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Influence of Iroko and Sapelli sawdust mixture on physical properties of compressed earth bricks (CEB).

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ABSTRACT:
This article analyzes the influence of the mixture of Iroko and Sapelli sawdust on the physical properties of compressed earth bricks (CEB). Different compositions were tested for 15% sawdust that included a blend of two wood species (Iroko and Sapelli) in different ratios. 8% cement or slaked lime was used to stabilize the earth+sawdust mixture. The physical properties studied were: maximum dry density, capillary absorption, total absorption, air shrinkage and air mass loss. The results showed that the studied properties vary with the composition of the sawdust mixture. However, the percentage of the species with the highest density (Sapilli) in the sawdust mixture does not systematically change in the same way as these physical characteristics..

KEYWORDS: Earth block; physical properties ; sawdust; Iroko ; Sapelli .

I. INTRODUCTION

Adobe, rammed earth, earth-straw, cob, compressed blocks, and cob are the most widely used of the twelve earth construction techniques currently in use (Houben et al., 1996).

Compressed earth bricks are the newest of the aforementioned earth construction methods. The use of compressed earth bricks (CEB) is relatively new. With its simplicity and portability, Colombian engineer Raul Ramirez's first manual press (CINVA Center in Bogota) dominated the global market around 1950, producing 300 to 800 bricks per day. Following a number of enhancements, the method gained popularity in the context of affordable housing initiatives in Latin America and Africa (Terra Award, 2015).

Reference zonesof soils suitable for CEB production have been established by Houben et al. (1996), the NF XP P 13-901 standard (2001), and CRATERRE (1989), which BIT (2002) cited.Earth in its natural state requires almost no energy to use as a building material (Meukam, 2004). Plant fibers such as coconut fibers (Djohore et al., 2018), and sawdust (Ouattara, 2013) are used in the manufacturing of compressed earth brick (CEB).It is therefore interesting to know the influence of the mixture of sawdust from various species on the physical properties of CEBs.

II. METHODOLOGY

Adobe, rammed earth, earth-straw, cob, compressed blocks, and cob are the most widely used of the twelve earth construction techniques currently in use (Houben et al., 1996).

Compressed earth bricks are the newest of the aforementioned earth construction methods. The use of compressed earth bricks (CEB) is relatively new. With its simplicity and portability, Colombian engineer Raul Ramirez's first manual press (CINVA Center in Bogota) dominated the global market around 1950, producing 300 to 800 bricks per day. Following a number of enhancements, the method gained popularity in the context of affordable housing initiatives in Latin America and Africa (Terra Award, 2015).

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Our method is as follows:

- Using a 3.15 mm mesh sieve, mix the previously dried and sieved laterite with 15% of the sawdust mixture (Sappelli+Iroko) in the following proportions: (100%; 0%), (75%; 25%), (50%; 50%), (25%; 75%), and (0%; 100%);
- Using a 3.15 mm mesh sieve, mix the previously dried and sieved laterite with 15% of the sawdust mixture (Sappelli + Iroko) in the following proportions: (100% ; 0%); (75% ;

25%); (50% ;50%); (25% ; 75%); and (100% ; 0%) plus 8% of binder (cement or lime);

- Establish the ideal compaction water content for every composition; use these mortars to create compressed earth bricks. We then assessed the earth bricks' thermal characteristics using the asymmetric hot plane method test;
- To determine how the presence of the various wood species in the sawdust mixture affects the physical characteristics of the resulting earth bricks, highlight the results for the various compositions of the bricks on the same graph or table.

2.1 Materials characterization

Tea following properties were determined on tea basis of the standardized tests : density dry , capillary absorption , absorption total , air shrinkage and mass loss in the open air.

2.1.1 Density dried maximum

The principle of this test consists in moistening dry mortars at several water contents and compacting them under static pressure of 3.6 Mpa . The dry density of the material according to the different water contents is determined and the curve showing the variations of the dry density as a function of the water content is plotted.

2.1.2 Total absorption

The total water absorption capacity was determined according to standard NF EN 1097-6 (2014).
The purpose of this test is to evaluate the capacity of earth bricks previously dried in the oven to absorb water during 24 hours of total immersion, as illustrated in Figure 1.

