IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 21, Issue 5, Ser. II (Sep - Oct 2019), PP 33-40
www.iosrjournals.org

The Thermal Capacity Of Walls Made Of Rammed Earth As A Comfort Component At Housing In Tampico, Tamaulipas.

Rubén Salvador Roux Gutiérrez[1], José Adán Espuna Mujica[2], Gloria Esmeralda del Ángel Cavazos[3]
[1]*Graduate in Architecture, Instituto de Estudios Superiores de Tamaulipas A.C.*
[2]*College of Architecture, Design and urban Panning of the Universidad Autónoma de Tamaulipas,*
[3]*Graduate in Architecture, Instituto de Estudios Superiores de Tamaulipas A.C.*

Abstract: *This article discusses the importance of the thermal capacity of the materials used as architectural fence, as these determine the degree of interior comfort inside the homes so built.*
The new policies taken by Mexico have given significant importance to the conservation and restoration of the environment. The research of the soil usage in construction, is taken up again due to its natural properties.
That is how this investigation approaches the use of rammed earth as an analysis unit, to test its advantages as a natural temperature regulator and how it influences the thermal comfort in houses with a warm humid weather as in Tampico, Tamaulipas.
Key words: *Rammed earth, thermal retardation, housing*

Date of Submission: 02-10-2019 Date of acceptance: 18-10-2019

I. Introduction

In this research it is intended to prove the importance that the thermal inertia of walls built with the soil construction technique known as rammed earth, has in the thermal comfort of the houses so built.

It is known that thermal insulators are materials of low transmittance that hinder the transit of heat through them. Soil has a thermal inertia of 0.5 W/mK and the one in conventional thermal insulators,has a thermal inertia of 0.4 W/mK, therefore, soil is a suitable material for the thermal isolation of a house.On the other hand, soil and an insulator material (as mineral wool), theyhave a specific heat of 1000 J/ (Kg K),by weight unit(Bunysec,2017).

Penetration, which should be also considered, is the thickness that the specific heat has to go through in a 24-hour period, and basically depends on its specific heat and its thermal inertia, so that the thicker a material is, its thermal behavior will be better.

In previous studies it has been proved that soil has an approximate penetration of 10 cm in 24 hours, just like conventional thermal materials (Bunysec,2017).

Thermal comfort inside architectural spaces is possible by achieving an inner thermal stability when it is within comfort parameters, though it is known that comfort also depends on the type of user of the space.

The surfaces that surround the architectural space represent another important element, as these must have a radiation temperature, similar to the comfort temperature for an adequate comfort degree, and they do not irradiate either heat or cold that causes discomfort. (Bunyesc, 2017)

One of the important programs of the Comisión Nacional de Vivienda[1] (CONAVI), is to reduce the electric energy consumption due to active air conditioning to achieve comfort, in homes built in Mexico. The problem that has been detected is nationwide, there are very few of any green labeled materials, among the most important characteristics of the materials there is the thermal capacity, but specially its thermal retardation, as this characteristic allows to know the depth of these materials and thus determine the time heat or cold takes to pass from the outside to the inside, to keep a comfortable environment without the need to use an artificial air conditioning system for long periods of time, and consequently, a high consumption of electrical energy (Roux Gutiérrez, 2018).

II. Problem Statement.

The major issue of housing in Mexico is that quantity and cost have been prioritized, in spite that in the fourth trimester of 2015it had a 0.29 % decrease (Topelson de Grinbert, 2016) on quality and sustainability,

[1]National Housing Commission

which has contributed to be one of the causes of housing abandonment in Mexico.On the other hand, the Programa Nacional de Vivienda (National Housing Program) 2014 – 2018, subsection V sustainable housing states:

"The environmental impact generated in houses on a daily basis is undeniable.

It is estimated that this sector is responsible of 32 % of greenhouse gases in Mexico, "which represents 16.2% of the total energy consumption and 26% of total energy consumption" (Gobierno Federal Mexicano, 2014).

