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Analysis for the construction of low cost housing with recycled plastic bricks with no negative environmental impact proposed for Tijuana, B.C

Análisis para la construcción de vivienda de bajos ingresos con ladrillos de plástico reciclado sin impacto ambiental negativo propuesta para Tijuana, B.C

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Abstract

In the city of Tijuana, there is inefficient planning and settlements, due to strong migratory currents coming from the interior region of the country (Corona, 2018). Citizens buy social interest houses and acquire mortgages of up to 30 years or carry out self-construction without a proper planning. In Colombia, the possibility of building with recycled plastic bricks is possible. Being the plastic one of the main polluters in the world, the creator and director of the construction system project Brickarp, Fernando Llanos, explains that the degradation time of this material is an advantage for this brick, composed of polypropylene, polyethylene and plastic. The construction with recycled plastic, is an ecological housing construction method with a lifetime up of 500 years according to Fernando Llanos and being a material rescued from landfills and oceans that also has no negative environmental impact in its fabrication. This document analyzes the viability of the use of this alternative construction system for the construction of inexpensive and accessible housing in Tijuana, considering the environmental factors and the needs of the population, and the analysis of the potential use of the PET material that is recycled in the region.

Plastic Recycling, Ecological, Low Cost

Resumen

En la ciudad de Tijuana, hay mala planificación urbana y asentamientos acelerados de vivienda debido a las fuertes corrientes migratorias provenientes del interior del país (Corona, 2018). Los ciudadanos compran casas de interés social y adquieren una deuda de hasta 30 años o realizan la auto-construcción sin planificación previa. En Colombia, la posibilidad de construir con ladrillos provenientes del reciclaje del plástico es posible. Siendo el plástico uno de los principales contaminantes en el mundo, el creador y director del proyecto del sistema constructivo brickarp, Fernando Llanos, explica que el tiempo de degradación de este material es una ventaja para este ladrillo, compuesto por polipropileno, polietileno y plástico. La construcción con plástico reciclado, es una vivienda ecológica y con un tiempo de vida de hasta 500 años según Fernando Llanos y siendo un material rescatado de vertederos y mares que además no tiene impacto ambiental negativo en su elaboración. En este trabajo se analiza la viabilidad de la utilización de este sistema constructivo alternativo para la construcción de viviendas económicas y accesibles en Tijuana, considerando los factores ambientales y necesidades del habitante, y el análisis del potencial de uso de material PET que se recicla en la región.

Reciclaje De Plástico, Ecológico, Bajo Costo

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Introduction

The construction materials are obtained from natural resources, which are exploited and never return to their natural state. The price of these materials continues to rise and this will not stop, that is why despite the increase in global demand for plastic (El Sol de Tijuana, 2018), it is proposed to use this material for the construction sector.

Developing

In Tijuana, B.C. we have seen the accelerated increase of poorly planned settlements due to the migration of people seeking to cross to the border and in their failed attempt they decide to reside in this city. As the population grows, with this the needs and demands of the city grow, the city council of Tijuana has not been able to effectively control the garbage collection that ends at the beaches of Tijuana, Rosarito and Imperial Beach where the call to the International Boundary and Water Commission for the high levels of pollution that these beaches present (Martínez, G. 2018). In the streets of any urban area the contamination by plastic trash has caused a hygiene problem for the inhabitants and in the rainy season the sewage lines do not fulfill their function since they are full of garbage and would make impossible the free automobile traffic.

Looking for a solution to reduce the exploitation of natural resources for the construction industry that only degrades ecosystems, a project was found that proposes recycled plastic as the raw material to achieve the obtaining of plastic bricks that can be recycled again and again. The brick "brickarp" patented by Fernando Llanos, founder of the FICIDET project and company, and the architect Oscar Andres Mendez, co-founder of the company Concenptos Plásticos, managed to obtain a brick with zero environmental impact and uses plastic bottles, bags and other elements facts based on this material.

Value added

The preparation of this material has no environmental impact, avoiding the emission of CO2 (Casa de Plastico, s.f.), does not use mortars for the adhesion of the blocks and beams since they are assembled and drilled with screws and fastened with metal plates.

It does not require specialized labor and a house can be built in 5 days with the help of 4 people. A house with this system recycles 6000 plastic bottles per 40 m² of construction with two rooms, a living room, a dining room, a bathroom and a kitchen. This construction system is 30% cheaper than traditional systems in rural areas, around $ 6,800 USD (Valencia, 2016).

The raw material is cheap compared to the price increase of 9% to 12% in the cement that was presented in Mexico this year, which is affecting the public and private construction sector (Expansión, 2018).

