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Desde el año 2012, el Departamento de Ingeniería de Obras Civiles de la Universidad de La Frontera, se ha comprometido a promover la divulgación de investigaciones científicas- tecnológicas que se realizan a nivel nacional como internacional. Esta tarea se realiza a través de la Revista Ingeniería de Obras Civiles, la cual mediantes sus publicaciones regulares, se ha transformado en una fuente de divulgación continua para jóvenes y experimentados investigadores, representando un aporte a nivel regional, nacional e internacional.

El volumen N°10 de la revista RIOC presenta investigaciones que son altamente atingentes a las problemáticas mundiales actuales, desde la utilización de materiales reciclados en materiales constructivos, hasta la modelación de modelos hidrológicos de cuencas urbanas, reflejando el compromiso de la revista de promover el intercambio y actualización de conocimientos en ingeniería y gestión en la construcción.

Este volumen, al ser publicado virtualmente, permite ser un insumo valioso para profesionales, académicos y estudiantes que han decidido, en tiempos tan complejos como los actuales, seguir enriqueciendo sus conocimientos a través de investigaciones.

Dra. Viviana Letelier González
Directora del Departamento de Ingeniería de Obras Civiles
Universidad de La Frontera

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RIOC es una revista de carácter científico - tecnológico que proporciona un foro nacional e internacional para la difusión de la investigación y desarrollo en todos los ámbitos relacionados con la construcción, entendiéndose áreas como materiales de construcción, ciencias de la ingeniería aplicada, arquitectura, edificación, obras civiles, gestión de proyectos, entre otras.

En un momento en que existe una gran necesidad en todos los profesionales del área de la construcción por estar continuamente actualizados, para optimizar el uso de recursos, utilizar nuevas tecnologías que sean sustentables y eficientes, y a su vez, emplear nuevos métodos de construcción y materiales, RIOC proporciona un espacio para compartir y divulgar conocimientos, de manera tal, de abrir la discusión en estas temáticas planteadas, entregando información esencial que ayudará a mejorar la eficiencia, la productividad y la competitividad en los profesionales del área de la construcción. Por lo tanto, es una lectura esencial para proporcionar a los profesionales del área, académicos y alumnos que trabajan e investigan en este campo, un material de discusión que renueve y actualice sus conocimientos.

En este contexto, RIOC hace extensiva la invitación a todos los interesados a publicar sus artículos con la finalidad de divulgar la producción científica - tecnológica de académicos, investigadores, profesionales y estudiantes en temas relacionados con el desarrollo del área de la construcción.

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Avda. Francisco Salazar 01145,
Temuco,
Región de La Araucanía,
Chile.

Departamento de
Ingeniería de Obras Civiles,
Universidad de La Frontera.

Fono:
+ 56 (45) 2325680

Fax:
+56 (45) 2325688

Correo Electrónico:
rioc@ufrontera.cl

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Sumario

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RIOC REVISTA INGENIERÍA DE OBRAS CIVILES

Thermal conductivity of straw bales and other materials used in Ecuador's masonry by the thermal needle probe method.

Conductividad térmica de fardos de paja y otros materiales usados para realizar mampostería en Ecuador por el método de la aguja térmica.

Viera Paulina[1], Rivera Jean[1], Coox Octavo[1], Monzó José[1]

[1]Facultad de Ingeniería y Ciencias Aplicadas, Universidad Central del Ecuador, Quito, Ecuador, postal code: 170150
lviera@uce.edu.ec, teléfono: +593 99 612 8117

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Abstract

The construction industry in Ecuador faces a series of challenges regarding the implementation of the energy efficiency law passed in 2019. This law stipulates that the builder informs the buyers of the projects of their energy rating. Therefore, it is necessary to study and contrast the thermal properties of traditional and new building materials in the country. The main objective of this research is, through the thermal needle probe method, to obtain thermal conductivity data of materials used in bricks. This is the first time in Ecuador that such a comprehensive study about thermal conductivity in construction materials is developed. Also, the thermal needle is constructed by using basic principles and tools which reduce its cost to a minimum. The conductivity results obtained are between 0.344 and 0.986 W / K.m. Subsequently, the wheat straw bale, made from agro-industrial waste, is analyzed, obtaining that the average conductivity of this element is 0.045 W /K.m. It is concluded that it is possible to obtain the thermal conductivity of bricks by the method of the thermal needle and, that the bale of straw, with respect to the analyzed elements, is the only one that according to the Ecuadorian Standard of Construction meets the criteria of thermal insulator, so it could be constituted as an alternative for energy efficient homes.

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Resumen

La industria de la construcción en Ecuador enfrenta una serie de retos respecto a la implementación de la ley de eficiencia energética aprobada en 2019. Esta ley estipula que el constructor informe a los compradores de los proyectos sobre su calificación energética. Por lo tanto es necesario estudiar y contrastar las propiedades térmicas de los materiales de construcción tradicionales y nuevos en el país. El principal objetivo de esta investigación es, mediante el método de la aguja térmica, obtener datos de la conductividad térmica de los materiales utilizados en ladrillos. Esta es la primera vez, en Ecuador, que se lleva a cabo un estudio tan completo sobre la conductividad térmica en materiales de construcción. Además la aguja térmica ha sido construida usando herramientas y principios básicos lo cual reduce su costo al mínimo. Los resultados de conductividad obtenidos están entre 0.344 y 0.986 W/K.m Posteriormente, se analiza el fardo de paja de trigo, hecho a partir de desechos agroindustriales, obteniendo que la conductividad media de este elemento es 0.045 W/K.m Se concluye que es posible obtener la conductividad térmica de ladrillos por el método de la aguja térmica y que el fardo de paja es el único elemento que cumple con criterios de aislante térmico de acuerdo a la Norma Ecuatoriana de la Construcción, con respecto a otros elementos analizados, por lo cual puede constituir en una alternativa para viviendas energéticamente eficientes.

1. Introduction.

In March 2019, the Energy Efficiency Law, in spanish: "Ley Orgánica de Eficiencia Energética" (Asamblea Nacional, 2019) was approved by the Ecuador's National Assembly. In the Article 13 of this law, referenced to the construction sector, it is indicated that the building energy behavior should be reported. But the country does not have data in this regard. However, it is known that the residential sector is the second largest consumer of energy after the transport sector. The historical trend for the year 2020 indicates that this situation will not vary significantly. (MIDUVI, 2018)

To establish the energy efficiency of buildings, a first step is to determine the thermal properties of building materials. Note that, according to statistics obtained from the 2010 population and housing census, in Ecuador 58.7% of homes have block and brick walls (INEC, 2010). Within the design approach used on constructions on Ecuador, there are no normative considerations about thermal parameters that promote an efficient use of materials which, in addition to its minimal mechanical characteristics, reflect adequate thermal conditions, in the context of energy saving and housing comfort. Based on this reality, this study offers results of thermal conductivity obtained from the principal masonry used on Ecuador.

However, one of the difficulties in determining, for example, the thermal conductivity of these materials on-site, is the portability of the equipment. Previous studies in soft rock have shown the possibility of doing it with a thermal needle (Mosquera, 2013). Other research papers in Argentina and Ecuador have shown the possibility of using this method to evaluate thermal properties of masonry (Obando & Pachacama, 2018). The thermal needle method consists of an apparatus that injects current into the medium to be analyzed, thus raising the temperature. At the same time, the sensor is responsible for recording the variation of this value, taking into account the time elapsed in the test.

On the other hand, there are 4617 hectares of wheat planted in the country (INEC, 2017), which when harvested produce straw as a waste product, which is usually burned. That is, it is a totally wasted material, despite its importance in volume. With the purpose of including an ecological construction alternative that takes advantage of this material, this study also addresses its insulating properties.

2. Methodology

Below are the materials and methods of data collection and analysis used in this investigation.

2.1 Materials

The "traditional" materials that were used to determine their thermal conductivity were: burned clay, which is used in artisanal bricks, and cement concrete with and without pumice, which are used in concrete block walls.

A total of 26 trials were carried out with burned clay, and 20 with cement concrete with and without pumice. The samples were obtained from bricks and blocks of greater production in the Mejía Cantón, Pichincha Province, Ecuador**. Table 1** shows a summary of elements, material, identification, number of trials, average density and moisture content.