In Mexico, alternative materials used in housing construction are very scarce. In order to reduce energy consumption; construction has been based more on thermal insulators that are neither cheap nor sustainable, and regulations for alternative local materials to replace the conventional ones, have not been promoted.

From the above, the following question follows:

If the thermal retardation of rammed earth walls is determined in accordance to its thermal properties in a laboratory and a controlled environment; What influences the thermal comfort of the house?

III. Objective

Analyze the thermal properties that rammed earth walls have, to determine the thermal retardation they show when applying a heat source in a controlled environment, in this case, the laboratory.
To determine how much, it impacts the degree of thermal comfort in houses of Tampico, Tamaulipas.

IV. Methodology

Rammed earth walls were fabricated by the researchers in the materials laboratory of the Architecture Department of the Instituto de Estudios Superiores de Tamaulipas, A.C. of the Anahuac University Network.

For the construction, two types of soil were used, the first one was a fine clay soil with a volumetric weight of 1700 Kg/m33, with a liquid limit of 26.1%, a plastic limit of 20.3%, which results in a plasticity index of 5.8%, and according to the Unified Soil Classification System (USCS) it's a low plasticity clay.

The second soil was river sand, with a volumetric weight of 1800 kg/m33, the clay mixture was 50% of each soil.

The control sample was made only with clay and sand without stabilizer, the wall's dimensions where of 0.60 x 0.60 x 0.15, a wooden formwork made of 1" thick planks, and 4 beams of 2" x 2" x 2' tied with threaded rods of 19mm of diameter with hexagonal nuts and washers were used for its construction, as shown in images 1 and 2.

Images 1 and 2.Soil screening, mixing and colocation in the formwork for later tamping. Photo:Gloria Esmeralda del Ángel Cavazos. Architect.

The second specimen was fabricated the day after, it had the same dimensions and the same proportion of sand and clay, the only difference was that a 6% concrete CPO-30 was added as a stabilizer. As shown in images 3, 4, 5, 6, and 7.

Images 3, 4, 5, 6 and 7.Soil screening stabilized with lime, tamped down, heat source colocation and thermocouples.Photo:Gloria Esmeralda del Angel Cavazos. Architect.

Lastly, the last specimen was fabricated on the third day, it had the same dimensions and the same proportion of sand and clay, the only difference was that a 7% lime was added as a stabilizer.

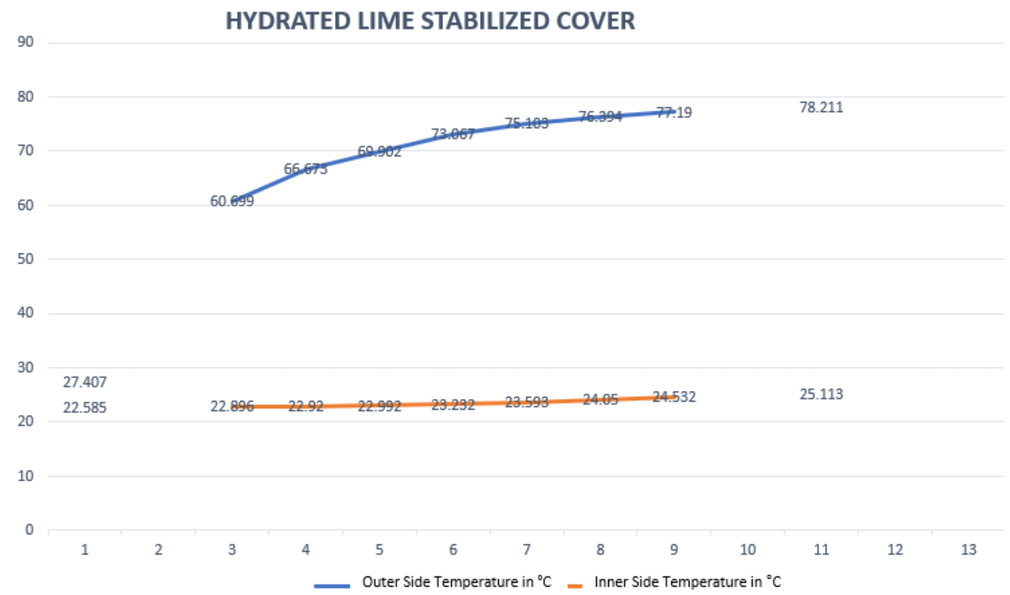
Thermal conductivity tests will be limited to apply a constant heat source, to take the temperature measurements presented by the different walls tested, to compare their behavior.