Figure 1Total BTC absorption test.

The total water absorption coefficient was obtained from equation 1.

$$Cb = \frac{(P1-P0)}{P0} \quad (1)$$

Or

- P1 is the mass of the brick in grams after 24 hours of total immersion;
- P0 is the dry mass in grams of the brick.

2.1.3 Absorption by capillarity

The capillary water absorption coefficient was determined according to standard NF XP 13-901 (2001). The principle of the test consisted, as illustrated in Figure 2, in immersing a previously dried earth brick in the tank with a draft of 5 mm and, subsequently, in measuring the proportion of water absorbed by the brick after 10 minutes.

Figure 2Capillary absorption test.

The capillary water absorption coefficient was obtained by equation 2.

$$Cb = \frac{100(P1-P0)}{S\sqrt{t}} \quad (2)$$

With:
S: area of the submerged face in cm²;
P1: mass of the brick in grams after immersion for 10 minutes of partial immersion;
P0: dry mass in grams of the brick;
Immersion time in minutes (t=10 min).

2.1.4 Shrinkage

Air shrinkage was determined using a 0.1 mm precision digital caliper;The measurement of the shrinkage in open air (at a temperature of 27±7°C and a relative humidity of 69 ±6%) of the bricks consisted of measuring daily using a digital caliper as illustrated in Figure 3, the dimensions of the bricks exposed to the open air, sheltered from

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the weather for a period of 30 days and deducing their volume.

Figure 3Measurement of BTC dimensions.

The air withdrawal at day 30 was obtained from equation 3.

Rtr = $\frac{(V0-V30)}{V0}$(3)

Or

V0 is the volume of the brick in cm3 measured on day 0;

V30 is the volume of the brick in cm3 measured on the 30th day .

2.1.5 Mass loss in open air

The test consisted of measuring, after 30 days, the mass of the BTC samples placed in the open air (at a temperature of 27±7°C and a relative humidity of 69 ±6%), protected from the weather, using a digital scale with a capacity of 600 g and a precision of 0.01 g.

The mass loss to free air on day j was obtained from equation 4.

Pm= $\frac{(M0-M30)}{V0}$(4)

Or

M0 is the mass of the brick in grams measured on day 0;

M30 is the mass of the brick in grams measured on the 30th day.

2.2 Materials

2.2.1 Soil

The site selected for soil sampling is located in the city of Douala, coastal region of Cameroon, at Pk18. Figure 4 illustrates the location of the sampling site .

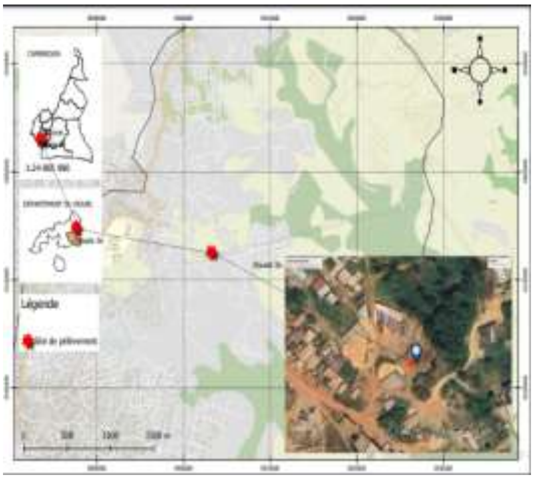

Figure 4.Location of the sampling point.

2.2.2 Binders

Cement of type CEM II and class 42.5R is utilized. It was bought in the city of Douala from regional vendors.

The type of file utilized is CL90S. Additionally, it was bought from Douala-based local vendors.

2.2.3 The wood

The two wood species utilized in our study are Iroko, a class 2 wood (CIRAD, 2023), and Sapelli, a class 3 wood (CIRAD, 2024). The wood was bought in the Logbaba area and then sawed to create sawdust.

III. RESULTS AND DISCUSSION

3.1. Sapelli and Iroko wood sawdust on the maximum dry density

Figure 5 illustrates the influence of the proportion of Iroko in the sawdust mixture on the dry density of BTC. It can be seen that the maximum dry density does not systematically evolve in the same direction as the proportion of essence having the highest saturation point of fibers in the sawdust mixture.