Element	Material	Type	Number of trials	Average dry density (kg/m^3)	Average moisture content (%)
Artisanal bricks	Burned Clay	LA	8	1504.56	1.95
		LB	8	1467.98	0.80
		LC	10	1476.67	0.74
Artisanal blocks	Cement concrete with pumice	BA	10	1586.13	13.81
Industrial blocks	Cement concrete	BB	10	1298.22	18.89
Straw bale	Straw	F	13	60.65	10.91
Plaster		R	10	1651.06	15.14
		Total	69		

Table 1 also shows that as a "non-traditional" material, straw bale was used, which also has a plaster mortar made with lime and cement, in a proportion of 1 to 6 as indicated by the North American standard (ICC, 2015). A total of 23 trials were performed. The test was carried out with the thermal needle perpendicular to the direction of the straw fibers. The material was obtained from wheat crops in the Mejía Cantón.

2.2 Methods of data collection and analysis

The method to determine the thermal transmittance was that of the thermal needle. The necessary apparatus was built by the researchers of this study, complying with ASTM D5334. [8]

Figure 1 and **Figure 2** show a plan view and the fundamental elements of the apparatus specially constructed for this work. It is observed that it is a device that captures temperature variations, which are transformed into digital signals by means of an Arduino board. Its cost is around 10% of the commercial

Figure. 1. Thermal needle.

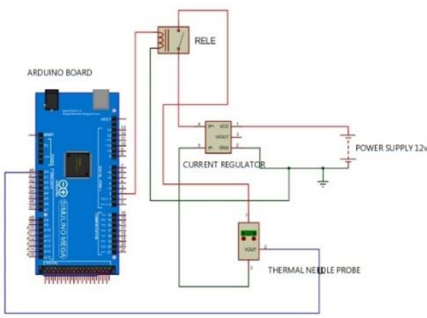

Figure. 2. Thermal needle layout.

In general, the theory indicates that the thermal needle method consists of a needle-shaped probe that has a large length-to-diameter ratio to simulate the conditions of a heat source of infinite and extremely thin length. The sensor (needle) must heat the medium under study and record the temperature variation of the medium.

The thermal needle sensors used in this research were produced by the East 30 Sensors Company (East 30 Sensors, 2019), and allowed the capture of temperature variation data, as well as the input of a direct current to increase heat in the medium to be tested. The dimensions of the needle sensor are: 6.00 cm in length and 1.00 mm in diameter. Additionally, the manufacturer provided the resistance values of each sensor purchased, which is summarized in the **Table 2.**

Table 2. Resistance of sensors used in the tests (SOURCE: EAST 30 SENSORS CALIBRATION CERTIFICATE. (EAST 30 SENSORS, 2019)

Sensor serial number	Heating element resistance (ohms)
1619	69.6
1620	69.6
1621	69.6

Calibration of these needle sensors was performed in two stages. The first consisted of correlating the voltage and bit values that it threw, to transform them into temperature data. For this, known values were used that correlate: voltage, bits and temperature of a waterproof submersible ds18b20 thermocouple from HK Shan Hai. (HK Shan Hai Group Limited, 2019).

Both the needle sensor and the thermocouple were subjected to a process of heating and cooling in water, to find an equation that in turn correlates the data from the thermocouple with the data from the needle sensor.

Figure 3 shows the relationship that exists between the data identified as temperature in the thermocouple ds18b20, in relation to the voltage data thrown by the needle sensor. After a regression process within a spreadsheet, the equation shown in **Figure 3** was obtained. This equation models the behavior of the needle sensor, with a coefficient of determination value of 0.9993.

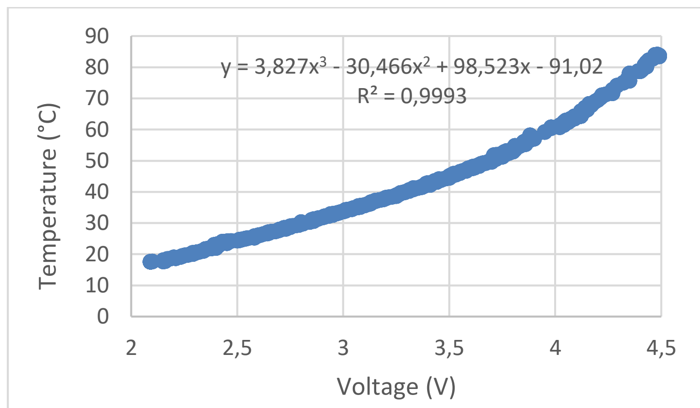

Figure. 3. Temperature vs Voltage.

From this information, the equipment as such was assembled, which schematically consists of a 12-volt power supply, a current regulator, a relay board and an Arduino board, on which the programming was carried out. and definition of the logic for the operation of the equipment as specified in the ASTM D5334 standard. **Figure 1** and **Figure 2.**

In the case of this study, the needle was heated for 120 seconds: initial 30 seconds, which are not taken into account in the data log, as it is the time required for the sample to enter thermal equilibrium; 90 seconds, in which data were taken from an average of 46 measurements per sample.

The dimensions of the sample, again according to ASTM D5334 (ASTM D5334, 2014), have to be at least those of the calibration specimen, which is made with anhydrous glycerin: cylinder of 7.20 cm in length and 4 cm in diameter. Additionally, the calibration of the apparatus was carried out with reference to the conductivity of glycerin (0.286 W/Km (ASTM D5334, 2014)) as shown in **Figure 4.** A calibration factor "C of 0.9698"was obtained.

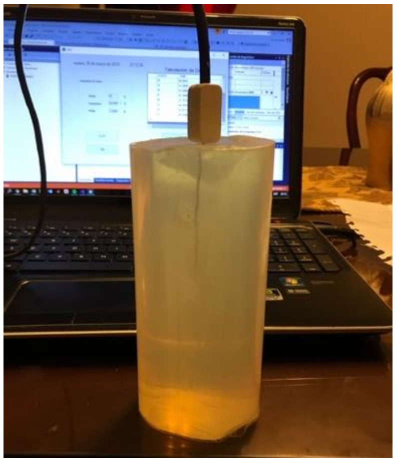

Figure. 4. Calibration process of the equipment in a glycerin cylinder

The samples were left inside the laboratory 24 hours prior to the test, so that they enter into thermal equilibrium with the environment.

It should be noted that, depending on the hardness of the sample, the needle may simply be sunk or perforation of a gap of slightly larger dimensions may be required.

To ensure the contact between the needle and the material, and therefore the transmission of heat to the medium under study, a thermal grease (thermal paste / grease) of high conductivity was used. The perforation had the same needle length (6 cm in length). The diameter of the needle is 1 mm.

Figure 5 shows one of the tests carried out on the blocks of cooked clay, where the needle was placed at the top, after drilling the sample and placing thermal grease**. Figure 6** shows the test carried out on the straw bale.

Figure. 5. Thermal needle probe on a block of cooked clay

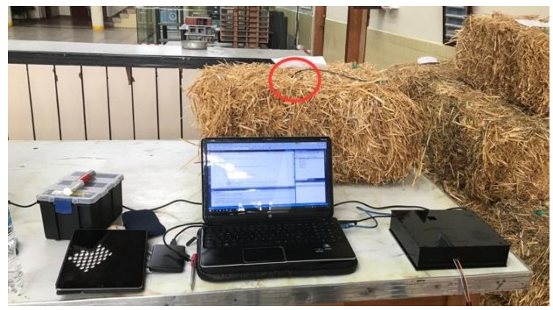

Figure. 6. Thermal needle probe on a straw bale

Once the needle is entered, a constant current is applied, so that the recorded temperature changes are less than 10 Kelvin in 1000 seconds. Relating the current with the voltage value (Ohm's law) the following values were used: 8.50 volts for the bricks and block, 8.55 for the plaster and, for straw 3.20.

With the data obtained, a linear regression of the temperature vs the natural logarithm of time was performed. An adjustment curve was obtained whose slope (S) is related to the heat input (Q) and the calibration factor (C) to calculate the thermal conductivity (λ):

$$Q = \frac{V^2}{R*L} \quad (1)$$

$$\lambda = \frac{C*Q}{4*\pi*S} \quad (2)$$

V = Voltage
R = Characteristic resistance of the needle (69.9 ohms, provided by the manufacturer)
L = Needle Length (6cm)

Of all the trials (69) in the different samples (26 artisanal bricks, 10 artisanal blocks, 10 industrial, 13 bales of straw and 10 plaster mortars), the median was calculated to characterize the materials. The NTE INEN 3066 Standard, Concrete Blocks. determines that the number of blocks to be tested according to the selected property is at least three.

The tests were conducted during the month of April 2019. The average temperature of the laboratory was 19.64 degrees Celsius and the relative humidity 59.91%.