The test consisted in the analysis of the registered temperatures in both faces of the walls, were the thermocouples were collocated. The thermal charge was done with incandescent light bulbs, with a charge of 1,050 (One thousand and fifty) w/hr., with a first day duration of 5 hours, that where put in operation simultaneously with the measuring device, Dataloggers type, hobo brand, U-12 model, with the use of thermocouples for the simultaneous temperature registration of both, the outer surface, exposed to the charge and the inner surface, in the wall's center each half hour to determine the heat transition and determine which type of material is adequate for a reduction in the heat conduction to the inside of a plausible house in case of being used as a construction material the denominated rammed earth.

Next, the experimental process, and obtained results throughout the research, are shown:

HYDRATED LIME WALL:

It presented a thermal retardation in just over 4 minutes and 30 seconds to rise the temperature just below 3 degrees to the interior of the wall, given that the initial temperature on the outside was 27.4ºC, and at the moment of unplugging it was of 78.2ºC, and in the inner wall, the initial temperature was of 22.5ºC, and the last temperature record was 25.1ºC, meaning 2.6ºC, less than a Celsius degree, see graphic 1.

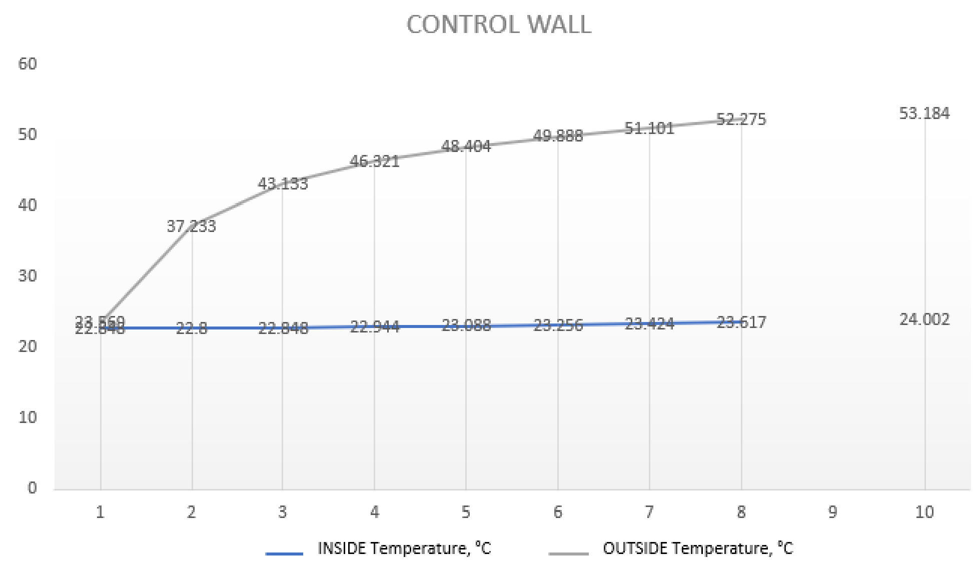


Graphic 1. Outside and inside temperatures were recorded in the hydrated lime stabilized rammed earth wall, graphic made by PhD. José Adán Espuna Mujica

CONTROL WALL:

Measured at the same time than the last one, showed a thermal retardation in the same time of just over a degree in the interior surface, since the initial exterior temperature was of 23.5ºC, and when unplugging was of 53.2ºC, while in the interior, at the beginning, a temperature of 22.8ºC was recorded, and by the end it was of 24.0ºC, meaning 1.2ºC, just over one Celsius degree.

However, it had less thermal gain than the previous one, probably because this wall showed porosity in the absence of stabilizing material, which increased its physical resistance, see graphic 2.



