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Ecological block prototype from construction waste and waste materials to reduce humidity in buildings

Prototipo de block ecológico a partir de residuos de construcción y materiales de desecho para reducir la humedad en las construcciones

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Abstract

Currently, the construction industry is one of the main causes of pollution worldwide. Prepare an ecological block from waste materials such as construction debris and give them a second use and natural additives such as nopal mucilage, nejayote and molasses to combat humidity. The quasi-experimental methodology of a quantitative, descriptive type. The prototype of block 1 is the one with the highest axial compression resistance with 72 kg/cm^2 and can be used as a load-bearing concrete block and its absorption percentage is under 7%, which shows that waterproof materials such as nopal mucilage and nejayote. In the second prototype with the addition of sawdust and molasses, the resistance to axial compression was not achieved, since it only reached 11 kg/cm^2, but it was waterproof with a percentage of 12%.

Ecological block, Debris, Nopal mucilage, Nejayote, molasses

Resumen

En la actualidad la industria de la construcción es una de las principales causas de contaminación a nivel mundial. Elaborar un block ecológico a partir de materiales de desecho como escombros de la construcción y darles un segundo uso y aditivos naturales como el mucílago de nopal, nejayote y melaza para combatir la humedad. La metodolodía cuasi experimental de tipo cuantitativa, descriptiva. El prototipo del bloque 1 es el que tiene la mayor resistencia de compresión axial con 72 kg/cm^2 pudiendo ser utilizado como un block de concreto de carga y su porcentaje de absorción es bajo de 7% lo que se demuestra que los materiales impermeables como el mucílago de nopal y el nejayote. En el segundo prototipo con adición de aserrín de madera y melaza, no logró la resistencia a la compresión axial ya que sólo alcanzó los 11 kg/cm^2, pero logró ser impermeable con un porcentaje de 12%.

Bloque ecológico, Escombros, Mucílago de nopal, Nejayote, Melaza

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Introduction

The project arises from the Interinstitutional Program for the Strengthening of Research and Postgraduate Studies of the Pacific (DELFÍN Program), in the stay of the XXVII Summer of Scientific and Technological Research of the Pacific, at the Tecnológico de Estudios Superiores de Valle de Bravo (TESVB), with the participation of students, who helped design and build the ecoblock prototype, having as a line of research that of Alternative Materials and Technologies for Construction.

Currently, the construction industry is one of the main causes of pollution worldwide because it contains high demands for renewable and non-renewable raw materials, which becomes a problem because at the end of the useful life of the building these materials they are discarded, are not renewed or most do not have a useful life again.

The environmental pollution caused by these organic and inorganic wastes are very visible nowadays, the latter more worrying since they are not biodegradable, so they remain outdoors for a long time, causing damage to the environment and human health; This is why it is of great importance to start evaluating how to mitigate these effects from planning from the beginning of the work and its completion, it is important to take into account the reuse of its waste.

Another great environmental problem that we face is the issue of humidity since it is present in buildings worldwide, often advancing to such an extent that solutions cannot be found other than demolition. Controlling this factor would help increase the useful life of buildings and improve the quality of life of the inhabitants.

That is why this research sought to provide feasible solutions from the execution and research on alternatives of Mexican ecological raw materials that help mitigate the aforementioned collateral damage. The idea of this project arose from analyzing the environmental problems generated by the construction industry observed in houses and other buildings in the city. Which led to investigate the background of the problem and what solutions can be found from the reuse of waste and implementing raw material from the Valle de Bravo area, State of Mexico.

By replacing the materials currently used with new ones of ecological origin, the environmental impact generated by the construction is reduced. Currently, sustainable materials are a booming topic in architecture since they have innumerable benefits for the planet, which seek to save, reuse and take advantage of existing natural resources.

Climate and meteorological conditions are impossible to modify, what can be changed are the construction and material processes so that this type of inclement weather is prevented from the beginning and the buildings, health and economy of the population are protected.

Burgos and Manrique (2022), in their research describes the production process of the mycelium bricks and the results of the practical exercise carried out on 13 specimens in accordance with the provisions of NTC 4017 and ASTM C62, which allowed establishing that the biomaterial generated by mycelium on different substrates, it allows its use as a non-structural masonry element; however, it cannot be used properly as a brick or solid block in the construction of residential units since it does not meet the resistance required by regulations, but it allows its incorporation as an insulating panel between walls, taking advantage of its thermo-acoustic properties, in addition to decorative use. or artistic that can be given to the blocks with mycelium.