Characteristic

Brick and recycled plastic beams contain polyolefins of high rigidity, crystallinity, high melting point and excellent chemical resistance (Ficidet, s.f.). Additives are added to make them resistant to fire (Ecoinventos, 2017), in addition that the structure of the plastic makes it naturally resistant and is accredited by Colombian regulations.

Problem and solution

There is a high level of environmental pollution caused by the consumption of single-use plastic packaging, the emission of CO_2 when extracting traditional construction materials and the erosion of natural ecosystems. The production of this recycled plastic brick could be the solution for a city (Tijuana) that does not know what to do with 2 tons of garbage that is collected every day and that its only function until now is to be a pollutant that will exist for more of 3000 years (Ficidet, sf). Low-income people could acquire these recycled plastic construction materials that are efficient and affordable for decent housing, in addition there would be a reduction in the demand for materials from sources of natural resources.

Methodology

An analysis was carried out with the Ener-habit program to evaluate the behavior of the walls made of plastic bricks according to the average temperature of the hot month and cold month of Tijuana with the components of the recovered plastic brick compared with other traditional systems of construction as a house of wood and another of concrete.

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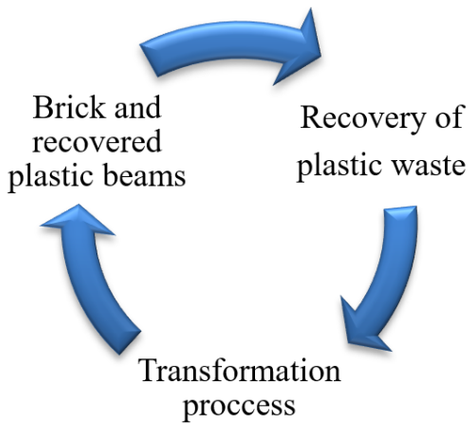
It should be noted that this program shows results in conditions without air conditioning implementation. As shown in graph 1, the cycle begins with the recovery of plastic waste by means of collection in clean-up campaigns, as is the case in Mexico City; that began to sensitize the citizens by incentivizing them by means of electric money for cultural and social use each time they recycle PET bottles in machines destined for their collection. Subsequently, a transformation process is carried out.

With the use of crushing machines, a particularized material (polyethylene and polypropylene) is obtained from the plastic collected for an extruder to create it and finally, the different elements necessary for the construction are manufactured, such as beams and bricks. The plastic can be transformed into different elements according to the need. The same material can be reused to have other forms of use each time it is recycled (graph 1).



Graphic 1 *Cycle of recycled plastic*
Own elaboration

Properties and characteristics of materials

The Ener-Habit program asks to add the materials that make up each constructive system by layers whether it is a wall or a ceiling. In the constructive system of recycled plastic brick as the first material, it is proposed: a layer of polyethylene and another layer of polypropylene (table 1) with a thickness of 0.15 m, these components being plastic by nature. (Ficidet, s.f.).

Registered materials					
#	Material	Thermal conductivity (W / mK)	Density (kg / m3)	Specific heat (J / kgK)	Source
1	Polyethylene	0.465	970	1900 0	Goodfellow.com
2	Polypropylene	0.22	930	1800	

Table 1 Registration of materials
Source: Goodfellow.com

In the same program the materials (table 2) of the traditional housing construction systems in Tijuana were selected, it is common to see houses made of wood and those of social interest made with concrete.

In the system of recovered plastic brick, the material 1 and 2 (polyethylene and polypropylene), have a better performance and thermal insulation compared to concrete constructions.

Construction systems			
	Brick Recovered plastic S.C.1	Wood S.C.2	Concrete S.C.3
Absorption	0.2	0.2	0.2
Material 1 [W / m2k]	0.465 Polyethylene	Triplay Denso 0.15	Mortar High Density 0.88
Thickness 1 [cm]	0.075	0.025	0.025
Material 2 [W / m2k]	Polypropylene 0.22	Wood 0.14	High Density Concrete Two
Thickness 2 [cm]	0.075	0.075	0.10
Material 3 [W / m2k]		Material 3 Vermiculite 0.19 [W / m2k]	Mortar High Density 0.88
Thickness 3 [cm]		0.05	0.025
Material 4 [W / m2k]		Plaster 0.16	
Thickness 4 [cm]		0.025	

Table 2 Construction systems
Source: Ener-habitat

Results

The best construction system is the one with the lowest decrement factor, this parameter indicates that the oscillation of the air temperature in the interior has been damped so much with respect to the sun-air temperature.