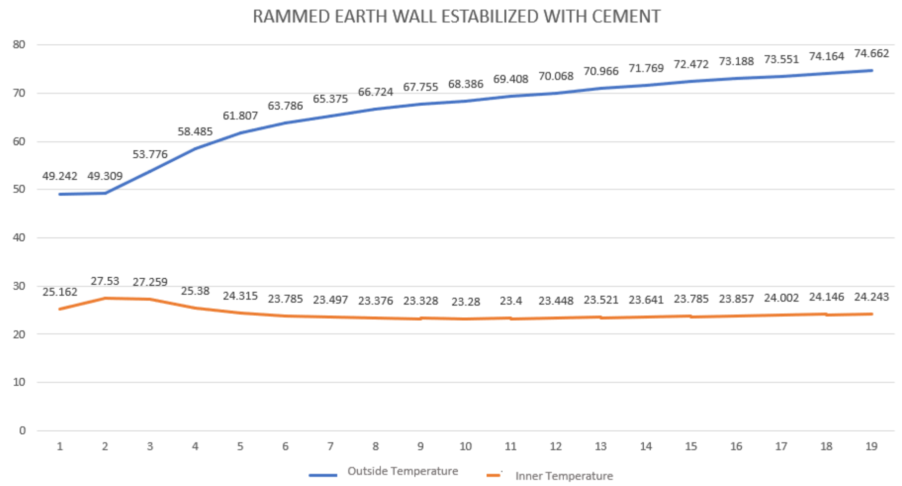
Graphic 2. Exterior and interior temperatures recorded in the control rammed earth wall; graphic made by PhD. José Adán Espuna Mujica

PORTLAND CONCRETE WALL

It was decided to leave this one for a longer period of time while recording the temperatures, as it was the weekend, the intention was to find the thermal retardation between the highest outer temperature, and its difference in time with the inner highest.

The initial temperature at 9:30 that day in the outside record was of 27.0ºC and when unplugging the thermal charge at 13:30, the record was of 72.3ºC, while in the interior at the beginning, a temperature of 23.3ºC was recorded, and the last record was of 24.3, meaning one Celsius degree.

The highest temperature of this wall on the outside was recorded at 13:30 hours of January 11th, and the inner highest was of 25.5ºC at 16:30 hours, presenting a thermal retardation of 3 hours, see graphic 3.



Graphic 3. Outside and inside temperatures recorded in the concrete stabilized rammed earth wall, graphic made by PhD. José Adán Espuna Mujica

Next, are thermographers of each tested panel where the temperature increase is seen on both sides.

