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Article

Physicochemical characterization of the material used in the manufacture of brick in an artisanal way

Caracterización fisicoquímica del material empleado en la fabricación de tabique en forma artesanal

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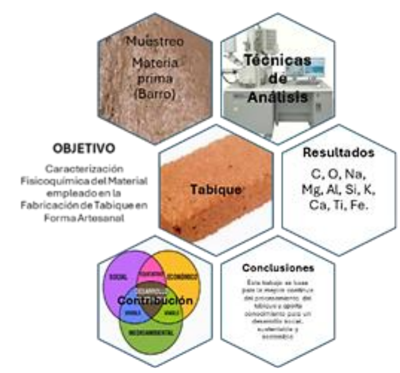
Abstract

The manufacture of Brick in an artisanal way is a traditional activity carried out by the knowledge and experience transmitted from person to person, due to this there are no work instructions, nor data on the chemical composition of the raw material used, nor control of the process of manufacturing. The objective of this study was to physicochemically characterize the raw material for the manufacture of Brick. The elemental chemical composition found was the following. C, O, Na, Mg, Al, Si, K, Ca, Ti, Fe. Elements to which the mechanical properties of the Brick are attributed. The compressive strength of the Brick without heat treatment was 12 to 15 kg/cm^2, after heat treatment it was 24 to 45 kg/cm^2. Regarding morphology, particles from 4 to 301 µm were observed in the raw material. And in the Brick from 18 to 257 µm. It is concluded that the homogenization of the raw material, as well as the temperature control in the thermal treatment of the Brick allowed to obtain greater resistance to compression, since the Peruvian Standard ITINTEC 331.017. And Standard NMX-C-404-1997 establishes 60N/cm^2. and 24kg/cm^2 minimum respectively.

Artisanal brick, Raw material, Compression resistance

Resumen

La fabricación de tabique en forma artesanal es una actividad tradicional realizada por el conocimiento y experiencia transmitido de persona a persona, debido a ello no se cuenta con instrucciones de trabajo, ni datos sobre la composición química de la materia prima utilizada, ni control del proceso de fabricación. El objetivo de este estudio fue caracterizar fisicoquímicamente la materia prima para la fabricación de tabique. La composición química elemental encontrada fue la siguiente. C, O, Na, Mg, Al, Si, K, Ca, Ti, Fe. Elementos a los cuales se le atribuye las propiedades mecánicas del tabique. La resistencia a la compresión del tabique sin tratamiento térmico fue 12 a 15kg/cm^2, después del tratamiento térmico fue de 24 a 45 kg/cm^2. En cuanto a la morfología se observaron partículas de 4 a 301 µm en la materia prima y en el tabique de 18 a 257 µm. Se concluye que la homogenización de la materia prima, así como el control de temperatura en el tratamiento térmico del tabique permitió obtener mayor resistencia a la compresión, ya que la Norma Peruana ITINTEC 331.017. Y la Norma NMX-C-404-1997, establecen 60N/cm^2. y 24kg/cm^2 mínimo respectivamente.



Tabique artesanal, Materia prima, Resistencia a la compresión

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Introduction

A brick is a ceramic piece, generally orthohedral, obtained by molding, drying and firing at high temperatures of a clay paste, whose dimensions are usually 24 x 11.5 x 6 cm. It is used in masonry, for the construction of walls, houses, industries, etc. It is estimated that the first bricks were created around the year 6,000 BC. (Tell Mureybet and Ali Kosh).

The brick is unalterable to humidity and has, as a fired material, a very useful network of capillary ducts. Its capacity to retain moisture and its thermal inertia are great. One of its characteristics is to absorb moisture from the environment with higher water vapor pressure, transfer it through its capillary network and dissipate it in the environment with lower pressure. The brick wall "breathes" until it is dry. For this reason, it is appropriate for constructions intended for wet processes, as long as the breathing of the brick is not obstructed. The thermal conductivity of the brick is moderate[II, VI, VII].

It is important that the conductivity is proportional to the conductivity of the water vapor. This means that in each section of a brick wall, as the temperature drops, the water vapor pressure decreases, therefore condensation does not occur. If a wall is not prevented from "breathing" its cold side remains dry[III, IV, V].

The Olmecs (1200 BC), for the construction of La Venta (Villahermosa, Tabasco) used red and yellow clay block walls also joined with clay[III].

The Mayans made large and impressive buildings and large cities since the middle preclassic period. The most notable monuments are the pyramids that they built in their religious centers, next to the palaces of their rulers. All stone for the Mayan structures appears to have been taken from local quarries; It was often limestone that, recently quarried, remained soft enough to be worked with stone tools, and only hardened after a time, losing its natural moisture. In addition to the structural use of limestone, they used crushed, burned and beaten limestone that had properties similar to cement and was widely used both for plaster finishes and for joining stones; In the Valley of Mexico (in the preclassic period, 700 BC) masonry was already used for various purposes[III].