Sornoza et al. (2022), comments that in their research results were obtained as a result of the review, in two categories of types of alternative materials used in the construction of houses in the country, related to natural or organic materials and natural materials mixed with inorganic; the first include the earth, the wood, the wall, the adobe, bahareque, the bamboos, the bamboo cane; the second refer to elements blocks or bricks made with natural elements in combination with inorganic waste such as plastic and others; elements such as geopolymeric mixtures, soil cement and earth blocks, insulating panels.

Mendoza (2022), generated in his research a comparative cost analysis between the new sustainable concrete block with RCD and the conventional concrete block, where it is stated that the block with 100% replacement of RCD coarse aggregate, significantly exceeds the traditional block in terms of economy, density, water absorption and resistance to compression established in the Ecuadorian standard, demonstrating that the prototype contributes to the reduction of energy and raw material expenditure.

Merino and Rosado (2022), developed an eco-brick prototype using recycled polyethylene terephthalate. Concluding that, the mix design with 10% PET was used 1.02 kg, for 20% 2.05 kg and for 30% 3.07 kg, in 7 eco-bricks for each mix design, the eco-brick with 20% of PET was the most efficient, obtaining 114.35 kg/cm^2 of compressive strength, 2.17% absorption, recommended for housing construction.

Concrete block

Concrete Blocks are precast modular elements designed for confined and reinforced masonry. The block is made of cement, sand and aggregates, they are of great structural resistance. As a constructive system it is excellent since it is a very versatile product. The block is very suitable for tropical or hot climates. Measurements: 11x14x28 cm.

According to the NMX-C-404-ONNCCE-2012 standard, for parts for structural use, the concrete block is a prefabricated piece with the shape of a straight prism and with one or more vertical holes, for use in simple or structural masonry systems This is due to the possibility of reinforcing the vertical and horizontal pieces. For the erection of walls, in order to give the desired height and width to the wall. In order to build with the block, they are placed one at a time with fresh mortar.

Debris (construction debris)

The construction industry is one of the sectors that consumes the most natural resources, in addition to generating a large amount of waste produced during the construction of different works and the demolition of buildings or houses when they reach the end of their useful life or for reasons of remodeling.

In developing countries, such as those in Latin America, exact figures for CDW production are not available (Chica et al., 2018). However, in countries such as Holland, Germany, China, Spain, Brazil, Chile, among others, the study of the mechanical behavior of these materials, as well as the creation of laws and programs so that they can be reused in different applications, each day gets more momentum.

In Mexico, as of August 2013, builders are required to comply with the formulation of a construction and demolition waste management plan in accordance with the NOM-161-SEMARNAT-2011 standard, which establishes that construction waste is classified as special handling waste, which requires actions for its reuse and recycling or, where appropriate, correct disposal (Ossa and García, 2015).

Taking into account the above, it was found that from 2013 to the present, construction companies and other managers are beginning to think about and demand plans for the final disposal of construction waste in Mexico, however, the problem is so broad that even the regulations and demands fall short, which is why it is imminent to start thinking about how this waste can be recycled and used again in construction or other areas of intervention.

The National Housing Commission (Conavi) indicated that the construction sector is responsible for more than 50% of polluting emissions in the world, from the manufacture of materials, transportation, building construction processes and use.

In the case of Mexico, it is expected that by 2050, 7 million homes will be built, which will emit close to 25 million tons of greenhouse gases, this is because traditional building processes require the use of fossil fuels and energy demand, that generate an environmental impact, according to studies by the National Autonomous University of Mexico (UNAM) (Esperanza, 2018).

Given the above, Conavi suggests that Nationally Appropriate Mitigation Actions (NAMAs) be carried out, in which up to 25% of polluting emissions can be avoided; These actions must be aligned with sustainable development and supported by financing, technology and capacity development.

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According to NACDMX007-RNAT-2019, Environmental standard for Mexico City, which establishes the Classification and Specifications of comprehensive management for construction and demolition waste in CDMX.