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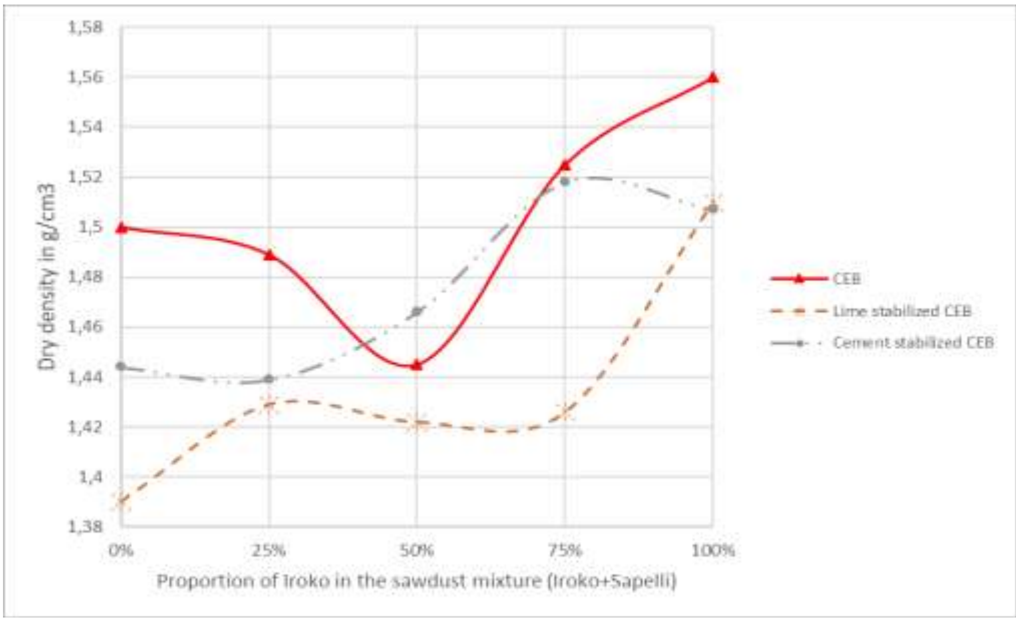
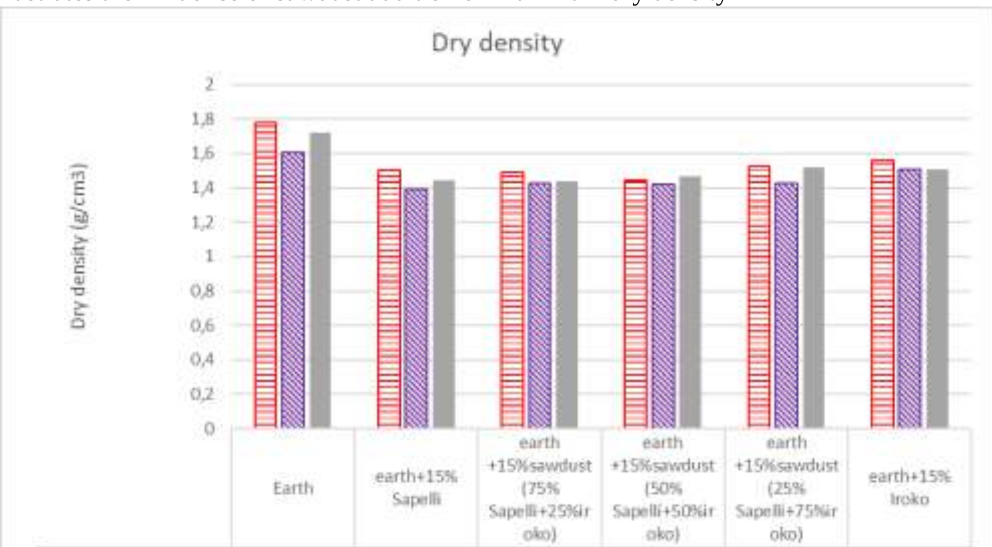


Figure 5Curve showing the evolution of maximum dry density as a function of the proportion of Iroko in the sawdust mixture.