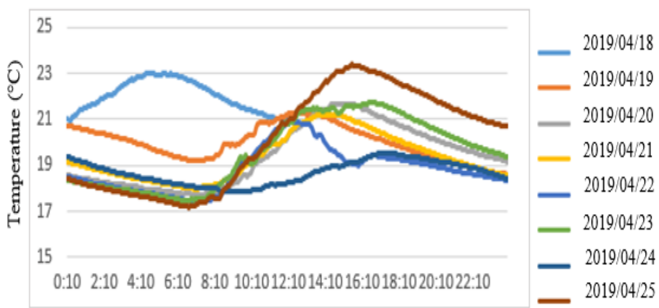

Figure. 7. Hourly Temperature of Materials testing laboratory in Faculty of Engineering and Applied Sciences Universidad Central del Ecuador.

From the previous figure, minimum temperature values of 17.20 ° C and maximum of 23.38 ° C were recorded, and that the average temperature in the analyzed period was 19.64 ° C.

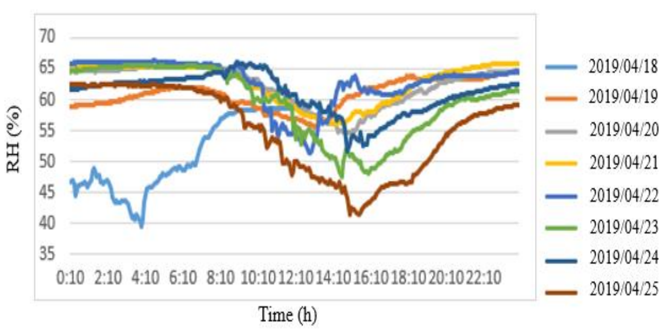

Figure. 8. Hourly Relative Humidity of Materials Testing Laboratory in Faculty of Engineering and Applied Sciences Universidad Central del Ecuador.

Similarly, the minimum relative humidity value recorded was 39.43%, the maximum was 66.25% and the average was 59.91% (**Figure 8**).

These data (**Figure 7** and **Figure 8**) determine the atmospheric conditions in which the tests were developed and should allow their repetition in future research. This is due to the fact that the influence of these factors is not fully understood. In fact, the effects of temperature and pressure on thermal conductivity are ambiguous: "Temperature is known to affect thermal conductivity, but how and to what extent is still uncertain" (Midttømme & Roaldset, 1999).

3. Results and Discussion

The thermal conductivity results are shown in **Table 3**.

Table 3. Thermal conductivity of the materials tested. [12](IRAM, 2004) [5](Costes et al., 2017) [13](Lira-Cortés et al., 2008) [3](Bustamante et al., 2018) [6](Cuitiño et al., 2015) [7](Dondi et al., 2004) [18](Sassine et al., 2017) [8](Gurskis & Skominas, 2013)

Id	Element	Thermal Conductivity (W/K.m)				
1	*Artisanal bricks*	0.344	0.910 [12]	0.492 [7]	0.690 [4]	0.811 [5]
2	*Artisanal blocks*	1.207	0.810 [12]	0.391 [13]	0.312 [3]	1.630 [6]
3	*Industrial blocks*	0.986	0.810 [12]	0.391 [13]	0.312 [3]	1.630 [6]
4	*Straw bale*	0.045	0.070 [5]	0.0487 [8]	0.050 [8]	0.067 [6]
5	*Plaster*	1.243	1.160 [12]	1.410 [4]		

In **Table 3**, the first column of data is that of the median of the experimental results of thermal conductivity of the materials with which the tested mountings are made. The other columns show results obtained in different studies.

In analysis of results, it shows variability of the thermal conductivity values obtained with respect to various references. This variation, (Ouedraogo et al., 2019), is due to factors such as: density, porosity, content of averagee humidity and temperature of the material.

In the case of straw bale, its variations are much smaller compared to those of other materials.

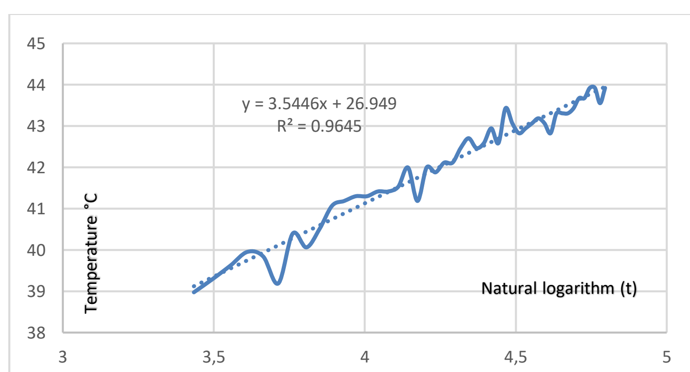

Figure. 6. Temperature vs natural logarithm of time plot.

The figure above shows the standard plot that it´s obtained analyzing the results of the thermal conductivity test. As seen, the adjusted curve has a positive slope pointing out that, with an increase of time, the temperature will rise. This behavior shows significant variances along the curve, in points where the data trend indicates an abrupt drop or rise of temperature in a small interval of time (Mosquera, 2013). This method has a high sensibility to temperature variations. Based on the results of this investigation, we can speculate that this discrepancy depends on the porosity and density of the material on study. To assure this, on all the tests performed the correlational coefficient (R2) was calculated. The trend shows that bricks, whom are more compact in this case, tends to have a greater coefficient than the others materials in study. This implies that this kind of materials (compact and with less porosity), show less variance of temperature.

The following **Table 4** shows the standard deviation of the obtained thermal conductivity data.

TABLE 4. Standard deviation of the obtained thermal conductivity data.

Element	Material	Type	Standard Deviation of the data (Thermal Conductivity)
Artisanal bricks	Burned Clay	LA	0.385
		LB	0.332
		LC	0.314
Artisanal blocks	Cement concrete with pumice	BA	1.149
Industrial blocks	Cement concrete	BB	0.986
Straw bale	Straw	F	0.045
Plaster		R	1.243

According to the Ecuadorian Construction Standard NEC 11, (MIDUVI, 2018) is considered thermal insulating material when its surface heat exchange coefficient is λ less than λ < 0.085 kcal / m2.°C measured at 20°C (mandatory) or 0.10 W / m2.K. The thermal transmittance is inversely proportional to the thermal resistance.

Likewise, an insulating material is one that has a thermal conductivity value less than 0.05 W/K.m. (Sassine et al. 2017)

4. Conclusions

The thermal needle probe method yields result of the same order of magnitude as those presented in the literature.

The results are especially close to those of the literature in the case of straw and plaster mortar. For artisanal brick, the results are relatively low, but it is the opposite for artisanal and industrial blocks. These differences can be explained by considering the constructive differences between Quito and other sites.

The thermal needle probe method clearly shows differences between construction materials, which allows to establish, in a first approximation, its thermal quality.

A limitation of the study is the cost of commercial thermal probes, around 8,000 USD, apart from the need to import them, which forced its handmade construction. This may affect the results due to the need for probe calibration.

On the other hand, the results of the bales of straw indicate their excellent insulating properties, which makes it an alternative to obtain indoor environments with controlled temperatures with low energy consumption.

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Authors' information

Luisa Paulina Viera-Arroba was born on October 8, 1973 in the city of Ambato in Ecuador. She studied undergraduate and postgraduate studies at the Technical University of Ambato. Professor Viera graduated in Civil Engineering with a specialization in Structures in 2001, and as a Master in Seismic Resistant Structures in 2004. She is currently pursuing a doctoral degree at the Universitat Politècnica de Valencia. Professor Viera currently teaches at the Universidad Central del Ecuador in the chairs of Constructions I and II.

UNIVERSIDAD DE LA FRONTERA
Departamento de Ingeniería de Obras Civiles
Facultad de Ingeniería & Ciencias
RIOC
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Characterization of new insulators for architectural envelopes with non-traditional materials.

Caracterización de nuevos aislantes para envolventes arquitectónicas con materiales no tradicionales.

