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Study of the Physical Properties of a Clay-Typha Composite Agro-Material

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Abstract: This work focuses on the study of the physical properties of an innovative clay-Typha composite agro-material. The clay was taken in southern Benin from the sites of Dangbo and Houéyogbé, the Typha "Domengensis" from southern Benin invading our lagoons, and lake environments in general was used to solve an ecosystem problem and the balance social. This article aims as the general objective to determine the density, the humidity rate, and the water content of this eco-material obtained from Typha taken in a clay matrix. Thus, using the appropriate conventional methods, the physical parameters mentioned were measured. The analysis of the results obtained clearly show that the density of the samples increases according to the rate of the binder, the determination of the water absorption coefficient is affected by the presence of the clay matrix in the composite and that the rate of humidity increases according to the grain size class of typha fibers. These experimental tests are the harbinger of more in-depth work in the field of thermal comfort of the habital, in order to better understand and improve these agro-bricks.

Keywords: Typha "Domengensis", Clay, Agro-Material, Composite, Physical Properties

1. Introduction

According to Maslow [12], the human being must first satisfy the primary needs in order to be able to realize those which are at the higher level. Among these primary needs is housing, which protects the individual against bad weather (sun, cold, storm, etc.). The evolution of the population and the birth of great civilizations have led to different socio-cultural exchanges between the peoples of the world. Thus, man has gradually integrated into his habitat, elements from other horizons [3].

Today, in the face of modernism, new construction materials have appeared and are adopted in large numbers out of conformity. These include cement, concrete and steel which are now recognized as conventional building materials [9].

The latter have risen to the forefront not only in the construction of urban infrastructures, but also in the construction of dwellings in rural areas, to the detriment of local materials, which are less expensive and capable of ensuring the minimum functions required for the envelopes. housing [12]. Still, materials with a cementitious matrix are not often adapted to the hot climate of tropical countries [6], even though their uses are framed by standards and regulations required by building designers [4, 15]. Dwellings erected in this way are often uncomfortable during periods of high heat, which generally makes it necessary to resort to mechanical ventilation systems, sources of significant energy and therefore financial expenditure for populations with very limited average incomes such as those in Benin. Naturally, in order to improve the comfort inside these habitats, man must think of gradually replacing these cement mortars with bricks made with local construction materials associated with plant fibers in order to obtain agro-materials or eco-materials [3, 5, 10].

In buildings in general, walls mounted with composite materials such as "agro-materials" provide good thermal insulation [11, 14]. In this sense, many research works have focused on experimenting with eco-materials integrating substitute materials such as hemp, straw, kenaf, flax, millet stalks, etc. [8, 15].

The integration of Typha stems in the design of composite construction materials undoubtedly enhances the usefulness of this plant, which constitutes a salutary solution for the exploitation of our waterways often invaded by these typha stems. Mastering the use of a construction material therefore requires a study of the physical, mechanical, hygrometric, etc. properties of this material [1, 2, 4, 7, 10, 13].

To do this, the present work entitled "study of the physical properties of a clay-typha composite agro-material" aims as a general objective to determine the physical properties of an agro-material based on Typha taken in a clay matrix.

2. Material and Methods

Experimentally, to successfully study the physical properties of the clay-Typha composite agro-material intended for the construction of residential partitions, different types of materials and various devices have been used.

Figure 1. *Photo of clay in its natural state.*

2.1. Material

For the design of the eco-material to be tested, the following materials had to be used: clay, typha and water.

Figure 2. *Photo of typha plants.*

Figure 3. *Photo of cut and dried Typhas.*

Table 1. *Table of the different types of briquettes made.*

% clay +% Typha Class	80% clay (Hoéyogbé) and 20% typha	80% Clay (Dangbo) and 20% Typha	90% clay (Hoéyogbé) and 10% typha	90% Clay (Dangbo) and 10% Typha
Class 1	G1H	G1D	G'1H	G'1D
Class 2	G2H	G2D	G'2H	G'2D
Class 3	G3H	G3D	G'3H	G'3D

The clay and the ground typha were mixed with water in various and adjustable proportions according to the varieties of clay and the particle size of the typha particles in order to obtain briquettes ready for experimentation as indicated in the table above.

Figure 4. *Photos of specimens obtained after 21 days.*

Devices used

i. An oven

A GM brand oven is used to dry the typha aggregates, it is set at 105° C for 24 hours during the various tests.

Figure 5. *Photo of the oven.*

ii. An electronic scale

A Dawood brand electronic balance (see figure 3) was used for the rapid weighing of the different samples of material with an accuracy of 0.1 g. It offers a measuring range from 1g to 3000g.