Figure 6 illustrates the influence of sawdust addition on maximum dry density



	Earth	earth+15% Sapelli	earth +15%sawdust (75% Sapelli+25%iroko)	earth +15%sawdust (50% Sapelli+50%iroko)	earth +15%sawdust (25% Sapelli+75%iroko)	earth+15% Iroko
CEB	1,78	1,5	1,489	1,445	1,525	1,56
Lime stabilized CEB	1,603	1,39	1,429	1,422	1,426	1,51
Cement stabilized CEB	1,718	1,444	1,439	1,466	1,518	1,507

Figure 6. Influence of sawdust addition on maximum dry density

We observed that the addition of 15% sawdust reduces the maximum dry density of mortars by:

- 12.36% to 18.82% compared to mortar made from earth;
- 1.59% to 9.94% compared to mortar made from earth + lime;
- 11.64% to 16.24% compared to mortar made from earth + cement.

3.2. Influence of the mixture of Sapelli sawdust and Iroko wood on absorption total of water

Figure 7 illustrates the effect of the proportion of Iroko in the sawdust mixture on the total BTC absorption.

It is observed that the total absorption does not systematically evolve in the same direction as the proportion of the wood species having the highest fiber saturation point in the sawdust mixture.

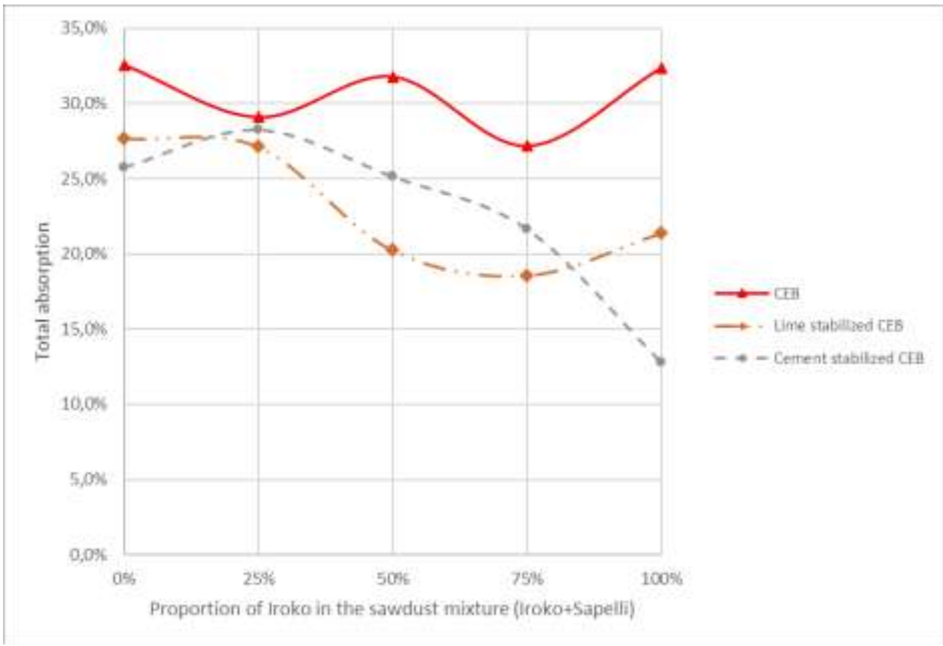
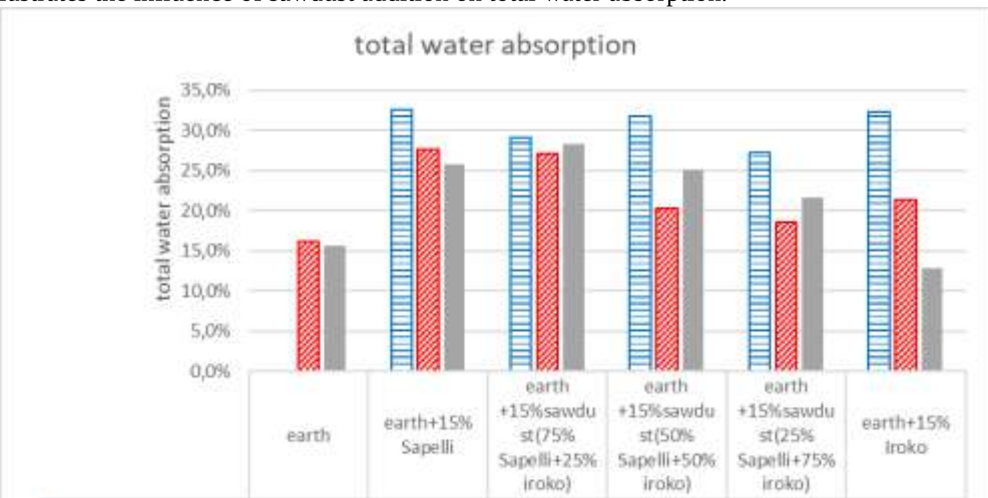