Becerra Abraham[1], Busnelli Roberto[1]

[1] Universidad Nacional de San Martin, Instituto de Arquitectura. abecerraman@gmail.com

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Abstract

This work deepens into the need to study synergies between fundamental criteria for sustainable development in construction: environmental, socio-economic and techno-scientific. According with this, the sustainability of an envelope based on the Sistema Constructivo 3C is characterized, which is self-constructed and uses recycled plastic bottles. This system has a light wooden framework structure that uses a pile of compacted polyethylene terephthalate (PET) bottles inside and two faces, one inside and other outside, with a coating made with traditional cement plaster. In order to consider the social benefit for the development of the Sistema Constructivo 3C, criteria of techno-scientific, environmental and social were used. This system showed high thermal performance in insulation and fire resistance compared to other systems based on traditional materials. A positive synergistic effect was observed between the air and the plastic bottles that allowed increasing thermal performance of the construction system. The air between the bottles decreases the thermal conductivity and the thermal transmittance of the construction system. Besides, the bottles compacted in the core system reduced the flame spread. These beneficial synergies by the use of non-traditional materials could be explored and enhanced according to the thermal properties offered by other non-traditional materials. The implementation of strategies to reuse PET bottles by mechanical means without the use of energy, it exposes the potential of these non-traditional materials for: their use in construction, the development of local resources and capacities, and the promotion of circular economy. The characterization of the construction system presented in this work contributed to generating a manual that, as a work protocol, allowed it to be traced, establishing guidelines for waste management and its subsequent implementation. This manual will allow the training of human resources both for the production of plastic piles and to participate in some process of the construction of the houses.

Resumen

Este trabajo profundiza en la necesidad de estudiar las sinergias entre los criterios fundamentales para el desarrollo sostenible en la construcción: ambientales, socioeconómicos y tecnocientíficos. De acuerdo con esto, se caracteriza la sostenibilidad de un sobre basado en el Sistema Constructivo 3C, que es autoconstruido y utiliza botellas de plástico recicladas. Este sistema tiene una estructura de armazón de madera ligera que utiliza una pila de botellas de tereftalato de polietileno (PET) compactado en el interior y dos caras, una interior y otra exterior, con un revestimiento realizado con yeso de cemento tradicional. Para considerar el beneficio social para el desarrollo del Sistema Constructivo 3C se utilizaron criterios tecnocientíficos, ambientales y sociales. Este sistema mostró un alto rendimiento térmico en aislamiento y resistencia al fuego en comparación con otros sistemas basados en materiales tradicionales. Se observó un efecto sinérgico positivo entre el aire y las botellas de plástico que permitió incrementar el rendimiento térmico del sistema constructivo. El aire entre las botellas disminuye la conductividad térmica y la transmitancia térmica del sistema de construcción. Además, las botellas compactadas en el sistema central redujeron la propagación de la llama. Estas sinergias beneficiosas mediante el uso de materiales no tradicionales podrían explorarse y mejorarse de acuerdo con las propiedades térmicas ofrecidas por otros materiales no tradicionales. La implementación de estrategias para reutilizar botellas de PET por medios mecánicos sin el uso de energía, expone el potencial de estos materiales no tradicionales para: su uso en la construcción, el desarrollo de recursos y capacidades locales, y la promoción de la economía circular. La caracterización del sistema constructivo que se presenta en este trabajo contribuyó a generar un manual que, como protocolo de trabajo, permitió rastrearlo, estableciendo lineamientos para la gestión de residuos y su posterior implementación. Este manual permitirá la formación de recursos humanos tanto para la producción de pilotes plásticos como para participar en algún proceso de la construcción de las viviendas.

1. Introduction

Problems generated by the increase and shortcomings in final disposal of Non-Hazardous Industrial Waste (NHIW) and Urban Solid Waste (USW) produced in the district of General San Martín, Province of Buenos Aires, generated a line of investigation in the Instituto de Arquitectura y Urbanismo (IA) - de la Universidad Nacional de San Martín (UNSAM), for its transformation into new materials or supplies for construction and market creation in the recycling industry. On many occasions, these wastes end up accumulating in landfills for years, decades, or even centuries as they degrade.

The development and technical verification of materials based on NIHW-USW is an important focus of research and development in the world. In the same way, the impulse given to a variety of new materials manufactured from construction and demolition waste and from pruning and crop residues has increased, to try to mitigate the great impact on energy use, CO_2 production and environmental pollution associated with the life cycle of buildings.

The International Energy Agency (IEA) estimates that: 60% of the materials that are extracted from the lithosphere are destined for construction, 40% of the primary energy consumed on the planet and 75% of the electricity is destined to buildings, 60% of solid waste is produced in the construction and deconstruction of buildings (1.3 t per person/year) and that approximately 50% of the polluting CO_2 emissions are emitted by them. These consumptions and impacts occur during the extraction of raw materials, with their transformation from industrial processes, during the construction of buildings, throughout their useful life, with their use and also at the end of this with deconstruction of the building. The complexity of theses processes makes it difficult to propose strategies that are common in other consumer products. However, these data are already sufficiently illustrative to realize that we cannot continue on this current path and that we must initiate a process of change of great proportions, in our sector, to be able to talk about sustainability. An area where we especially see an intensive use of industrialized materials, which originate from the use of fossil fuels, is the thermal, acoustic and waterproof insulation that we use in the envelopes of our buildings. We understand that there is a great potential for the development of new products or materials, as a result of the reuse or recycling of NIHW-USW, that allow these products to be replaced by solutions with less environmental impact. That is why from the IA UNSAM we have been developing a line of research, accredited in Conicet, an Atlas of Industrial Solid Waste that allows converting this waste into new inputs to incorporate into the world of construction. This repertoire of new materials and techniques of sustainable construction challenge the very heart of technical regulations and propose new logics of analysis to regulatory frameworks; establishing new criteria and weighing new standards, where the requirement and objectives of these protocols are not only established based on strict compliance with their technical dimension but also in light of an environmental cost, which as such, will have a decisive impact when it comes to evaluate their technical performance.

2. State of the question

The performance of envelope in buildings increases as energy consumption decreases to preserve comfort. At the same time, comfort is maintained when: air quality inhibits the development of diseases, the temperature range is comfortable, and noise pollution is low (Sundell 2004, Däumling et al. 2005). Today, indoor air quality has become very important due to forced confinement by the global pandemic. The enclosure must comply with standards that consider: thermal conductivity, acoustic absorption, thermal transmittance (K value), content of harmful substances and fire resistance. K values requirements are defined by IRAM 11.605 standard, for each bioclimatic zone in Argentina. According to IRAM 11603 standard, Metropolitan Area of Buenos Aires (MABA) has a bioclimatic zone III, with temperatures in winter between 8°C and 12°C. Therefore, an enclosure system approved for use in MABA must have a K value less than 1.85 W/m2K. This value ensures that there is no surface condensation inside the home throughout the year, according to the IRAM 11625 standard.

The approval of products for use in construction in Argentina is carried out following the guidelines of the Certificate of Technical Aptitude (CTA), which is governed by the Regulation approved by Resolution SVOA No. 288/90. The CTA requires compliance with a number of essential requirements related to the application of building materials and systems. In general, the homologation of non-traditional materials requires more tests than traditional ones, due to the limited experience in the use of non-traditional materials on site. Non-traditional systems are those that do not have norms, regulations, provisions or resolutions of national organizations that establish the conditions to which the use and manufacture must comply, or that it is not clearly disseminated (Ministerio del Interior Obras Públicas y Vivienda 2019). Among the non-traditional materials are those based on NIHW-USW and reuse sources, such as plastic waste and natural fibers. The certification by CTA focuses only on techno-scientific criteria, so it is unable to weigh the environmental and social impacts that the development of non-traditional materials involve. For example, a product that is easy to manufacture and based on NIHW-USW can bring benefits: environmental (Khatib 2016), reduction of the CO2 load in the environment, soil recovery; social (Kono 2018), job creation in regions with low technological development and improvement of outdoor air quality; and economical.

According to the dictionary of the Real Academia Española (RAE), when we speak of technique we refer literally to the "set of procedures used by a science or art". According to Juan Herreros: “technique appears before us as a powerful instrument of anchoring ideas to their time", so it seems essential that we revise this definition beyond the traditional notion that associates technique only with the positive resources directly involved in the idea of build and extending the limits of this definition so that we allow us to understand our responsibility as actors involved in the construction industry and not only in the endogamous environment of the technical-scientific discourse. The challenge is to identify which are the variables and dimensions that should interest us in this complex and contradictory present, which accounts for a permanent deterioration of our ecosystem and which has led us, contrary to what the Brundtland (Brundtland 1987) report promulgated as a definition of sustainable development, to have today to live with an environmental mortgage.

One strategy to make this possible is to produce transfers from other knowledge that allow us to look at and understand other places, cultural and social contexts, new patterns of consumption, to obtain new references, lexicons and models with which to operate. A comprehensive and holistic look that not only intervenes in the pre-established protocols in the form of rules or norms, but also investigates how to obtain new ideas and instruments with which to negotiate in our imperfect context. In an inequitable world, technology continues to be today an unequally distributed heritage, so we must assume a responsible position to avoid the imposition of the strongest at any scale and promote dialogue, equal and democratic participation with the same resources and possibilities that promote the development of a sustainable conscience that activates a new agenda to reorient our practice.