Figure 6. *Photo of the electronic scale.*

2.2. Methods

a. Determination of the density of the samples produced

The true density of a material is the mass of one cubic meter of this material minus the voids between grains.

The dimensions of the specimens are determined using a vernier caliper, which makes it possible to calculate their volume. The mass of these samples is then measured using a precision balance, which allows then calculate their densities. The results of the measurements thus carried out are recorded in table n°1.2.

Table 2. *Values measured to determine the density of the samples.*

Sample	Mass (kg)	Volume (m^3)
G1H	0.2444	222.26
G2H	0.2458	204.6
G3H	0.2385	211.6
G1D	0.2618	239.48
G2D	0.2374	237.09
G3D	0.2304	242.01
G'1H	0.2368	172.5
G'2H	0.2458	199.7
G'3H	0.2385	205.1
G'1D	0.2618	201.89
G'2D	0.2488	226.40
G'3D	0.2555	222.57

b. Determination the moisture content of the samples

To assess the resistance to certain weather conditions, namely (water, air, etc.) of the samples, we determined the humidity rate of the specimens according to the variety of clay and according to the granulometry of the Typha. These results are recorded in the table below.

Table 3. *Measurement values to determine the humidity level.*

Class of typha Mass m Sample	Class 1	Class 2	Class 3
Mass before the oven (in grams)	$m_{G_{1H}} = 233$ $m_{G_{1D}} = 256$	$m_{G_{2H}} = 252$ $m_{G_{2D}} = 242$	$m_{G_{3H}} = 237$ $m_{G_{3D}} = 232$
Mass after the oven (in grams)	$m_{G_{1H}} = 220$ $m_{G_{1D}} = 245$	$m_{G_{2H}} = 237$ $m_{G_{2D}} = 228$	$m_{G_{3H}} = 221$ $m_{G_{3D}} = 218$
Mass before the oven (in grams)	$m_{G'_{1H}} = 239$ $m_{G'_{1D}} = 253$	$m_{G'_{2H}} = 239$ $m_{G'_{2D}} = 253$	$m_{G'_{3H}} = 238$ $m_{G'_{3D}} = 239$
Mass after the oven (in grams)	$m_{G'_{1H}} = 228$ $m_{G'_{1D}} = 240$	$m_{G'_{2H}} = 226$ $m_{G'_{2D}} = 240$	$m_{G'_{3H}} = 224$ $m_{G'_{3D}} = 225$

The humidity level is calculated using the following formula:

$$W_e = \frac{m_e}{m_s} = \frac{m_h - m_s}{m_s}$$

With m_e: the mass of water; m_h: the wet mass of the sample; m_s: the dry mass of the sample.

c. Determination the absorption rate of the specimens produced

To determine the absorption rate, the test pieces are immersed in water to be removed 24 hours later for weight gain, but we find that these test pieces have all burst in the water because they are too soaked.

3. Result and Discussion

3.1. Determination of the Density of the Samples Produced

The results of the density measurements carried out are recorded in the table below. From these results, it appears that the density of the sample increases with the percentage of clay. The higher the binder content, the higher the density.

Table 4. *Measured values of the density of the samples.*

Sample	Mass (kg)	Volume. 10^{-6} (m^3)	Density (kg/m^3)
G_{1H}	0.2444	222.26	1099.58
G_{2H}	0.2458	204.6	1201.32
G_{3H}	0.2385	211.6	1100.48
G_{1D}	0.2618	239.48	1093.2
G_{2D}	0.2374	237.09	1001.28
G_{3D}	0.2304	242.01	952.02
G'_{1H}	0.2368	172.5	1372.32
G'_{2H}	0.2458	199.7	1230.56
G'_{3H}	0.2385	205.1	1162.48
G'_{1D}	0.2618	201.89	1296.74
G'_{2D}	0.2488	226.40	1098.93
G'_{3D}	0.2555	222.57	1147.95

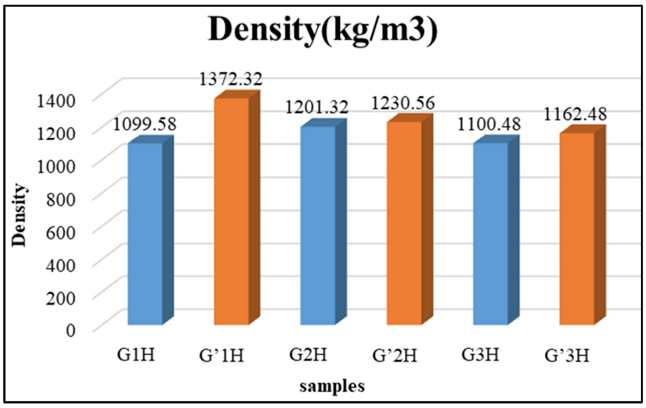

Figure 7. *Histogram showing the densities of category G' samples: Houéyogbé clay case.*