Figure 7of the proportion of Iroko in the sawdust mixture .

Figure 8 illustrates the influence of sawdust addition on total water absorption.



	earth	earth+15% Sapelli	earth +15%sawdust(75% Sapelli+25% iroko)	earth +15%sawdust(50% Sapelli+50% iroko)	earth +15%sawdust(25% Sapelli+75% iroko)	earth+15% Iroko
CEB	0,0%	32,5%	29,1%	31,8%	27,2%	32,3%
Lime stabilized CEB	16,1%	27,7%	27,1%	20,2%	18,6%	21,4%
Cement stabilized CEB	15,7%	25,8%	28,2%	25,1%	21,7%	12,8%

Figure 8. Influence of sawdust addition on total water absorption

BTCs not stabilized with binder and not containing sawdust dissolve in water in less than an hour, which does not allow the measurement of their total absorption coefficient. The addition of sawdust increases the stability of BTCs immersed in water. In BTCs stabilized with binders, we found that the addition of 15% sawdust causes:

- An increase in the total absorption coefficient of the order of 15% to 71.3% compared to the BTC sample made of earth + lime;
- A variation in the total absorption coefficient of the order of -18.2% to 80.2% compared to the BTC sample made of earth + cement (the only

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reduction was observed for the earth + Sapelli + cement sample).

3.3. Influence of the mixture of Sapelli sawdust and Iroko wood on absorption of water by capillarity

Figure 9 illustrates the effect of the proportion of Iroko in the sawdust mixture on the capillary absorption of BTC. It is observed that the capillary absorption does not systematically evolve in the same direction as the most high saturation point of fibers in the sawdust mixture.

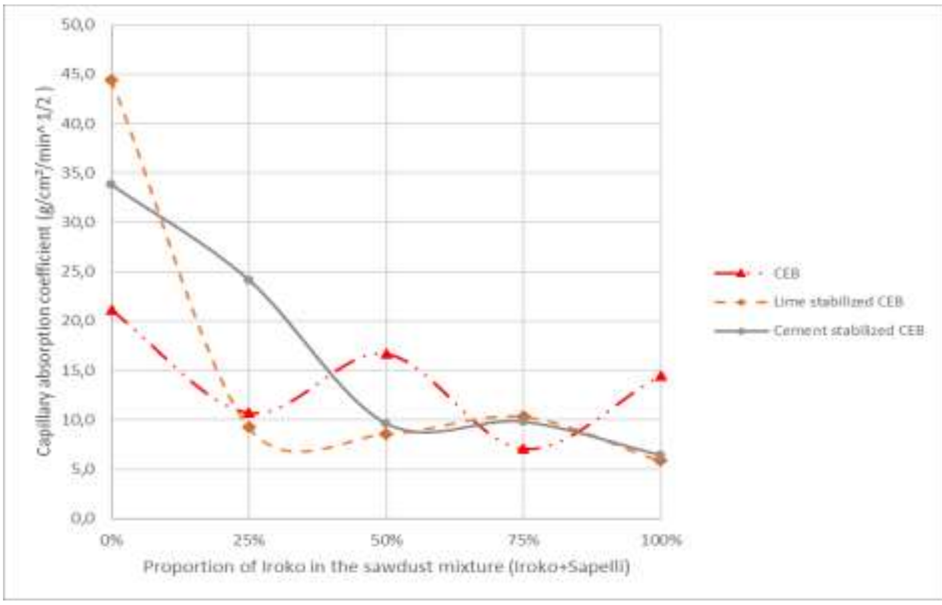


Figure 9Curve showing the evolution of capillary absorption of BTC as a function of the proportion of Iroko in the sawdust mixture.