The development of non-traditional materials plays a fundamental role in the construction of this new agenda and in the fulfillment of at least nine of the 17 Sustainable Development Goals of the 2030 Agenda (Opoku 2019). This agenda was promoted by the United Nations and includes 169 specific goals that must be achieved before 2030. In addition, this year the “New Plastics Economy Global Commitment” was signed, which promotes the reinsertion of plastic waste in the manufacture of new materials. The challenge for construction sector is to ensure that new or renovated building is sustainable throughout the life of the building. This also applies to the materials that make up the building. While many materials are touted as sustainable, they lack beneficial synergy between the three criteria of sustainability (social, economic, and environmental) because they neglect the relevance of synergy. Synergy comes from the Greek word συνεργία, which derives from συνεργός (synergos), which means "to work together". According to the RAE, synergy is the action of two or more causes whose effect is greater than the sum of the individual effects. On the other hand, in one of the first scientific works that mentions the word synergy, the sociologist W. Lester (Lester 1918) defined it as the universal constructive principle of nature. Studying the synergy between criteria is also relevant because it does not always generate benefits. For example, polyurethane is an inexpensive synthetic insulation with high thermal performance, but it contains harmful substances in its chemical composition (techno-scientific criteria) that harm human and environmental health (social and environmental criteria). Therefore, the study of the synergy between the three social, economic and environmental criteria helps to promote sustainable development, but it is usually complex due to the multidisciplinary nature of the subject.

Currently, there are tools that weigh the useful life, recyclability and environmental impacts of materials in construction, but these are still dissociated from techno-scientific evaluations of social and environmental ones. Considering these difficulties, Akadiri (Akadiri2011) and Govindan (Govindan2016) propose indicators for the sustainable selection of construction products. These indicators arise from an extensive review of works and surveys carried out on 490 architects and designers with a long professional career. The indicators are grouped into criteria environmental, techno-scientific, social and economic, which confirms the need for a multidisciplinary and holistic approach for the sustainable selection of materials. The indicators proposed by Akadiri and Govindan are useful to design a methodology for the approval or development of sustainable materials. This methodology can be unified with the one proposed by the CTA, since in this way the essential requirements of the material would be included as indicators of the techno-scientific criteria, together with the social and environmental criteria.

According to works of Akadiri and Govindan, to evaluate sustainability of a material is important to quantify the indicators of each sustainability criterion, then to detect the interconnections that exist between them and finally promote those that generate beneficial synergy. In this way, impacts of criteria social, environmental and economic generated during the manufacture, use and final disposal of the material can be weighed. A quantitative way to compare the environmental performance of products in construction is through their environmental product declarations (EPDs). The EPD is a statement based on a life cycle assessment according to ISO 14025 and EN15804. In Argentina, the development of EPDs is still incipient in the construction industry. However, to get an idea the magnitude of environmental impact of a material, it is useful to compare EPDs developed with the same product category rule in the same geographic region.

The quantification of the techno-scientific criteria in materials is carried out with the characterization process. This process includes micro and macroscopic technical analyzes that report on the mechanical, physical and chemical properties of the material. The characterization of traditional materials in construction is well advanced due to the extensive knowledge of these materials. However, this knowledge is limited in non-traditional materials, so it has to be expanded to facilitate the homologation of these materials. In an interesting work, Asdrubali et al. (Asdrubali 2015) summarize the thermal and acoustic performances of various non-traditional materials based on industrial and agricultural waste. These authors report that in general the thermal performance is characterized, but not the behavior against fire during a fire or the properties related to the degradation of the material. The degradation of a non-traditional material could affect the health of the home and its occupants after a long time (> 1 year). This fact makes the study of degradation less relevant when compared to the thermal study. By improving the thermal performance of the material, the consumption of the electricity bill is reduced and this is perceived easily and quickly. On the other hand, the current regulations in Argentina lack standardized tests that evaluate the degradation performance of non-traditional materials in various environments. This makes both the evaluation of the sustainability of the non-traditional material and the certification difficult. Asdrubali et al. (Asdrubali 2015) also mention that due to the prototypical state of various non-traditional materials, information on their environmental impacts is not yet available. This is due to the fact that most of these material developments are limited only to an experimental and laboratory stage, making their insertion into the construction products market difficult.

3. Objectives

This work arises from the need to draw links between the fundamental criteria for a sustainable approach: environmental, socio-economic and technical. In this line, a non-traditional construction system for self-construction is studied, based on wood and plastic waste. In addition, in order to weigh the social benefit for the development of the construction system, techno-scientific and social criteria will be used.

This social dimension is what can introduce a new factor, which we can call service, which makes the development of a repertoire of new materials timely and necessary (as a result of the reuse or recycling of NIHW-USW waste), in response the deep environmental deterioration and an endless number of new social and cultural phenomena that we can identify.

4. Working hypothesis

Within these processes of invention of new systems, the use of new materials makes special sense, and consequently their techniques jeopardize the traditional logic of certifications and architectural construction regulations. Almost 90% of the material we discard is recoverable.

This creativity of the new resource is based on the possibility of “seeing” the value that each waste has, this value is implicit in the material, in the status that we assign to the materials that come from recycling and the potential possibility that the design has and architecture to transform our perception of waste.

In this context, and with a number of entrenched interests, the application of new inventions in architecture becomes a political issue, where bureaucratic barriers often drive innovation outside of architecture. A well-developed and technically approved transgressive innovation can offer innovative and unexpected solutions.

This repertoire, of new materials and techniques of sustainable construction, challenge the very heart of technical regulations and propose new logics of analysis to regulatory frameworks; establishing new criteria and weighing new standards, where the requirement and objectives of these protocols are not only established based on strict compliance with their technical dimension but also in light of an environmental cost, which as such, will have a decisive impact when it comes to evaluate their technical performance.

This view allows us to describe this project process and its construction as a research work and include it in a superior network of experiments in which a scientific community participates and is nurtured, which not only appreciates the results but is also interested in reading the initial conditions, the choice of new parameters and the invention of systems that allow the participation of the end user. An ethical dimension of technological development that, on a global scale, allows us to understand and question the logic of the rules by which societies build.

5. Experimental method

5.1 Constructive study system

This work technically characterizes a development that arises from the Sistema Constructivo 3C for insulation of the envelope, based on a wooden framework under the CIRSOC 601 standard. This system was designed using “intermediate” technology (economical and simple implementation, with production capacity industrial with high performance for the pre-manufacturing) and “adapted” (that can use installed knowledge or promote training workshops to transfer this knowledge to the community). The Sistema Constructivo 3C has a structure of three differentiated layers: internal, intermediate and external. The internal face was made up of a 3 cm thick lime-plastered synthetic fiber mesh. The outer face consisted of a synthetic fiber mesh plastered with a water-repellent mortar and lime finish 3 cm thick. However, for the test that measured the thermal transmittance of the material (standard RAM 11564) both on the internal and external faces, they were covered with 12.5 mm thick plasterboard, one vertical and other horizontal. The decision to use these plates on both sides, for the specimen of this test, responds to the fact that the K values of these products are already known, so it is very easy to discount these values to obtain the result corresponding to the compacted PET pile.

The inner layer of the Sistema Constructivo 3C consists of a pile of plastic waste located within the wooden framework and fulfills the role of thermal insulation of the building system. The plastic mound was made up of a compacted bale of recycled polyethylene terephthalate (PET) bottles. In order to promote self-construction of the system, a pulley-activated manual press was manufactured to compact the recycled PET bottles, **(Figure 1a).** The compaction load was adjusted until obtaining molds of dimensions 105 cm x 60 cm, containing 180 compacted bottles, **(Figure 1b).** To build a panel of the construction system, 2880 recycled bottles (16 piles) with a total mass of approximately 96 kg were used. The plastic pile had a mass per area of approximately 18 kg/m2. The wooden frame was made of Ellioti pine slats of 0.18 mx 0.05 m section and variable length. This frame covered a total area of 3 m x 3 m and was built by placing the vertical slats 60 cm apart from each other, **(Figure 1c).** The vertical slats served as a guide to arrange the plastic molds between them.