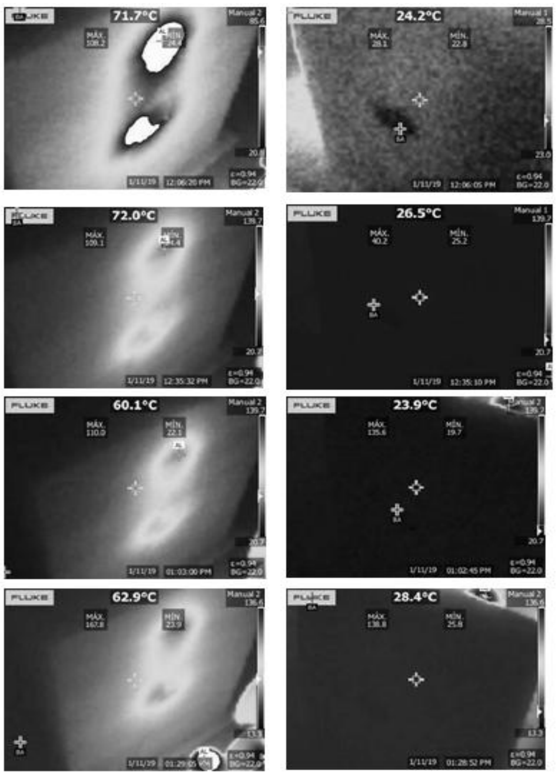
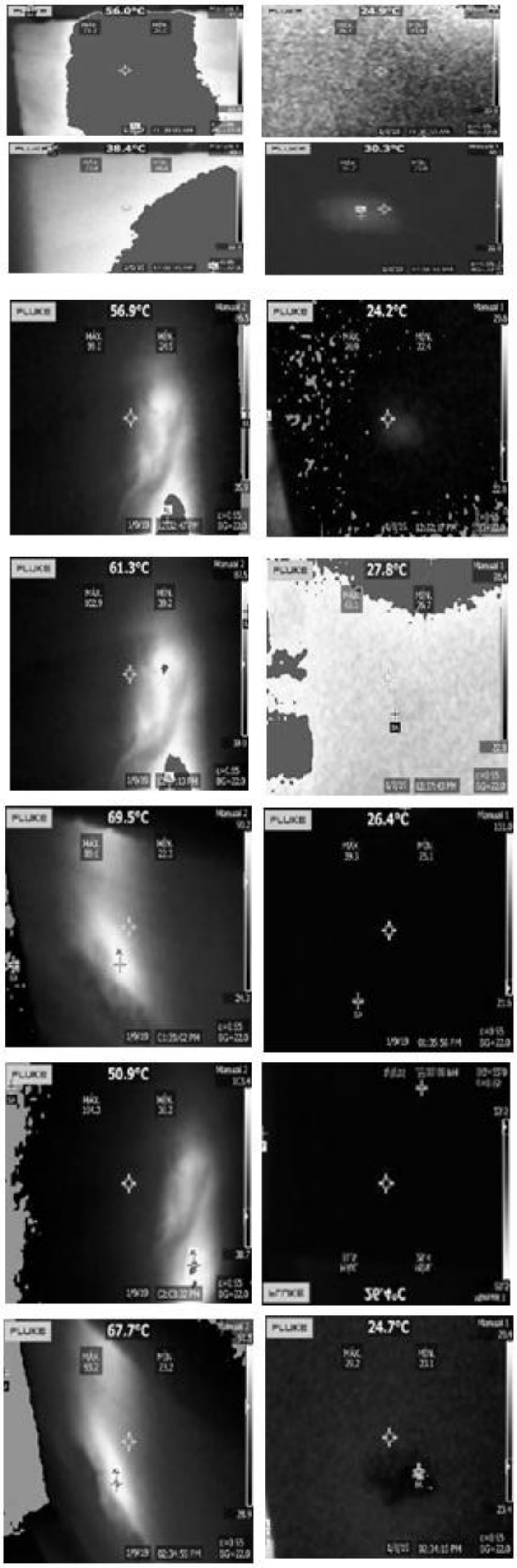


Image 8. Thermographic study of the outer and inner faces of the lime stabilized rammed earth wall during the 5 hours test.Made by the author.


56.0°C
24.9°C
38.4°C
30.3°C
FLUKE
56.9°C
FLUKE
24.2°C
FLUKE
61.3°C
FLUKE
27.8°C
FLUKE
69.5°C
FLUKE
26.4°C
FLUKE
50.9°C
FLUKE
67.7°C
FLUKE
24.7°C

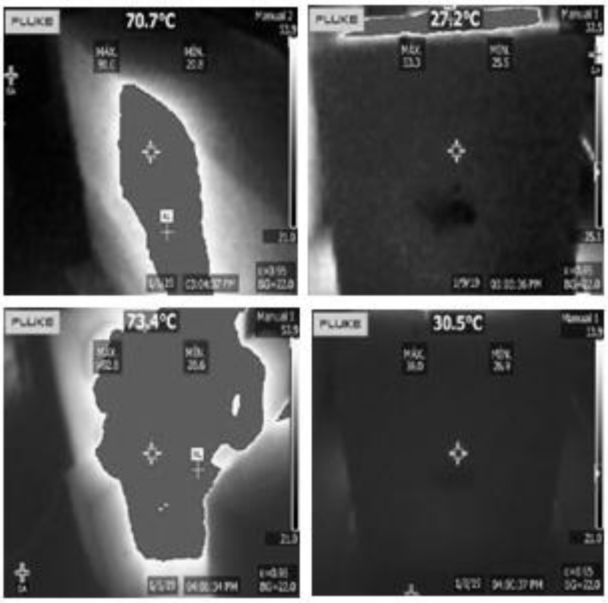


Image 9. Thermographic study of the outer and inner faces of the lime stabilized rammed earth wall during a 5 hours test.Photo by PhD. Rubén Salvador Roux Gutiérrez

In chart 1, a summary of the highest temperatures that the different tested materials reached, is shown, and it also shows the retardation record; meaning how much time passed since the moment the highest temperatures were recorded in each side of the wall, which is thermal retardation.