Figure 10 illustrates the influence of sawdust addition on capillary water absorption.

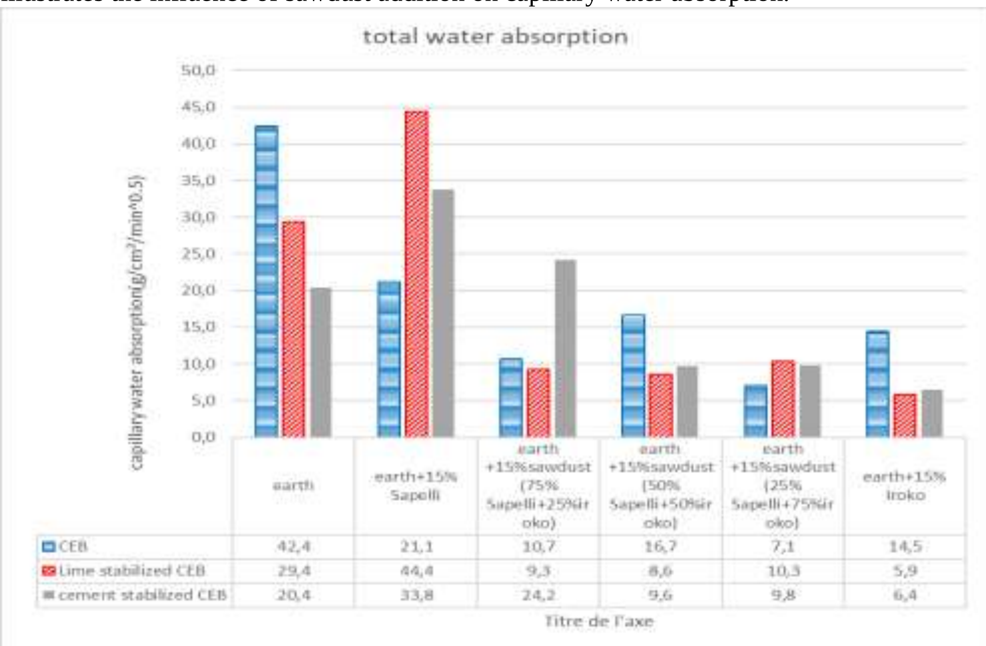


Figure 10.Influence of sawdust addition on capillary water absorption

3.4. Sapelli and Iroko wood sawdust on mass loss

Figure 11 illustrates the effect of the proportion of Iroko in the sawdust mixture on the mass loss of BTC in the open air. It is observed that in the presence of binder, the mass loss does not systematically evolve in the same direction as the proportion of species having the highest fiber saturation point in the mixture. On the other hand, for unstabilized BTC, it is observed that the mass loss would evolve in a quasi-linear manner and inversely with the proportion of species having the highest fiber saturation point in the sawdust mixture (sapelli).