According to the data published in the Solid Waste Inventory of Mexico City 2019, during the year 2019 a total of 659 Management Plans were presented to the Secretariat, with the report of 149, 468.29 m3 / year Construction Waste and Demolition, 250,929.27 m3 /year Recycled Construction Waste and 311,808.32 m3 /year Excavation Waste.

The Solid Waste Law of the Federal District classifies construction and demolition waste as special handling waste, both because of the amount of material involved, and because of the impact on the environment that could be generated by improper disposal, as well as because of its potential for reuse and recycling, to be used as recycled aggregates (Gaceta oficial de la ciudad de México, 2021).

Environmental Problems Associated with the Current Management of Construction and Demolition Waste (RCD):

The disposal without separation or treatment, frequently in clandestine sites, of a mixture of excavated material, remains of brick, tiles, mortar, concrete, plaster, wood, plastics, solvents and traces of paint, metals and other materials used in the processes constructive works, generate a significant environmental impact (Cámara Mexicana de la Industria de la Construcción, 2013).

As a result of the inadequate handling of CDW, mainly in final disposal, various environmental, urban image and health problems have been identified, highlighting the following:

- Obstruction of streams, ravines and ravines.
- Affectation of natural drainage.
- Silt in the lower parts and flooding of surrounding areas in the rainy season.
- Impact on the physical and biotic environment (flora and fauna).
- Sources of contamination due to mixed waste, including hazardous waste.
- Contamination of the soil and subsoil and even of aquifers.
- Affectation of groundwater recharge areas.
- Visual impact of the environment.
- Proliferation of dust (air pollution) causes respiratory diseases.
- Proliferation of harmful fauna.

Nejayote

The term nixtamalization comes from the etymological root derived from the Nahuatl word “Nextamalli” which means water passed through ashes and from the word “Tamalli” which means wrapped bread.

This technique consists of alkaline leaching of corn grains at high temperatures. Corn is cooked in water (3:1) and quicklime (CaO) at 1% for several hours, with the purpose of separating the pericarp from the endosperm of the grain. (1, 2,3). At the end of the cooking time, 2 products are obtained, the first refers to the softened corn ready to continue its grinding process for the manufacture of flour (Nixtamal), while the second refers to the residual water from cooking it in presence of lime (Nejayote).

Nixtamalization is a thermal-alkaline process native to Mexico and carried out in Central America, the north of the United States and part of Europe and Asia (Valderrama et al., 2012). This process improves the nutritional and sensory characteristics of corn, since it allows the partial removal of the pericarp (Valderrama et al., 2013; Acosta et al., 2014), starch gelation and fiber hydrolysis (Domínguez & Pacho, 2003).

The conditions to which the corn is subjected during nixtamalization are of great importance, since temperature and agitation have a significant effect on the removal of the superficial layers, as well as on the adsorption of water and calcium (Ruiz-Gutiérrez et al., 2010). In this process, the action of calcium hydroxide generates two products: nixtamal, which is the soft grain available for making dough or derived products (Pflugfelder, Rooney, & Waniska, 1988), and nejayote, which is the water of cooking and whose physical-chemical properties result from the components present in the corn (ibid.).

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It has been estimated that a corn processing plant, producing nixtamal, with a capacity of 600 t·day-1, generates between 1,500 and 2,000 m3 of nejayote per day. This effluent is considered polluting due to its high pH (12 to 14) (Salmerón et al., 2003) and its high load of organic matter (2,540 mg L-1) (ibid.).

Recently, industrial nejayote has been dumped into bodies of water (rivers or lakes), into the ground or into the public sewage system, and seldom is any prior treatment applied (ibid.).

The term nejayote comes from the Nahuatl “Nextli” which means lime ashes and from the word “áyoh” broth or watery thing. Nejayote is mainly composed of suspended organic material from the endosperm and pericarp of corn that separate from the grain as a result of their temporary exposure to temperatures exceeding 150°C in the presence of CaO (Cal). It is then a solution rich in starch, cellulose and calcium (Valencia and Cardona, 2013).

Nopal mucilage

Opuntia ficus-indica, is a plant native to Mexico that grows in arid and semi-arid areas. Currently its cultivation for commercial reasons has spread to countries such as: Italy, the United States, Chile and Argentina (Torres, 2007; Martínez et. al., 2015).