To clarify, the data of the annealed mud brick and the concrete block, were taken from the thesis of Civil Engineer Diana Patricia Galleos Sánchez, dated February 2014, where the same methodology was applied.

Wall Type	Wall thick-ness	Maximum Temperature		Thermal retardation time	Reduction factor $\mu = \frac{T_i \max}{T_o \max}$
		Wall side			
		Exposed °C	Rear °C		
Control rammed earth wall	0.15	53.20	24.00	4:30	2.216
Lime-rammed earth wall	0.15	78.20	25.10	4:30	3.115
Concrete-rammed earth wall	0.15	72.30	25.50	3.00	2.835

Table 1. Retardation time and reduction factor of the different walls analyzed. Made by the author.

The same tool is used by the Ministerio de Empleo y Seguridad de España[2] to determine the local thermal discomfort with the obtained data, and a DP = 6.8% result is obtained, which according to this instrument, is a satisfactory situation.

V. Conclusions

After completing the studies, it can be concluded that the use of soil as a construction material is a technique that has been forgotten for many decades, and considering that it is a traditional handmade technique, there was not a proper backup of technical studies and its behavior in comparison to other conventional materials.

Therefore, the interest of studying the thermal characteristics of rammed earth walls. This research culminated in calculating the thermal retardation of lime stabilized, concrete stabilized and non-stabilized rammed earth walls for comparison.

[2]Ministry of Employment and Security of Spain

It is proven that rammed earth walls with lime stabilizer and without any stabilizer, have the same thermal retardation of 4:30 hours, even though the inner temperature difference was better in the unstable wall by 1.10º C, the concrete stabilized therammed earth wall.

References

[1]. Bunyesc, J. (10 de 11 de 2017). Ecoconstrucción. Obtained from https://www.ecoconstruccion.net/articulos-online/la-inercia-termica-rapida-o-lenta-versus-aislamiento-termico-base-del-confort-termico-UUxOa

[2]. Gallegos Sánchez, Diana Patricia. (2014). Construcción sustentable, análisis de retraso térmico a bloques de tierra comprimidos. Mexico: UAT.

[3]. Gobierno Federal Mexicano. (2014). Programa Nacional de vivienda 2014 - 2018. México: DOF.

[4]. Minke, G. (2005). Manual de construcción con tierra, La tierra como material de construcción y su aplicación en la arquitectura. Editorial fin de siglo. Uruguay.

[5]. Neves, C., & Faría, B. (2011). Técnicas Mixtas. En C. Neves, & B. F. Faría, Técnicas de Construcción con tierra (págs. 61 - 71). Brazil: Bauru: FEBUNESP.

[6]. Roux Gutiérrez, R. S. (2018). BAHAREQUE Y SU INERCIA TERMICA PARA MUROS DE VIVIENDA DE INTERES SOCIAL. En Revista Legado de Arquitectura y Diseño No 23 de la Universidad Autónoma del Estado de México; ISSN: 2448-749X;pp 25-32;; http://www.redalyc.org/jatsRepo/4779/477954382024/477954382024.pdf; Last day of access August 5

.

IOSR Journal of Computer Engineering (IOSR-JCE) is UGC approved Journal with Sl. No. 5019, Journal no. 49102.

Rubén Salvador Roux Gutiérrez. " The Thermal Capacity Of Walls Made Of Rammed Earth As A Comfort Component At Housing In Tampico, Tamaulipas.." IOSR Journal of Computer Engineering (IOSR-JCE) 21.5 (2019): 33-40.