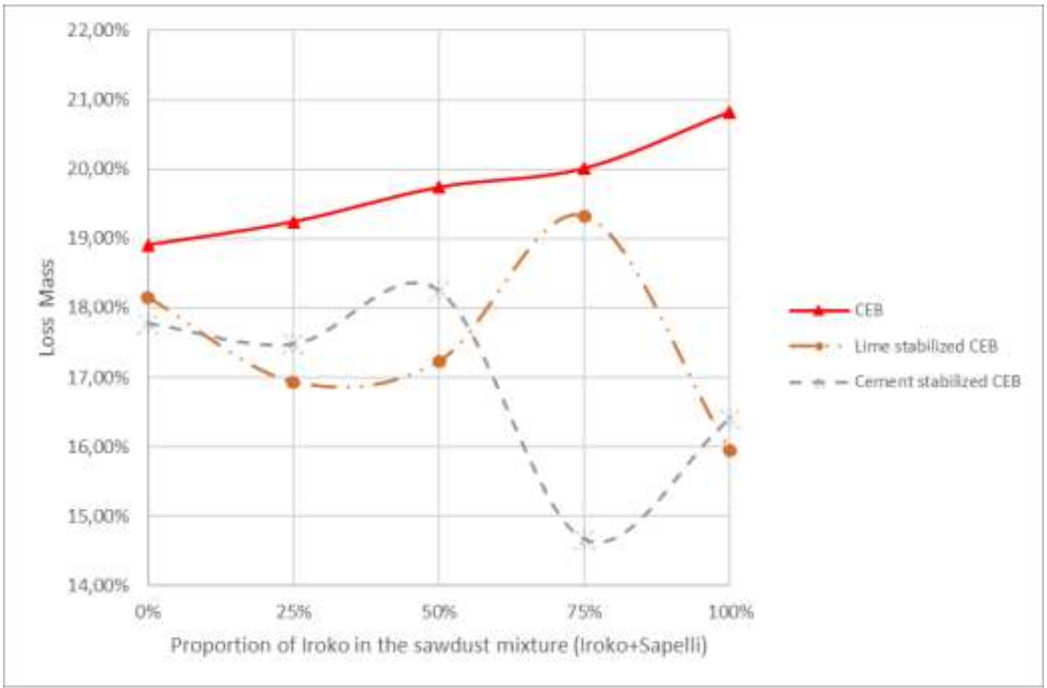
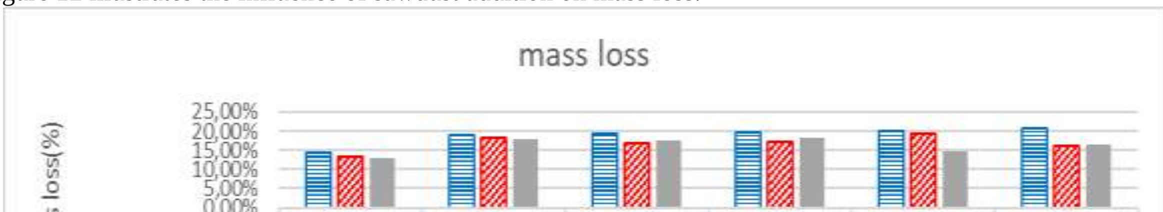


Figure 11Curve showing the evolution of the total mass loss in the open air of BTC after 30 days as a function of the proportion of Iroko in the sawdust mixture.

Figure 12 illustrates the influence of sawdust addition on mass loss.



	earth	earth+15% Sapelli	earth +15%sawdust(75% Sapelli+25%iroko)	earth +15%sawdust(50% Sapelli+50%iroko)	earth +15%sawdust(25% Sapelli+75%iroko)	earth+15% Iroko
CEB	14,23%	18,91%	19,24%	19,74%	20,01%	20,83%
Lime stabilized CEB	13,13%	18,15%	16,94%	17,23%	19,32%	15,94%
Cement stabilized CEB	12,94%	17,77%	17,48%	18,24%	14,67%	16,41%

Figure 12. Influence of sawdust addition on mass loss

The effect of sawdust addition was observed on mass loss and shrinkage in open air, capillary absorption and total absorption of BTC. It is found that the addition of 15% sawdust increases the mass loss of BTC in the following proportions:

- 32.83% to 46.33% compared to the BTC sample made of earth;
- 21.44% to 47.17% compared to the BTC sample made of earth + lime;
- 13.32% to 40.97% compared to the BTC sample made of earth + cement.

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3.5. Sapelli sawdust and Iroko wood on shrinkage

Figure 13 illustrates the effect of the proportion of Iroko in the sawdust mixture on the shrinkage of BTC in open air. It is observed that the mass loss does not systematically evolve in the same direction as the proportion of the species with the highest fibre saturation point in the sawdust mixture.