The purpose of this study was to characterize the raw material, as well as its processing for the production of the partition, since it is an important aspect on which its compression resistance will depend.

This study is addressed in the following sections:

- Introduction.
- Methodology.
- Results.
- Acknowledgment.
- Conclusions.
- References.

Methodology

Samples of the tepetate, mud and soil from the site were taken for elemental chemical and morphological characterization with a JEOL JSM-5900LV scanning electron microscope. Table 1 and figures 1, 2, 3, 4, 5, 6.

The raw material was mixed in the following proportions:

- Sandy tepetate (25%).
- Tepetate (25%).
- Mud (red soap) 25%.
- Land of the place 25%.

The materials were sifted in a mason's hoard.

The materials were kneaded with 20% water.

The mixture was made with a hoe until homogeneous consistency to be placed in the mold.

The mold was sandblasted.

The mold was filled with the dough.

The material protruding from the mold was trimmed with the tool called a trimmer.

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The partition was removed from the mold and placed face up in rows on the floor.

It was left to dry on the floor for 4 days.

The partition was dried in the sun for a month during the rainy season. (In the dry season it is enough for 15 days).

The partition was placed in the oven to cook for 30 hours.

The morphology of the septum was characterized Figure 4.

The compressive strength of the septum was verified (Table 2).

Results

As can be seen in table 1. The three types of soil used to mix the raw material to be used in the manufacture of the partition have the same chemical elements: Carbon (C), Oxygen (O), Sodium (Na) , Magnesium (Mg), Aluminum (Al), Silicon (Si), Potassium (K), Calcium (Ca), Titanium (Ti), Iron (Fe), only the one with the highest content of all of them is mud.

The tepetate of origin from San Lorenzo Cuauhtenco, presented a particle size of 50 to 300 µm, a very variable size due to the agglomeration of particles, which form conglomerates (Figure 1).

The mud from San Lorenzo Cuauhtenco had a particle size of 75 to 150 µm. Just as in the previous case, it presents conglomerates, due to a heterogeneous mixing operation (Figure 2).

Regarding the soil of San Bartolomé Tlaltelulco, particles between 5 to 90 µm were found (Figure 3).

The finished product (partition) had a particle size of 15 to 250 µm, which gives it different porosities throughout the partition, which can influence its compressive strength (Figure 4).

As can be seen in the three types of soil, different morphologies of the particles were found, ovoid characteristics typical of clays, partially folded edges characteristic of potassium feldspars, as well as spherical shapes.

The chemical element silicon denotes the presence of quartz (SiO_2).

Box 1

Table 1
Elemental composition of the raw material

Chemical Element	Mix of Snack and Sandy Tepetate %	Clay %	Land of the Place %	Brick%
C	19.53	29	24.4	21.42
O	40	38	40	40.68
Na	1.15	1.1	0.95	0.96
Mg	0.24	0.21	0.15	0.31
Al	10	7.6	8.23	8.64
Si	21.61	17.5	19.4	20
K	0.79	0.79	0.83	0.90
Ca	2.1	1.44	1.21	1.35
Ti	0.48	0.38	0.40	0.46
Fe	4.22	4.21	4.5	5.32

Source: Own elaboration

Box 2

Table 2
Compression resistance of brick

Brick	Compression Resistance (No Baking) (dried in the sun)	Compression Resistance (Baked)
1	10 kg/cm^2	20 kg/cm^2
2	12 kg/cm^2	31 kg/cm^2
3	12 kg/cm^2	20 kg/cm^2
4	10 kg/cm^2	30 kg/cm^2
5	11 kg/cm^2	36 kg/cm^2
6	13 kg/cm^2	40 kg/cm^2

Source: Own elaboration

Box 3

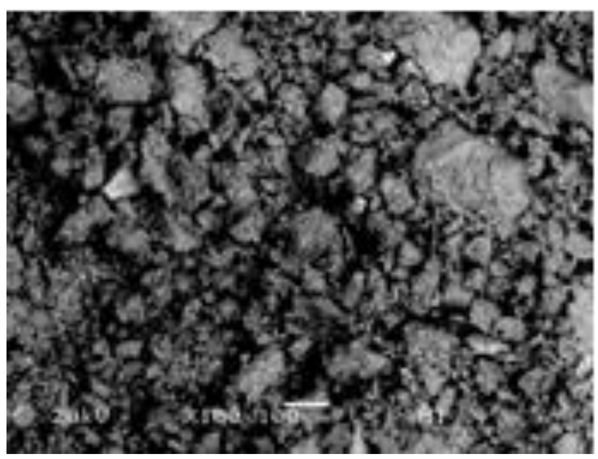

Figure 1
Morphology of the mix of snack and sandy temperate to 100X magnification

