This comparison provides a clear conclusion on the effectiveness of these materials in increasing the hardness of earthen blocks. The pressure value of an earthen lump is essential in determining the amount of its hardness. When a significant compressive force is applied, the stress value increases proportionally. This is due to the fact that the large applied force reduces the number of pores, thereby increasing the density of Earth blocks. This cause-effect relationship is a key principle in understanding the factors that influence the hardness of earthen blocks. Despite the decrease in the bulk density value of the samples resulting from adding fibers. Only the stress values increase to the specified proportions of palm fibers and glass and then decrease.

Palm fibers and glass increase the durability and cohesion of the compressed earthen blocks, thus increasing the value of the stresses required to break the samples.

This corresponds to the results of a search – Danso (2017).

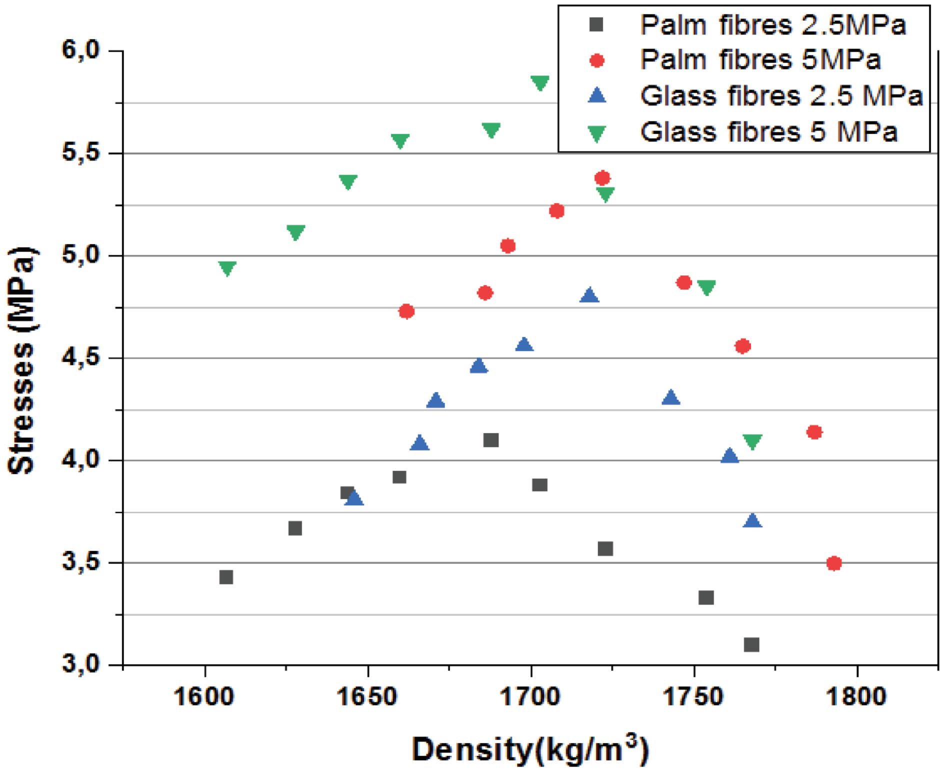

Figure 11. The effect of density on the value of stresses.

Correlation between ratio of water absorption and thermal conductivity

Based on the analysis of Figure 7, it noted that the thermal conductivity is low in earthen bricks between 0.25 and 0.38 w/m.k. This is what makes the earthen brick resistant to heat transfer.

When we take a look at the law of calculation of thermal conductivity shown in relation 7, which corresponds to the experimental Standard ASTM D 5334–00,

it noted that the thermal conductivity is related to the amount of thermal insulation of earthen blocks.

$$\lambda = \frac{\mathrm{Q.ln(t2 - t1)}}{4\pi(\mathrm{T2 - T1})} \tag{8}$$

When the value of the thermal conductivity decreases, the thermal insulation is greater.

When observing Figure 12, it becomes clear to us that increasing the ratio of palm fibers and glass increases the rate of water absorption and reduces the value of thermal conductivity.

When palm fibers and glass are added to (CEB), it increases the number of pores, thereby increasing water absorption and decreasing the value of thermal conductivity.

When adding glass fibers and palms, they increase the number of gaps inside the (CEB), which leads to two things:

The first is to increase the air gaps, and this is what reduces the thermal conductivity.

Secondly, increase the percentage of water absorption.This corresponds to the results of a search. Sutcu et al. (2015).