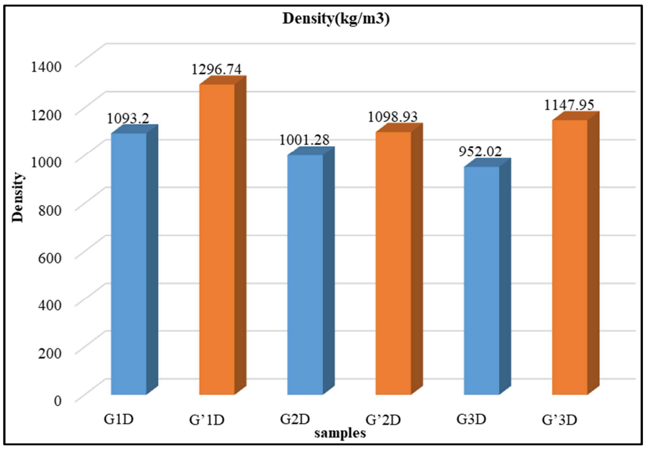

Figure 8. *Histogram showing densities of category G samples: Dangbo clay case.*

3.2. Determination of the Moisture Content of Processed Samples

In order to characterize the resistance of the samples to certain weather conditions, namely (water, air, etc.), we determined the humidity rate of the test specimens according to the variety. of clay and according to the granulometry of Typha. These results are recorded in the table below.

Table 5. *Humidity measurement data.*

Category G samples	Humidity level	Category G' samples	Humidity level
G1H	*5.91%*	G'1H	*4.82%*
G2H	*6.32%*	G'2H	*5.75%*
G3H	*7.24%*	G'3H	*6.25%*
G1D	*4.49%*	G'1D	*4.11%*
G2D	*6.14%*	G'2D	*5.42%*
G3D	*6.42%*	G'3D	*6.22%*

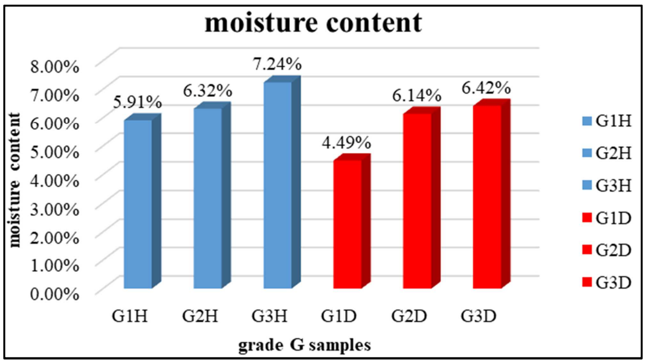

Figure 9. *Comparative study of the moisture content of the samples prepared according to the varieties of clay at 80%.*

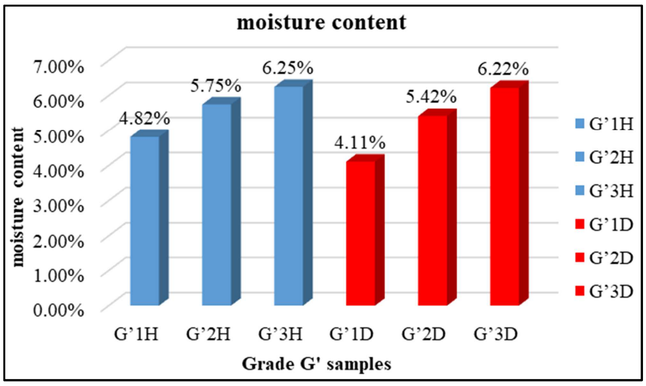

Figure 10. *Comparative study of the moisture content of the samples prepared according to the varieties of clay at 90%.*

Category G

G_{1H} or G_{1D} (20% Class 1 Typha + 80% Houéyogbé clay or Dangbo clay)

G_{2H} or G_{2D} (20% Class 2 Typha + 80% Houéyogbé clay or Dangbo clay)

G_{3H} or G_{3D} (20% Class 3 Typha + 80% Houéyogbé clay or Dangbo clay)

Category G'

G'_{1H}or G'_{1D} (10% Class 1 Typha + 90% Houéyogbé clay or clay)

G'_{2H}or G'_{2D} (10% Class 2 Typha + 90% Houéyogbé clay or clay)

G'_{3H}or G'_{3D} (10% Class 3 Typha + 90% Houéyogbé clay or clay)

We deduce from the data of the table that:

1) The moisture content of the sample decreases when passing from Houéyogbé clay to that of Dangbo (Figures 9 and 10)

2) The humidity rate increases according to the typha class (from class 1 to class 3) for the same proportion of clay (Figures 9 to 10)
3) The smaller the size of the typha particles, the higher the humidity (Figures 9 to 10)

3.3. Determination of the Water Absorption Coefficient

The water absorption coefficient is determined after 24 hours of immersion of the sample, but the bursting of the samples is observed a few minutes after their immersion in water. It can therefore be concluded that the samples produced have a water absorption coefficient of 100% and therefore cannot withstand rainy weather.