In Mexico, this plant is called Nopal and is a great source of food for the general population, as well as for livestock. Since ancient times, the gel produced by this cactus has been used to paint and cover adobe walls, as well as for the maintenance and preservation of churches and historic buildings in Latin America (Chandra et. al., 1998; Torres and Martínez, 2005; (ibid.).

Different studies agree that the compounds present in Nopal mucilage are very varied, being able to find proteins, as well as different types and compositions of polysaccharides (ibid.). In general, the composition of the carbohydrates in the mucilage contains variable proportions of l-arabinose, d-galactose, l-rhamnose and d-xylose, as well as the main sugar units (León et. al., 2011).

Some natural polymers are capable of modifying specific properties in cementitious materials during construction (Peschard et. al., 2004). Some properties of cement mortars in the fresh state can be improved with the addition of water-soluble polymers. Cement mixes modified with these polymers have high water retention compared to ordinary mortars. This behavior is mainly due to the hydrophilic parts of the polymers that fix the water molecules in the fresh mixture, preventing drying by evaporation and absorption in the surrounding porous material (Knapen and Van Gemert, 2009).

Ramírez et. al., (2012) analyzed the effect of Nopal in cement pastes, determining that setting times increased with the addition of this natural additive. In addition, they reported that there were changes in the microscopy of the mixtures with mucilage (Díaz et al., 2019).

Nopales contain viscous substances generally known as mucilage or hydrocolloid, which is made up of high molecular weight carbohydrates. It mainly contains two natural organic polymers: amylase and amylopectin. Amylase forms a helical chain that, in solution, has the ability to form thin films that, when dry, have high rigidity. Amylopectin, like all high molecular weight compounds, has a high viscosity in its pure state, but is highly soluble in water. Combined and in aqueous solution, both can form layers with different mechanical properties; these cohesion characteristics have been used to join different materials.

This material is obtained by leaving nopal remains to rest in water, in such a way that, in a few minutes, the water in which the raw material is suspended begins to thicken, it is this liquid that will be used in the elaboration. of the blocks (Cervantes, 2017).

The ancient indigenous people used the nopal slime to fix the walls of their buildings, a tradition that is still maintained in some towns to paint their houses. Based on this traditional technique, he used nopal mucilage to create a brick that does not require firing.

The nopal slime provides the partition with a barrier against humidity, the concentration of microorganisms and some pests, a frequent problem in adobe and common brick.

Sawdust

The wood industry has the characteristic of generating large volumes of waste during the process of exploitation and elaboration of this, this occurs before the wood is introduced in the process itself until the final product is obtained (Álvarez et al., 2010).

Talking about waste is relative. It arises from the world of the economy, from the value assigned to it, from the possibilities of use according to the scientific and technical knowledge of the moment. What is called waste today can be a raw material tomorrow, if it acquires a market value. Based on this vision, the use of forest residues in industrial processes, services, as well as in the residential sphere, is a social need in order to reduce the consumption of fossil fuels, and its use can constitute a solution not only to the environmental problems that their incorrect disposal has caused over the years, but also provides greater added value to the wood in the forestry industry (Ortiz, 2004).

At present, the use of forest by-products has a high degree of waste. Sawdust, shavings, cuttings, among others, are stored in large hills or burned in boilers, without having a greater added value or achieving greater energy efficiency (Soto and Nuñes, 2008), (Martínez, 2014).

In the process of cutting and carving wood residues are generated, which can be in the form of pieces, dust or thin sheets. The pieces, pieces of wood, are the result of the cuts that are made for the elaboration of tables with defined measurements, as well as wooden structures with different applications and utilities, boxes for vegetables, bases for refrigerators. For example, these structures also require a surface finish, for which they are subjected to carving or brushing, which consists of passing a brush that grills the surface of the wood, generating small slats of it.

This type of sawdust is known as chips, the dust is generated from the two previous operations and is, in general, the one with the least attractive properties for its integration into other processes. Wood chips are usually ground to obtain chip-type sawdust, this is the most used in other processes, since it has stronger structural properties (Monroy, 1999).