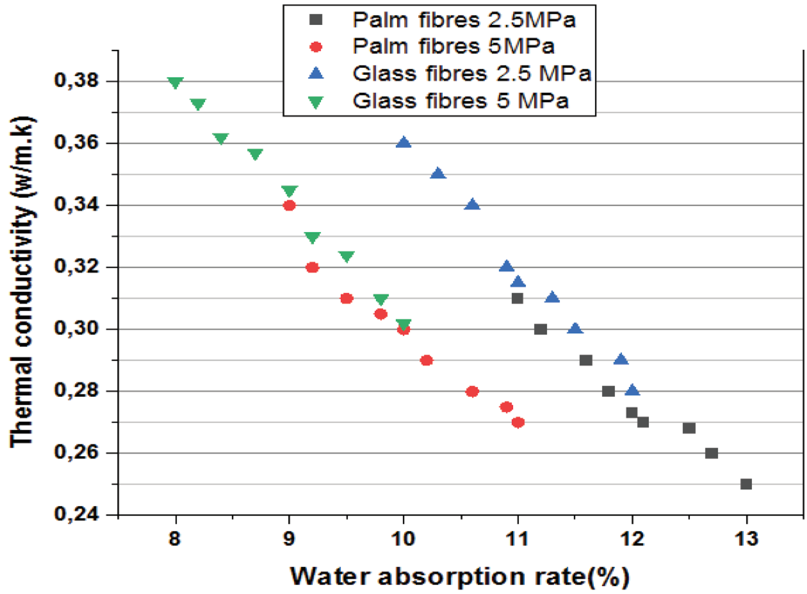

Figure 12. The effect of water absorption rate on thermal conductivity.

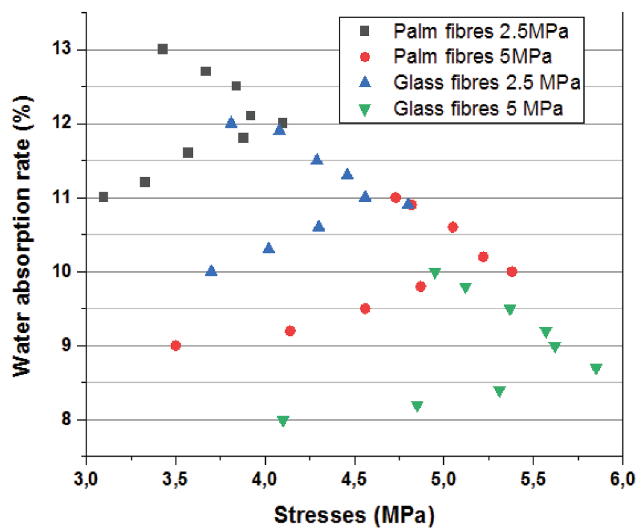

Figure 13. The effect of the water absorption rate on the stress value.

Correlation between water absorption and the value of stresses

Figure 13 shows the change in the value of stresses and the percentage of water absorption when we add palm fibers and glass.

From the analysis of trends, it turns out that the percentage of water absorption increases when adding palm fibers and glass from 8% to 13%, and the value of stresses increases within certain limits from 3.1 MPa to 5.8 MPa (0.15% glass fibers and 0.2% palm fibers) and then decreases.

When we add fibers, the rate of water absorption in the earthen blocks increases, despite the difference in the type of fibers and the compressive strength of the samples.

The amount of stress applied to the earthen blocks increases with an increase in the percentage of fibers, noting that the increase is greater with glass fibers.

This corresponds to the results of a search Islam et al. (2020).

Correlation between the value of thermal conductivity and the value of stresses

Starting from the transformation of Figure 14, which relates the thermal conductivity and stresses:

The conductivity decreases when adding glass fibers and palms, despite the different values of the force applied to compress the Earthen block.

While the stresses increase to specific limits in the palm fibers and glass and then decrease.

The decrease in the value of the carrier is associated with an increase in the number of pores resulting from the addition of fibers, while the fibers increase the cohesion of the Earthen block, this is what causes an increase in the applied pressure to shatter them.

This corresponds to the research results of Boulmaali and Belhamri (2023a).

When Cement is added to earthen blocks, it improves their mechanical properties in terms of increasing Hardness. Therefore, we focus the study on density and thermal conductivity and their relationship to thermal insulation and energy consumption.