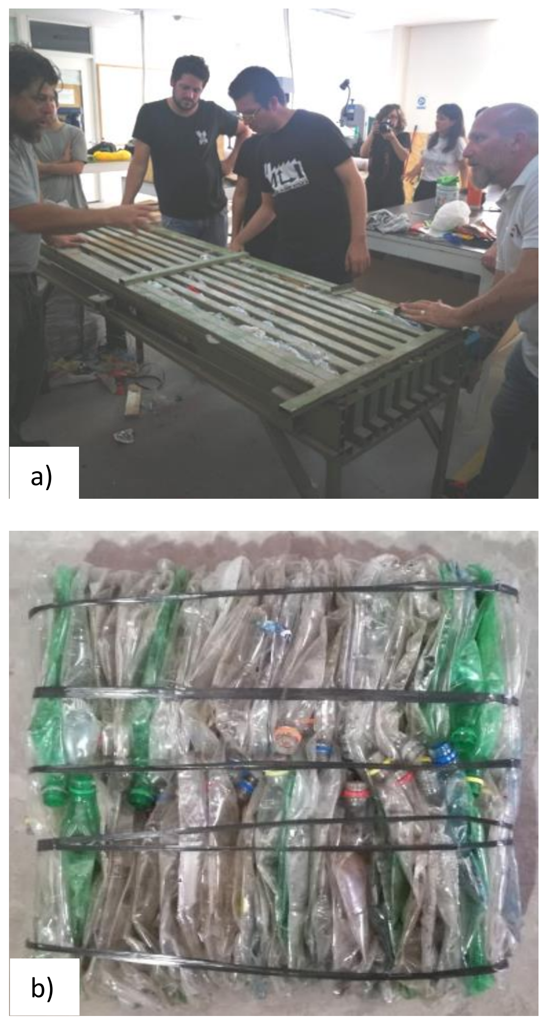

Figure 1 a) Works with the manual press activated by pulley. **b)** Pile of compacted plastic bottles**. c)** Dimensions and distribution of the wooden slats containing the plastic molds and the application of cementitious plaster. Source: Own elaboration.

5.2 Characterization of the construction system

The thermal and fire performance of the Sistema Constructivo 3C was characterized, using the standards: DIN 4102-1, IRAM 11949, IRAM 11950, IRAM 11912 and IRAM 11564. Depending on the test, samples with different dimensions and typologies were characterized, due to the different objectives and requirements of the above standards. It should be noted that all these tests were carried out in the facilities of the INTI Construcciones laboratories. With these tests it was determined: the behavior against fire of the materials and construction elements (DIN 4102-1), the fire resistance of the construction elements (IRAM 11949 and IRAM 11950), the optical density of the smoke generated by combustion or pyro decomposition of solid materials (IRAM 11912) and the properties of heat transfer in steady state of the building elements (IRAM 11564). Prior to all the tests, the PET bottles were washed to eliminate the remaining residues.

IRAM 11912 standard characterized the optical density of fumes from PET bottles. This test was applied exclusively to PET because the other materials that build up the Sistema Constructivo 3C have extensive experience and knowledge in the literature and on site. **Figure 2** shows the 1 m length of compacted PET bottles and the installation of the oven used in IRAM 11912, which was performed in quadruplicate. The evaluation of the optical density of smoke emitted by PET bottles was carried out without a flame to study their pyrolytic decomposition and with a flame to determine their combustion.

The flammability of PET bottles was characterized with DIN 4102-1 standard. The temperature rise in the furnace hood relative to the initial temperature and the length of the flame spread vertically were measured. This length is evaluated considering the residual length of the specimen that remains unburned after the test. According to DIN 4102-1, the residual length in each specimen must be at least 15 cm and in no case 0 cm, which would indicate that the specimen burned completely. The manufacture of this specimen had to be adapted to a metallic framework that is used to support the specimen according to the regulations **(Figure 2a).** Instead of using the press of compacted PET bottles **(Figure 1b),** a test tube was made consisting of four columns of perforated plastic sheets attached to the metal framework **(Figure 2b).** The bottles had to be cut because the edge of the base of the framework was less than the length of the plastic bottles. The bottle density of the mold had to be extrapolated to PET sheet geometry. These difficulties arose from a limitation of DIN 4102-1 standard, which lacks indications for testing materials with non-traditional geometries such as a bottle. It is relevant to mention that the discrepancy between the test geometries and the original used in the construction system could modify the final technical performance of the system. This modification is relevant when the geometry of the non-traditional material is a variable of the technical performance of the system. For the case of PET bottles, this effect of geometry is being studied by the authors of this work. The above observations suggest that DIN 4102-1 would have to be modified to include the geometrics of non-traditional materials and thereby lessen the difficulties in testing these systems.

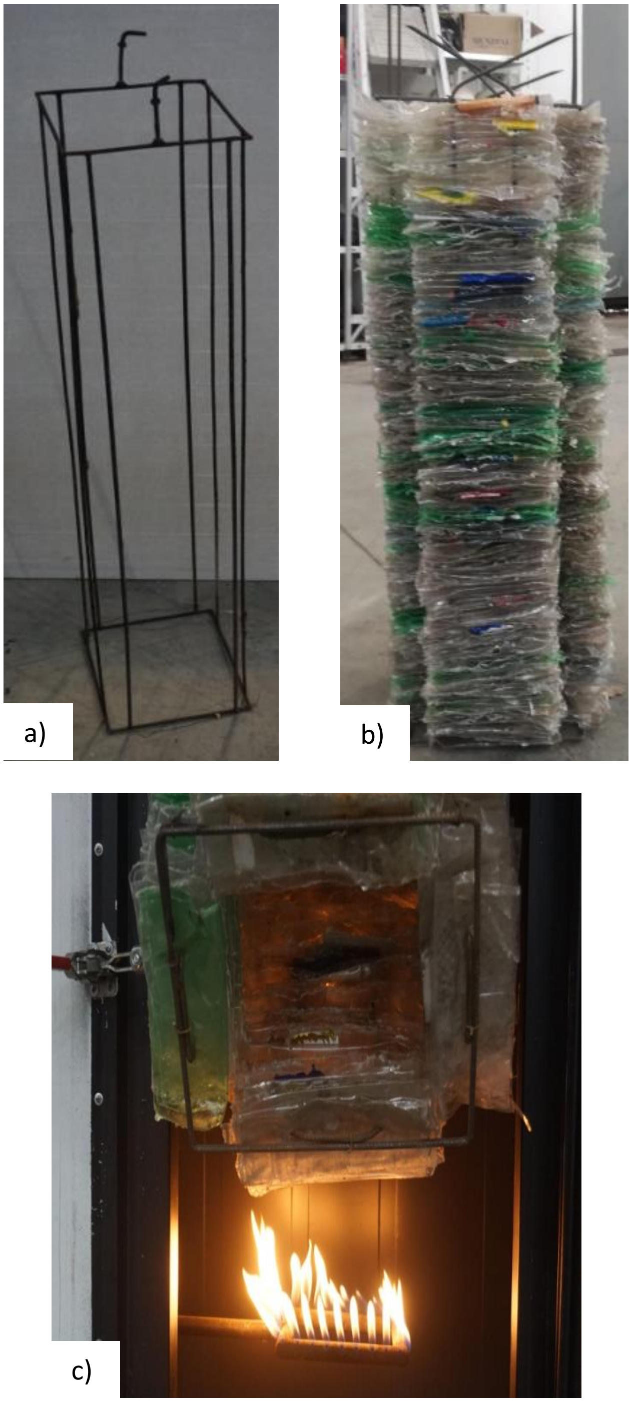

Figure 2 Photographs that show testing of combustibility and optical density of recycled PET bottles. **a)** Lattice of metal rods for the manufacture of the test tube**, b)** arrangement of the PET sheets extracted from the bottles to be able to form the test tube, c) detail of the burners located in the lower part of the test tube. Source: Own elaboration.

The stationary heat transfer properties of the building elements were determined (IRAM 11564). A square specimen with a 2.4 m edge and 0.205 m thickness was tested, using the hot box method with a storage box. This specimen consisted of 16 molds of PET bottles inside a wooden frame covered by gypsum panels on both sides. During the 120 h test, the ambient temperature was 21.9°C. Resistance to fire was characterized with IRAM 11949 and IRAM 11950 standards. A representative sample of a real case of a wall was used, that is, a 3m x 3m surface test piece, **Figure 1b**. This specimen was evaluated as a simple closure without load. To simulate the fire condition, a combustion furnace with eight burners was used on each vertical wall. The temperature measurement on the face of the exposed sample outside the oven was performed with five thermocouples located as shown in **Figure 3**. At the time of starting the test, the ambient temperature was 15°C.