Molasses

Sugarcane (Saccharum spp.) is currently the most productive agri-food crop in the world. Due to the chemical and biochemical nature of the raw material it produces, it has great potential for productive diversification. The piloncillo or in Nahuatl "chincaca" which means "brown sugar" is an ingredient that is made with the undistilled juice of sugar cane, the same one that is cut into long strips for the punch. According to the Agrifood and Fisheries Information Service (SIAP), the Spaniards introduced the cultivation of cane and many processes to refine it to Mexico.

The piloncillo when it is made in an artisanal way consists of several steps. First you have to collect the sugar cane and extract its juice in the mill. That juice is heated at very high temperatures in an oven until it boils. In order for the consistency to become solid, similar to molasses, the cane juice is placed in a blender until a thick mixture is obtained.

The mixture is poured into conical molds to give it the characteristic shape of piloncillo and is allowed to cool. At the end it is only unmolded and it is ready for use. One of the advantages of piloncillo is that no preservatives or dyes are added, making it a natural producto (Gómez et al., 2017).

Humidity

According to the ENVI 2020 national housing survey, humidity occupies the greatest structural problem that occurs in Mexican homes thanks to the fact that water leaks have a percentage of 44.2%, followed by cracks and cracks with 40.8%. The entities with the highest frequency in this type of problem are Tabasco, Yucatán, Campeche and Chiapas. Of their own homes, 58.5% have the need to carry out some repair or remodeling due to humidity or other effects (INEGI, 2021).

Taking into account that humidity is one of the major effects in the short, medium and long term in construction projects, it is necessary to investigate how its physical, structural and health effects are for the inhabitants of the houses of the different Mexican cities.

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The real problem with all types of damp is not that they cause a bad aesthetic effect. Its most serious consequence is the formation of fungi and microorganisms that are harmful to the health of our family, especially if we suffer from allergies. For this reason it is essential to know the different types of humidity and act on them as soon as we detect the first outbreaks.

According to Rico (2021) in her report protection against moisture in single-family home foundations 2021 states that moisture is the presence of liquid water or vapor that is inside a material and its drying inside is not possible, causing interior and exterior effects. on the physical quality of the material within the construction.

From this, factors that cause humidity are listed, which, knowing its origin, can be used to issue a concept to work with it, as the case may be:

1. Presence of water in the concrete used, which can be liquid or in vapor form.
2. Lack of insulation between the construction element and the water. This lack allows the water to be in contact with it and deteriorate it.
3. Presence of upper, central or lower penetration paths in the construction elements, in the form of openings, joints, cracks and/or pores that allow the entry, circulation and diffusion of water in them.
4. Impossibility or difficulty of drying or eliminating the water present that remains inside the materials or on their contact surface.
5. Lack of treatment for the possible climatic variation (humid) in the location of the Project.

Objective

Elaborate an ecological block from waste materials such as rubble and natural materials such as nopal mucilage, nejayote and molasses to combat humidity.

Materials

The materials that were used for the construction of the prototypes were from the region of the Municipality of Valle de Bravo, State of Mexico.

- Toltec brand gray cement.
- Sand.
- Construction waste (debris.)
- Water.
- Nejayote.
- Nopal mucilage.
- Sawdust.
- Molasses.

Tools

- Vernier
- Convection oven 110º temperature.
- Scale or weight capacity of 30 kilos.
- Shovels to carry out the mixture.
- 18 liter buckets.
- Probes for measurement.
- Iron mallet (Marro) to grind construction waste.
- Masonry spoon.
- Filtration sieve # 8, 30, ¾”.
- Metal container.
- Scalpel.
- Flexometer.

Machinery

- Vibro-Blocquera Machine
- Universal machine brand controls.

Methodology

The experimental methodology is based on the Mexican Standards (NMX) OF MASONRY (ONNCCE, National Agency for Standardization and Certification of Construction and Building, S.C., 2021).

Experimental prototype

Nopal mucilage

Figure 1 shows the procedure for obtaining nopal mucilage. The nopal was collected from a local public area. The nopal (4 pcs) was chosen and cleaned. The nopal was weighed: for the four pieces it was 3,141.47 gr. (3.14kg). The nopal was cut into smaller pieces. Subsequently, it was emptied into a large container and water was added at a 1:2 ratio (1 nopal, 2 water). It was left to stand for 48 hours. After the first day, the nopal pieces were manipulated to release more slime.