Source: Own elaboration

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Box 4

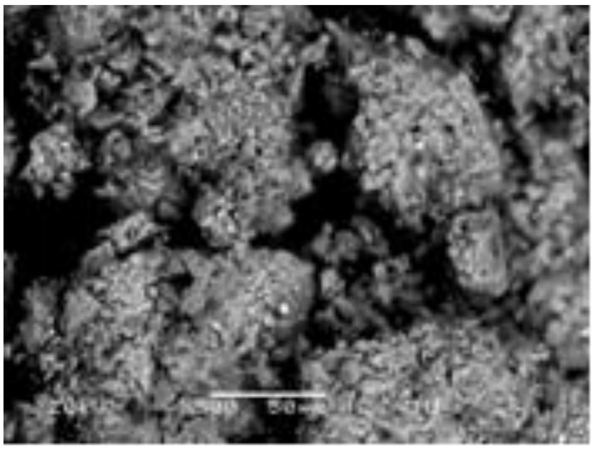

Figure 2
Morpholoy of Clay to 100X magnification
Source: Own elaboration

Box 5

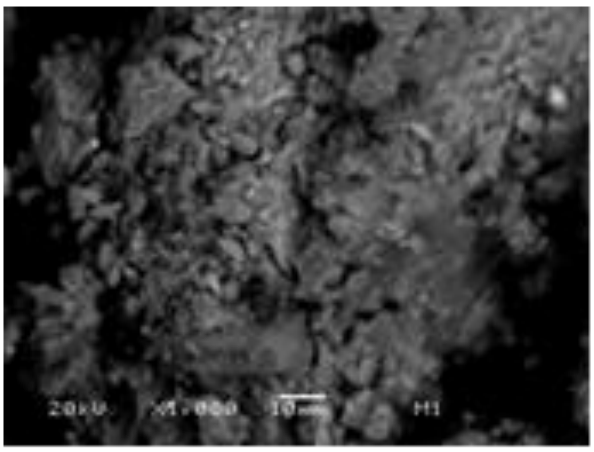

Figure 3
Morphology of the land of San Bartolomé Tlaltelulco to 100X magnification
Source: Own elaboration

Box 6

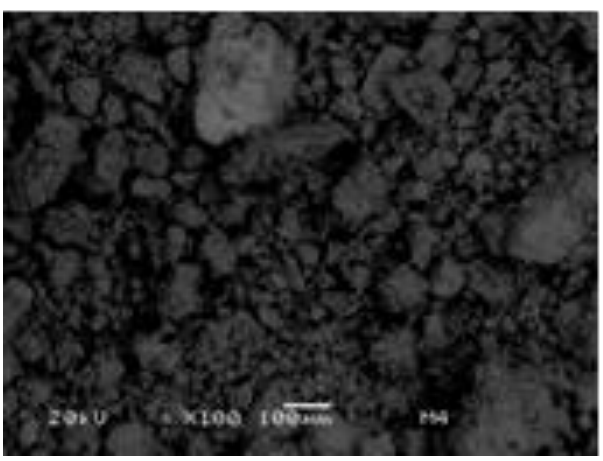

Figure 4
Morphology of the Brick to 100X magnification
Source: Own elaboration

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Conclusions

The results obtained allowed us to propose a series of morphological characteristics of the raw material used in the manufacture of the San Bartolomé Tlaltelulco Brick, as well as to determine the presence of chemical elements typical of quartz, feldspars and clays. The particle size observed microscopically allows us to conclude that there is a lot of variation, which contributes to the compressive strength of the septum, which tends to the minimum value established by the applicable Regulations. It is suggested to homogenize the mixing of the raw material during the brick manufacturing process, to control the particle size. Additionally, it is recommended to keep a record of the oven temperature for heat treatment, to increase the compressive strength of the product.

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article

Authors' Contribution

This is a collaborative work in which all the following authors:

Araceli Salazar Peralta, *Lina Agustina Bernal Martínez, José Alfredo Pichardo Salazar*, *and Ulises Pichardo Salazar*, contributed in teamwork in the following activities: taking of samples, methodology to be used, writing and revision of the article**.**

Availability of data and materials

The availability of the material was achieved with the contribution of the artisans of San Bartolomé Tlaltelulco, as for the measurement equipment for the tests was made with the collaboration of the laboratories of the ININ, as well as the Tecnológico de Estudios Superiores de Jocotitlán.

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