Correlation between thermal insulation and energy consumption

Adding natural fibers such as palm fibers, which have good thermal properties, thermal conductivity, and low density, can reduce the energy consumption in earthen buildings. The fibers increase the thermal insulation and thus reduce the heat flow from the outside of the building to the inside. This allows a low percentage of heat to enter, and make the cooling devices control the temperature better. Here, we mention the use of cooling devices with automatic stops, which stop and start automatically

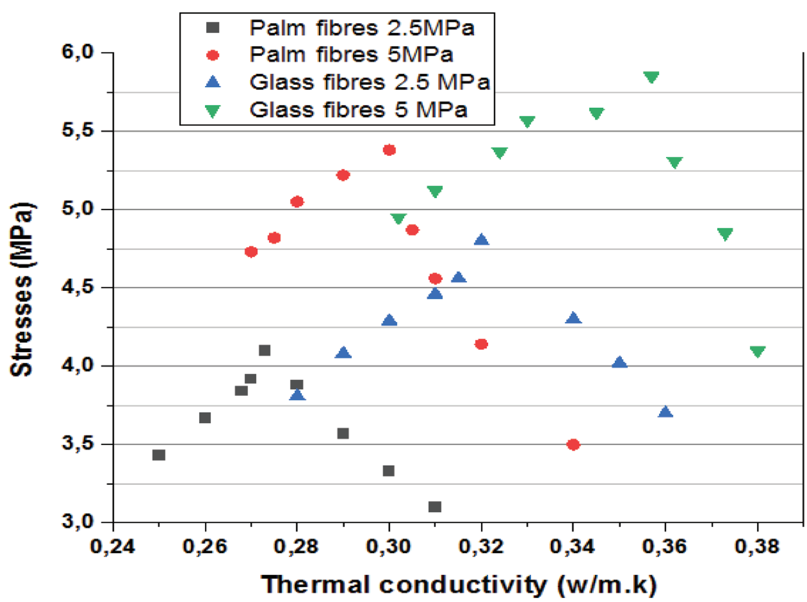

Figure 14. The effect of the thermal conductivity value on the stress value.

at certain degrees. These devices help to control the heat conditioning of the building. In addition to rationalizing energy consumption. Reduce energy consumption due to non-operation of air conditioners for an extended period. Low bulk density and thermal conductivity are essential in increasing thermal insulation and reducing the consumption bill.

Conclusion

This research studied the effect of adding palm fibers and glass on the physical, mechanical, and thermal properties of the compressed earth mass (CEB) consisting of 74% soil, 12% cement, and 14% water. Two different strengths were studied: 2.5 MPa and 5 MPa. We can summarize the results in the following points:

* When palm fibers and glass are added, the bulk density of the mass decreases between 7.3% and 9.1%.

* Increases water absorption in soil masses between 8% and 12%.

* The thermal conductivity decreases between 1.84% and 22.2%, increasing earthen blocks' thermal insulation.

* The addition of palm fibers and glass improves the mechanical properties of the compacted soil, and this increases the hardness between 24.4% and 42.7%.

* A 0.15% better glass fibers ratio and a 0.2% better palm fibers ratio increase the hardness of the earthen lump.

* Increasing the compressive strength from 2.5 to 5 MPa, increases the hardness of the earthen blocks and reduces the rate of water absorption and thermal conductivity.

* The use of fibers in the field of earthen construction increases thermal insulation. This results in reduced energy consumption inside buildings.

*Vegetable fibers are better in terms of thermal insulation, while synthetic fibers are better in terms of increasing the hardness of earthen bricks.

It is preferable to use natural fibers such as palm fiber because they are inexpensive and available and have a positive effect in terms of increasing the durability of earthen bricks and increasing thermal insulation.

Earthen bricks are energy-saving and environmentally friendly. Although they are not as durable as cement materials, they can be used to build. They also have a positive role in thermal insulation and reducing the energy used in air conditioning. The increased mechanical compressive strength and thermal insulation of the earthen block can contribute to sustainable building practices and reduce energy use. By making buildings in line with the Times and achieving the principles of environmental and Climate Conservation. It combines durability, lightness and thermal comfort.

Recommendations

The results of this study can be used in hot areas where rainfall is low. Palm fibers are a natural plant fiber that represents a sustainable solution to the problem of brittle bricks and traditional thermal insulation.

Disclosure statement

The authors of this manuscript emphasize that their article has no financial, business, legal or professional relationship with other organizations or people they work with (including the employer).

Highlights

- Use of fibers in construction
- The role of fiber in reducing energy consumption
- Improving the physical and mechanical properties of earthen bricks

- Increasing thermal insulation in earthen bricks using fibers
- The relationship between thermal insulation and reducing energy consumption and fibers

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