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On the second day, it was first filtered through filter screen no. 8 to separate the pieces of concentrated slime. The filtered pieces were filtered again, adding 3 liters of water to let it release all the slime that remained in the pieces. The nopal mucilage was saved to use later. This preparation was used both for adding the mixture and for covering it with sawdust.

Figure 1 Obtaining nopal mucilage
Source: Own Elaboration

Nejayote

Figure 2 shows the nejayote. This liquid state material is obtained from any manufacture where nixtamalization is involved. In this case it was obtained in a local tortilla shop. The water (approx. 10 liters) was filtered through a filter screen no. 30. The prepared nejayote was saved to be used in the mixture.

Figure 2 Obtaining the nejayote
Source: Own Elaboration

Sawdust

Sawdust is shown in Figure 3. Approximately 1 kg of sawdust was obtained from a local lumberyard. It was emptied into a container along with a part of the nopal slime (measured empirically so that there was enough mucilage for the wood to absorb it). It was left to stand for 48 hours. After both days, the amount required for the mixture was measured.

Figure 3 Obtaining sawdust
Source: Own Elaboration

Debris.

Figure 4 shows the rubble. Debris in good condition was collected from a vacant lot in the area, left by a nearby construction site. The pieces of rubble were crushed manually with the help of an iron mallet. The material was passed through the granulometry test with a ¾" mesh. The material was weighed and stored to be used in the batching of the blocks.

Figure 4 Obtaining the rubble
Source: Own Elaboration

Block making.

2 block prototypes were made and by the Mexican standard NMX-C-036-ONNCCE-2013 it was considered to make 3 block variants for each prototype to be manufactured, having a total of 6 ecological blocks. The water/cement ratio was reviewed in the proportion of the designed mixtures, which should be in the range of 0.42 and 0.60, which was fulfilled by having the ratio at 0.50.

Prototype block 1:

In this first prototype, the use of construction waste was the main material, since it responds to a global problem of the reuse of this waste and it is expected that this will contribute to improving the resistance of the block. At the same time, nopal mucilage was used in order to improve the waterproofing of the block under the environmental conditions of humidity and control its effects of tartar, fungus and mold.

In addition, the water was replaced by nejayote since it is a polluting waste that can contribute to its adhesive characteristics to the block and avoid the use of massive amounts of water used in construction. Not leaving aside the conventional dosage of sand and cement

The first prototype considered the following materials:

Rubble, sand, portland cement, nopal mucilage, nejayote and water. And the formula of this block was measured with a bucket of volumetric quantity of 0.00675 m3. This in order to check the reaction of mortar with rubble by adding mucilage to improve its impermeability.

The volume of a conventional bucket of 18 liters was calculated with the following formula:

$V = \pi * r2 * h$

Substituting:

$V=3.1416* (0.15m^2)* 0.3m = 0.00675\ m^3$

Next, the volume of the block was calculated:

$V= l \times w \times h$

Substituting:

$V= 0.12m*0.20m*0.40m = 0.0096\ m^3$

Proportions.

Material quantities (prototype 1)

2 rubble buckets = 0.02025 m^3
1 bucket of sand = 0.00675 m^3
½ bucket of cement = 0.003375 m^3
¼ bucket of nopal mucilage = 0.0016875 m^3
¼ bucket of nejayote = 0.0016875 m^3
∑ Total volume = 0.03375 m^3

(Total mix volume)/(Block volume)=
0.03375/0.0096 = 3.5 ≈3 Blocks (with waste)

Elaboration procedure

Figure 5 shows the wide and clean space where a little water and debris were spread. Together with the sand and the cement, it was paleo to integrate the three materials. The liquid elements were added; the nejayote, water, nopal mucilage.

By integrating all the elements, the mixture was manually added to the block making machine after cleaning and clearing the machinery.

With the help of the triangular trowel, the mixture is dispersed in three forms. The machine made the corresponding vibration and later the blocks were compacted. The blocks were left to rest outdoors for 24 hours to set. Once the time had elapsed, it was transported to an interior area for curing, it was weighed while still wet and left to rest to reach its maximum resistance (for 28 days).

Figure 5 Elaboration of the prototype of block 1
Source: Own Elaboration

Prototype block 2:

The main element in this prototype will be sand, sawdust and rubble of Ø 3⁄4” in order to provide lightness to the block and avoid porosity that could later be a cause of humidity. In the same way, the water will be replaced by the nejayote and molasses will be added to give the block adherence. The nopal mucilage was mixed with both the sawdust and the cement mixture to verify the waterproofing capacity of the block.