4. Conclusion

The results of physical tests have shown that the moisture content of the sample produced decreases when passing from Houéyogbé clay to that of Dangbo. This experimental approach is the harbinger of more in-depth work in the field of thermal comfort of the habitat, in order to better understand and improve these agro-bricks with a view to their practical use in the assembly of the walls of the separation walls at inside buildings of all kinds. We can appreciate the relevance of integrating this innovative biosourced material in the construction of social housing to reduce the environmental impact of buildings.

Nomenclature

We: humidity rate (%)
τe: absorption rate (%)
ρ: density (kg/m^3)
m: mass (kg)
V: Volume of the sample (m^3)
m_e: mass of water (kg)
m_s: dry mass of the sample (kg)
m_h: wet mass of the sample (kg)

References

[1] Dr Hadj Sadok, A. Course on Generality, classification of materials and their properties (2001).

[2] P. MEUKAM, Y. JANNOT, A. NOUMOWE and TC KOFANE, Thermo physical characteristics of economical building materials, Int. Journal Construction and Building Materials 18 (2004), 437-443.

[3] Elisabeth Akoivi ALLOGNON HOUESSOU, Contribution to the determination of the thermophysical parameters of local building materials in Benin, Doctoral thesis; University of Abomey-Calavi. December 2007.

[4] Lahcen Boukhattem: thermophysical characterization of materials and modeling of coupled heat transfers through a building. Doctoral thesis, ibn zohr-Morocco university, 2008.

[5] D. SOW, S. GAYE, M. ADJ and D. AZILINON, Valorization of Agricultural Wastes by their Integration in Construction Materials: Application to Rice Straw, *Proceeding of AMSE International Conference* MS'09, Trivandrum, India, 1- 3 December 2009, pp 314 -347 -ISBN: 978-84-8384-050- 4, Legal Deposit: PM 993-2008.

[6] Nassima sotehi, thermal characteristics of building walls and improvement of insulation, doctoral thesis, 2010.

[7] Armand Ayihaou DJOSSOU: Study of variations in thermophysical properties and durability depending on the humidity of eco-building materials in Benin. Doctoral thesis; University of Abomey-Calavi. January 2014.

[8] Ouedraogo al:[thermo-physical mechanical characterization of blocks of stabilized compressed earth or paper (cellulose) and/or cement, journal of materials and engineering structures 68-76, 2015.

[9] Azizi and Boukhechba: influence of temperature and humidity on the thermo-physical properties of local clay-based materials, master's thesis, Adrar University, 2016.

[10] Ababacar Sadikh Diaw, Djibril Sow, Mamadou Babacar Ndiaye, Azibert oumar Abdelhakh, Mamadou Wade, Salif Gaye. Valorization of Typha Australis by its Integration in Building Construction Materials. Journal [International Journal of Emerging Technology and advanced Engineering IJETAE] Vol 6, Issue 1 January 2016. DOI. ISSN: 2250-2459, ISO 9001: 2008 Certified journal [pp. 34 à 37] [2016].

[11] Ibrahim NIANG: Contribution to the certification of sustainable buildings in Senegal: case study of biosourced construction materials based on typha; June 2018.

[12] MILOHIN Gbènondé Sèna Gladys, LACHI, Mohammed, SANYA, Émile Adjibadé, et al. Recovery of scrap glass bottles and wood ash in the manufacture of fired clay bricks. 2019. Doctoral thesis. EPAC/UAC.

[13] Dr (MC) ALLOGNON Wife HOUESSOU Elisabeth Akoivi. Course on the thermophysical characterization of materials (2019).

[14] Henri Wilfried Hounkpatin *et al.*, 2020. Mechanical Characterisation of Insulation Panels Based on Vegetable Typha Domingensis and Starch. *Science Journal of Energy Engineering*. Vol. 8, No. 3, pp. 33-43. doi: 10.11648/j.sjee.20200803.11.

[15] Henri Wilfried Hounkpatin: Use of DOMINGENSIS typha to improve the energy performance of buildings in humid tropical environments, Doctoral thesis; University of Abomey-Calavi. March 2021.