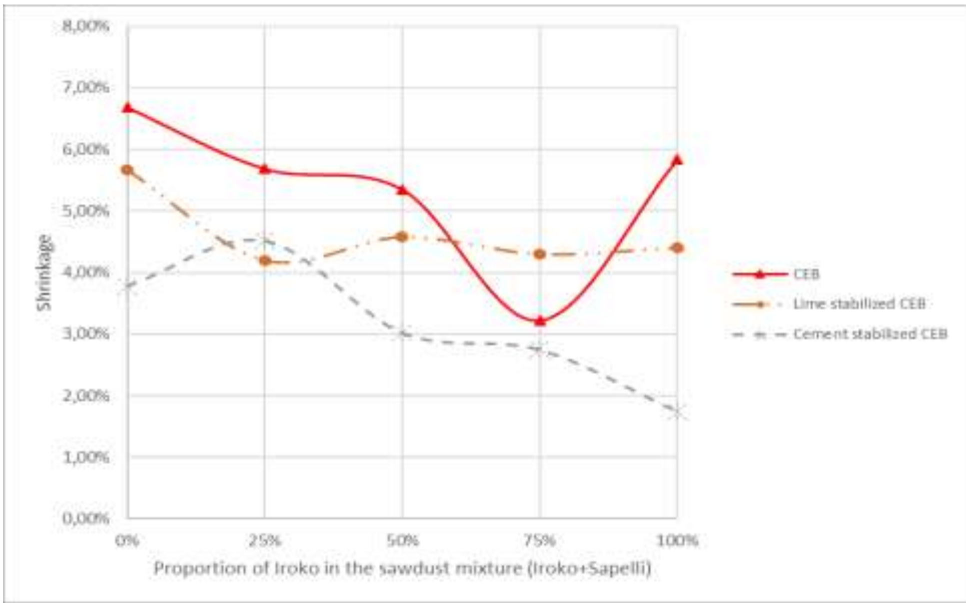

Figure 13a function of the proportion of Iroko in the sawdust mixture.

Figure 14 illustrates the influence of the addition of sawdust on shrinkage.

Figure 14. Influence of sawdust addition on shrinkage

As for the air shrinkage, we observed that the addition of 15% sawdust reduced the shrinkage of both non-binding-stabilized and cement-stabilized BTCs, while an increase in shrinkage was observed for lime-stabilized BTCs. We found:

- A reduction of 16.21% to 59.59% compared to the BTC sample made of earth;
- An increase of 23.16% to 66.34% compared to the BTC sample made of earth + lime;

- A reduction of 6.51% to 63.89% compared to the BTC sample made of earth + cement.

IV. CONCLUSION

We observed that the addition of 15% sawdust reduces the maximum dry density of mortars by:

- 12.36% to 18.82% compared to mortar made from earth;
- 1.59% to 9.94% compared to mortar made from earth + lime;
- 11.64% to 16.24% compared to mortar made from earth + cement.

Overall, the maximum dry density does not systematically evolve in the same direction as the proportion of the species with the greatest density in the sawdust mixture.

The effect of sawdust addition was observed on mass loss and shrinkage in open air, capillary absorption and total absorption of BTC. It is found that the addition of 15% sawdust increases the mass loss of BTC in the following proportions:

- 32.83% to 46.33% compared to the BTC sample made of earth;
- 21.44% to 47.17% compared to the BTC sample made of earth + lime;
- 13.32% to 40.97% compared to the BTC sample made of earth + cement.

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- A reduction of 6.51% to 63.89% compared to the BTC sample made of earth + cement.

Compared to capillary absorption, we observed that the addition of 15% sawdust causes the following effects:

- A reduction of 50.1% to 83.3% compared to the BTC sample made of soil;
- A variation of -80.1% to 51.2% compared to the BTC sample made of earth + lime (the only increase was observed on the earth + sappeli + lime sample);
- A variation from -68.5% to 66.0% compared to the BTC sample made of earth + cement (the only increase was observed on the earth + sapelli + cement sample).

BTCs not stabilized with binder and not containing sawdust dissolve in water in less than an hour, which does not allow the measurement of their total absorption coefficient. The addition of sawdust increases the stability of BTCs immersed in water. In BTCs stabilized with binders, we found that the addition of 15% sawdust causes:

- An increase in the total absorption coefficient of the order of 15% to 71.3% compared to the BTC sample made of earth + lime;
- A variation in the total absorption coefficient of the order of -18.2% to 80.2% compared to the BTC sample made of earth + cement (the only reduction was observed for the earth + Sappelli + cement sample).

Overall, these physical properties do not systematically evolve in the same direction as the proportion of the species with the greatest density in the sawdust mixture.

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