The second prototype of the block considered the following materials: rubble, sand, portland cement, nopal mucilage, nejayote, sawdust and molasses. And the formula of this block was measured based on kg in separate containers and ml in test tubes. This variation to test a greater lightness in the block while reducing its porosity with the sawdust and compacted with the mucilage to ensure its impermeability. In addition to testing the adherence of the molasses.

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Proportions

Material Quantities (Prototype 2)
Debris = 8.1 Kg
Sand = 18.9 Kg
Cement = 7.2 Kg
Sawdust = 1.8 Kg
∑ = 36 kg
Nejayote = 2.5 Lts
Nopal mucilage = 0.6 Lts
Molasses = 0.5 Lts
Note: These liquids correspond to 10% of the total weight of the dry mix.

Elaboration procedure

Figure 6 shows the elaboration of the block. In a wide and clean space, the stone aggregates (sand and rubble) and the cement were spread. As a whole, the mixture was paleo to integrate the three materials. The sawdust mixture with the mucilage was added and integrated. The liquid elements were added; nejayote, molasses and nopal mucilage. By integrating all the elements, the mixture was manually added to the block making machine after cleaning and clearing the machinery.

With the help of the masonry spoon, the mixture is dispersed in three moulds. The machine made the corresponding vibration and later the blocks were compacted. The blocks were left to rest outdoors for 24 hours to set. Once the time had elapsed, it was transported to an interior area, weighed while still wet and allowed to continue drying and setting the block under shade (for 20 days).

Figure 6 Elaboration of the prototype of block 2
Source: Own Elaboration

After the block was made, they were left to rest for setting, curing and drying. At the end of this process, they were subjected to absorption and resistance tests with the appropriate machines required (universal compression force machine, 30kg tilting weight). capacity, 110 ° convection oven). Figure 7 shows a specimen of each block prototype that was placed in the compression testing machine. Subsequently, the amount obtained was recorded.

Figure 7 Compression test of specimens
Source: Own Elaboration

When both blocks broke, remaining pieces were selected and placed in their respective trays according to the prototype to be treated. Both prototypes were then weighed and left in a curing pile completely submerged in water for 24 hours. At the end of the required time, both specimens were removed, their wet weight was obtained and each one was transferred to a new tray to be placed in the convection oven for 24 hours at 110° centigrade. When the estimated time passed, it was carefully removed from the oven and its dry weight was obtained.

Results

The results of the procedures for the analysis of absorption and compression are shown in table 1. It can be seen that the prototype of block 1 is the one with the highest axial compression resistance with 72 kg/cm^2 and can be used as a block of load concrete and its absorption percentage is under 7%, which shows that waterproof materials such as nopal mucilage and nejayote improve the physical characteristics to achieve waterproofing. In this first prototype you can see that it is a solid and heavy block.

In the second prototype with the addition of wood sawdust and molasses to give the block greater adherence, it did not achieve the compressive strength to be considered a load-bearing masonry block, since it only reached 11 kg/cm^2, but it managed to be impermeable to despite containing organic matter such as nopal mucilage and nejayote with a percentage of 12%.

Prototype	Test absorption (%)	Test resistance to axial compression (kg/cm^2)
1	7	72
2	12	11

Table 1 Results of absorption and axial compression test
Source: Own Elaboration

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Conclusions

With the results obtained, it is expected that in the future it will be possible to continue investigating and perfecting the mixtures of natural aggregates such as nopal mucilage, nejayote, molasses and sawdust, in order to create a prototype that meets all the specifications of the Standards. Mexican and that is friendly to the environment.

Theoretical and practical knowledge was obtained, which will be very useful for investigations that allow improving the impermeability of the blocks by reducing the amount of water taking advantage of the properties of the nopal mucilage as well as reducing the waste of the nejayote when it is poured into the drains and improve its axial compressive strength with molasses.

It is of great importance to give second uses to products that are waste such as construction waste, commonly called rubble, because it contributes to the care of the planet and thus raise awareness and promote ecological materials to help society and avoid contamination as much as posible of the planet.

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