It is important to clarify that the design of the test piece was carried out taking the most unfavorable conditions for this test, since no product was applied to protect the wooden structures or retard their ignition and subsequent fire spread, as well as the choice of termination of their faces with cementitious mortars in contrast to the possibility of having used industrialized plates that have already proven their resistance in this test. This decision was based on replicating the simplest and most economical conditions with which this constructive practice can be transferred to the territory, understanding that this installed knowledge, added to a small-scale economy, would guarantee universal access to this system.

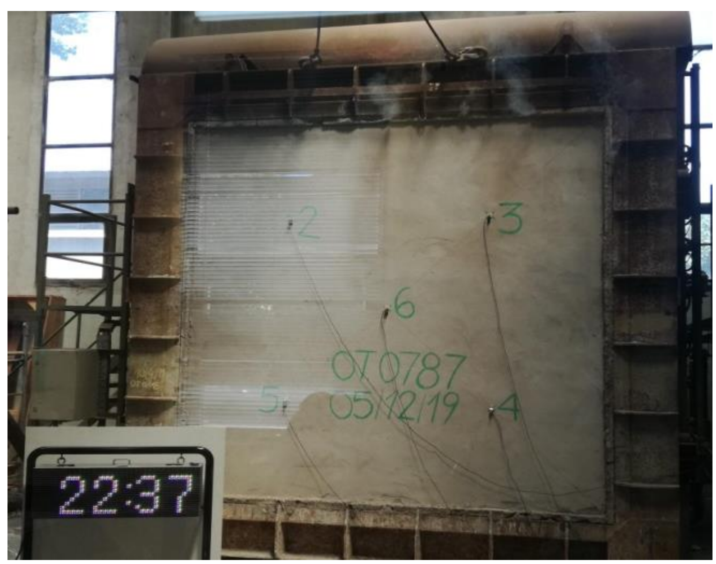

Figure 3 Specimen for fire resistance of 3m x 3m and arrangement of five thermocouples on the face exposed to the exterior, as indicated by the IRAM 11950 standard. This photograph was obtained at 22:37 minutes after the test began. Source: Own elaboration.

6. Results and discussion

6.1 *Thermal and fire performance*

PET bottles showed a reduced amount of fumes because it was classified as Level 1 according to IRAM 1192. This level corresponds to the best score that can be achieved according to this standard. In addition, PET bottles had low flammability because they were classified as B1 according to DIN 4102-1, **Figure 4.** These results were obtained for the four tested specimens, which confirm similar characteristics between specimens and standardization in the manufacturing process. Although it is true that these PET bottles presented greater compaction than the plastic molds **(Figure 1b)**, these results confirm that PET is a suitable material for use in construction.

Figure 4 Measurement of the burnt and residual lengths, which corresponded to 340 mm and 460 mm, respectively, during the flammability and optical density smoke tests. According to DIN 4102-1, the material exhibits low flammability when the residual length is at least 150 mm for all tests. Source: Own elaboration.

The thermal transmittance of the Sistema Constructivo 3C panel measured experimentally was 1.05 W/m2K, considering apparent convection coefficients of 7.69 W/m2 K for indoors and 25 W/m2K for outdoors. Discounting the thermal effect of the two internal and external plasterboards, the thermal transmittance of the wooden framework with plastic molds was calculated at 1.21 W/m2K. This value is lower than that required by IRAM 11.605 standard for thermal conditioning of buildings. According to this standard, a K value equal to 1.05 W/m2K certifies an interior temperature of 20ºC and the absence of surface condensation for a house built in the MABA region. Category B of the building code of the province of Buenos Aires establishes a value of 0.95, a value that is very close to that obtained with the two plasterboards, taking into account that it is a simple wall and the same plates were used only for the test (since the values K of these products were known and it was very simple to discount them to obtain the tested mole). For its real application, the external face should be replaced by another plate that guarantees resistance to weathering, so that the value required by category B could be achieved using a 6 mm OSB plate added cementitious plate of 10mm thickness on the outside.

Sistema Constructivo 3C demonstrated a fire resistance of FR 60, according to IRAM 11950: 2010. The tested system complied for 60 minutes with the parameters of stability, thermal insulation and tightness to the passage of flames and hot gases measured on the face not exposed to the fire and as such it can be used for two-story homes, according to the IRAM 11949: 2014 standard. According to what was observed at the end of the test, this resistance depends on guaranteeing the integrity of the coating on the interior face of the wall. It should be noted that the FR 60 value was obtained without treating the wood against fire, so the FR value could increase if this treatment is applied. There are various alternatives to protect wooden structures or retard their ignition and subsequent fire spread, also to preserve the integrity of the inner layer of the wall from the use of different types of plates (when we work with dry construction systems) or in the case of cementitious mortars, the need to guarantee a constant thickness of at least 3cm thick, as stated as a recommendation on page 15 of report OT No. 224-0787.

6.2 *Standardization in the construction of the construction system*

For the Sistema Constructivo 3C to maintain the thermal and fire performance characterized in this work, its manufacture must follow a protocolized standard. The variables of each stage of the process have to be defined simply and clearly, considering that this system is self-constructed. Therefore, the systematic and organized dissemination of this knowledge among the community is a key to ensuring the comfort and safety conditions of their homes.

Many contributions to this protocol were fostered from the performance of the aforementioned trials. Among the relevant variables for the manufacture of the 3C Construction System are the cleanliness and uniformity of the recycled plastic material. The presence of organic residues inside the PET bottles modifies the technical performance of the system and increases the dispersion of the results in the characterization tests. The liquids and organic matter remaining in the bottles have a different physicochemical nature than plastic, which could modify the behavior of the system. For example, during the reaction to fire test (IRAM 11950) that simulates the temperatures of fire, the remaining water inside PET bottles could suddenly evaporate and generate internal pressure in the panel. This pressure could increase to internally break the construction system and then crack it, which reduces its performance against fire. On the other hand, prior to compacting the PET bottles, the labeling tape and its screw cap have to be removed because they are manufactured with other materials. The tape is waterproof varnished paper and the cover corresponds to polypropylene or high-density polyethylene. These materials have a different physical-chemical nature than PET and therefore can modify the thermal and fire performance of the panel.

To ensure the systematization of the Sistema Constructivo 3C manufacturing, the variables of each stage must be kept within specific values. Among these variables are: the compaction load of the bottles, the number of bottles per m2 (which defines the mass per area of the product in 18 kg/m2 and the traceability of the construction system), the method and time of cleaning and drying the bottles, and the thickness of the cementitious plasters on the internal and external faces of the system, in the event that the system chosen to materialize the internal and external layers is with traditional construction systems. The degree of compaction of PET bottles regulates the amount of air present inside the system and, therefore, has an inverse relationship on thermal transmittance and fire resistance. If the amount of air is decreased by severe compaction, the fire resistance increases, but the insulation by the encapsulated air is reduced. The degree of compaction used in this work favored a low thermal transmittance and a high resistance to fire, making it suitable for setting it as a process variable. On the other hand, the homogeneity of the plaster in contact with the fire is relevant to ensure the fire resistance of the system. The plasters encapsulate the plastic molds and the wooden framework, thus protecting them from fire and increasing the resistance of the system.

6.3 Comments on the components of the construction system

Both PET and wood are combustible materials, which burn during a fire and produce gases that are harmful to health, such as carbon monoxide (CO). In a comparative study of the performance of wood briquettes and mixed with plastic, it has been observed that the CO emission is similar between oak wood briquettes and mixtures of recycled PET bottles with sawdust (Zannikos et al. 2012). Oak wood, a hard wood, generates more CO emissions during combustion than soft pine wood, as reported by Kistler et al. 2012. These results suggest that during the fire resistance test (**Figure 3**), the amount of CO emitted per kg of pine wood and bottles could be similar. So adding non-traditional recycled plastic material to the system would not intensify CO emissions during a fire. On the other hand, CO emission from PET could be reduced by using flame retardant additives. These additives reduce the flammability of plastic or delay the spread of flames along its surface. Although this measure is usually applied in industry, these additives tend to have a high environmental impact (Segev et al. 2009), which moves this construction system away from sustainability. In a recent work (Prada Botia et al. 2018), it was shown that recycled PET with flame retardant poorly improves its fire resistance compared to recycled PET. This is because PET, due to its chemical composition, is a thermally stable polymer compared to other waste plastics (Villain 1995). In line with this, PET recycled from bottles also has an oxygen limit index of 21% (Prada Botia et al. 2018), one of the highest values among thermoplastic waste (Omenexus 2020). This index corresponds to the minimum concentration of oxygen that sustains the burning of a material with flames. Therefore, among the existing plastic waste, PET is a viable option as a construction material, because for its combustion it requires a greater amount of oxidizer (oxygen) than other plastics. Finally, recycled PET has a similar limiting oxygen index than pine wood (White 1979), which suggests similar behavior for the start of combustion between both materials.

An additional condition to take into account in the design and use of the 3C Construction System, in relation to precautions against fire, is the need for the layout and execution of the electrical installation to be carried out independently of the plastic molds. Both the laying of pipes and the installation of panels, sockets, centers and actuating keys must be out of contact with the studs, being able to carry out external laying (using applied baseboard or duct systems) or by making canalizations that systematize the passage of these pipes through the use of horizontal or vertical posts specially located next to the wooden crossbars or columns of the structure. This autonomy of the electrical installation will avoid the production of potential sources of fire due to failures in this type of installation.

The construction of the framework using wood is a comparative advantage over other materials such as steel, in terms of environmental performance, mechanical behavior during a fire and thermal insulation performance. A wooden structure is able to retain its mechanical properties at high temperatures for longer than steel, due to the high resistance to creep of wood (Granello et al. 2019). Creep is a phenomenon by which the material permanently deforms under mechanical load at elevated temperatures, depending on the time of application of the load (Ross 2013). This is because the wood burns slowly at approximately 3.05mm / hour, while producing a charred layer on its surface. This surface layer protects and insulates the core of the wood from fire and allows the structure to be maintained

(Lowden 2013), since the layer acts as a thermal insulator. The wood below the charred layer retains a much greater mechanical strength than that of steel at these temperatures. In this way, the timber framing was able to maintain the structural integrity of the panel during the fire resistance test without collapsing, **Figure 3.** Regarding the environmental impact of pine wood, EDPs can be used to get an idea of its performance. environmental compared to other materials that fulfill the same function. The EDPs of pine-based products have global warming potential values, measured in kgCO2/equivalent, much lower than those based on steel. For example, 1 m3 of pine wood board manufactured in Spain (DAP-S-P-01314 2018), generates approximately -685 kgCO2/m3 during its production stage (stages A1, A2 and A3 of the life cycle). In contrast, during the same stages of the life cycle, 1 m3 of structural steel manufactured in the same country generates approximately 6 times more kgCO2/m3 than the previous wooden board (GlobalEPD 001-003.06 rev.3 2013).

7. Conclusions

The study construction system that contains non-traditional materials from plastic bottle waste showed very good performance in thermal insulation and fire resistance compared to other systems based on traditional materials. This system complies with the technical requirements demanded by the Argentine regulations to be used in two-storey homes in the province of Buenos Aires. This regulatory compliance was obtained by following the traceability for the manufacture of the system, which was described in this work. The enhancement of bottle waste exposes the potential of these non-traditional materials for use in construction and to promote a circular economy. This technology, added to an adequate process of "social activation" allows to generate a process of Local development and Circular economy in the communities where it is implemented. At the same time, the fabric of the community is strengthened within and with other communities. These are precisely those where there are great difficulties, or impossibilities, to generate jobs in a formal and sustainable way.

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Indique los objetivos del trabajo y proporcione un trasfondo adecuado, evitando una encuesta bibliográfica detallada o un resumen de los resultados. Debe aportar los antecedentes teóricos que justifican el objetivo del trabajo y especifican el punto de partida del conocimiento respecto del problema u oportunidad que desea abordar.

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Las notas al pie deben usarse con moderación. Numerarlos consecutivamente a lo largo del artículo. Muchos procesadores de texto crean notas al pie en el texto, y esta característica puede ser utilizada. Si este no fuera el caso, indique la posición de las notas a pie de página en el texto y presente las notas al pie de página por separado al final del artículo.

Figuras y tablas incrustadas en el texto

Asegúrese de que las figuras y las tablas incluidas en el archivo único se coloquen junto al texto relevante en el manuscrito, en lugar de en la parte inferior o superior del archivo. El título correspondiente debe colocarse directamente debajo de la figura o tabla. Cada tabla y figura deberán contar con un número identificador a través del cual debe estar citado en el cuerpo del manuscrito. El orden de presentación de cada figura en el cuerpo del documento debe ser consistente en su aparición; es decir no puede mencionarse la Figura 2 si antes no ha sido mencionada la Figura 1. Esta situación es análoga para la mención de Tablas y Ecuaciones.

Ilustraciones

Las ilustraciones pueden incluir gráficos, dibujos lineales, esquemas, diagramas y fotografías. Deben numerarse en forma secuencial, en el mismo orden en que son referenciadas en el texto como: figura 1, figura 2, etc. El título debe presentarse bajo la figura. Evite emplear Ilustraciones optimizadas para el uso de la pantalla (resolución muy baja) y evite gráficos que sean desproporcionadamente grandes para el contenido.

Leyendas de las figuras

Asegúrese de que cada ilustración tenga al menos un título. Una figura debe incluir un título breve (no en la misma figura). Figuras compuestas emplearán letras minúsculas para diferenciarlas (Por ejemplo Figura 3a, Figura 3b…). Cada parte de una figura compuesta debe estar mencionada en el cuerpo del manuscrito. Por su parte, el texto en la ilustración (en el interior de la figura) podrá emplear tamaño mínimo y explicará todos los símbolos y abreviaturas utilizados.

Tablas

Por favor envíe las tablas como texto editable y no como imágenes. Es recomendable que las tablas se adjunten al texto relevante en el artículo. Numere las tablas consecutivamente de acuerdo con su apariencia en el texto y coloque las notas de la tabla debajo del cuerpo de la tabla. Emplea las tablas responsablemente y asegúrese de que los datos presentados en ellas no dupliquen los resultados descritos en otra parte del artículo. Evite el uso de reglas verticales y sombreado en las celdas de la tabla.

Material suplementario

El material suplementario, como aplicaciones, imágenes y conjuntos de datos, se puede publicar con su artículo para mejorarlo. Los artículos suplementarios enviados se publican exactamente tal como se reciben (los archivos Excel o PowerPoint aparecerán como tales en línea). Por favor, envíe su material junto con el artículo y proporcione un título descriptivo y conciso para cada archivo suplementario. Si desea realizar cambios en el material suplementario durante cualquier etapa del proceso, asegúrese de proporcionar un archivo actualizado. Desactive la opción "Control de cambios" en los archivos de Microsoft Office ya que estos aparecerán en la versión publicada.

DESPUES DE LA ACEPTACION

Corrección de pruebas

Los autores correspondientes recibirán un correo electrónico con la presentación borrador de la prueba de impresión de su manuscrito. En un plazo establecido los autores podrán solicitar enmiendas sobre la prueba de impresión. Trascurrido dicho plazo sin pronunciamiento del autor de correspondencia se considera que la prueba es aceptada para su impresión. El autor debe tener en cuenta potenciales errores de edición asociados a la composición tipográfica, la integridad, la corrección del texto, las tablas y figuras.
Es importante asegurarse de que todas las correcciones nos sean enviadas en una sola comunicación. Verifique cuidadosamente antes de responder, ya que no se puede garantizar la inclusión de correcciones posteriores. En esta instancia la revisión es exclusivamente su responsabilidad.

Proceso de revisión por pares

El equipo editorial, tienen la responsabilidad de recibir los artículos y emitir un primer juicio sobre los aspectos formales; además de rechazar un artículo cuando este no cuente con suficiente mérito científico y académico para su publicación o esté fuera de la temática de la Revista.

El Editor envía el artículo a evaluadores externos especializados en el área temática; el cual realiza una evaluación de acuerdo a criterios establecidos por la RIOC. Cada evaluador externo puede rechazar, aceptar o bien aceptar con observaciones un artículo. En caso de rechazo se fundamenta esta situación, de otro modo artículos aceptados con observaciones son re-enviados al autor de correspondencia con las observaciones para la mejora del manuscrito.

Los evaluadores verifican el cumplimiento de todos los aspectos formales, y la consistencia entre las conclusiones, los métodos y objetivos propuestos. Por política de la RIOCA los evaluadores conocen la identidad de los autores, sin embargo los autores desconocerán a sus evaluadores.

En caso de observaciones el Editor se contacta con el autor de correspondencia para solicitar mejoras en el manuscrito en un plazo determinado. Una vez aprobadas por el comité editorial las modificaciones de un manuscrito, este estará es condiciones de ser aceptado para su publicación.

En caso que el resultado de una revisión sea el rechazo de alguno(s) de los evaluadores el manuscrito es enviado a otro árbitro; si el rechazo es confirmado, el artículo es rechazado definitivamente y se comunica se comunica la decisión al autor de correspondencia.

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