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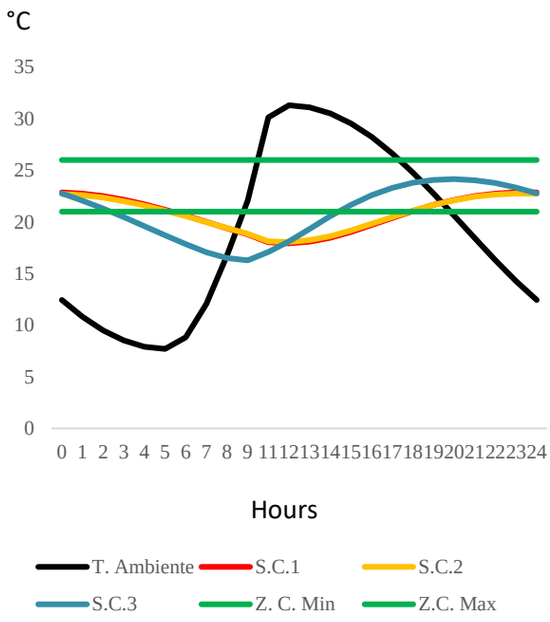
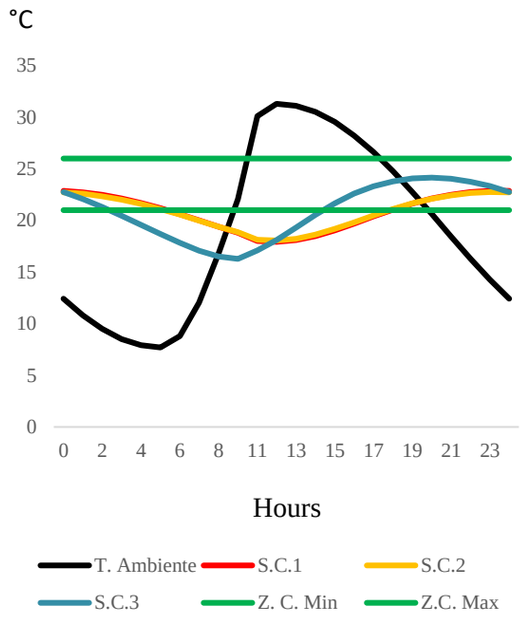
The factor of decrease, takes into account the absorptance of the material and the global solar radiation incident on the construction system, and has no dimensions. The decrement factor is a value between 0 and 1 (Ener-Habitat, 2014). In this case, the wooden walls have the lowest factor in all the orientations and the concrete walls have the highest decrement factor. The construction system of recycled plastic brick is similar to that of wood, varying by only one unit (table 3).

Walls in the warm month (July)				
	North	East	South	West
S.C.1	0.19	0.17	0.18	0.2
S.C.2	0.18	0.16	0.17	0.19
S.C.3	0.29	0.28	0.29	0.32

Table 3 Warm month decrement factor
Source: Ener-Habitat



Graphic 2 Indoor temperature behavior of the construction systems of the North Wall (warm month)
Source: Ener-Habitat



Graphic 3 Indoor temperature behavior of the south wall construction systems (warm month)
Source: Ener-Habitat

It is possible to observe the behavior of the materials (graph 2 and 3) that the construction system 1 and 2 have a very similar behavior, with one line joining another with a minimum variation. The green lines indicate the comfort zone of the interior temperature of the home in the approximate range of 21 ° C to 26 ° C for the warm month. It is appreciated that these two systems (S.C.1 and S.C.2) are stable and enter the comfort zone at 6:00 pm and leave at 6 a.m. being these hours in which they usually perform activities at home. On the other hand, the construction system with concrete walls (S.C.3) has no stability and is prone to make sudden changes in temperature, it enters the comfort zone in the 3 p.m. at 12 a.m. approximately according to the graphs.

Wall in the cold month (January)				
	North	East	South	West
S.C.1	0.18	0.17	0.17	0.17
S.C.2	0.17	0.16	0.16	0.16
S.C.3	0.29	0.27	0.27	0.27

Table 4 Cold month decrement factor
Source: Ener-Habitat

The decrease factor in the month of January (table 4) is similar to the month of summer (table 3).

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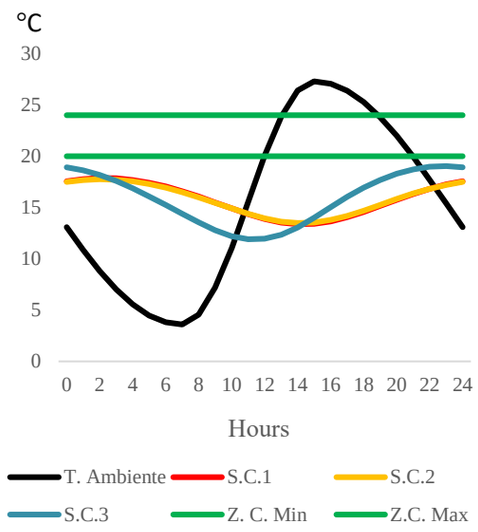
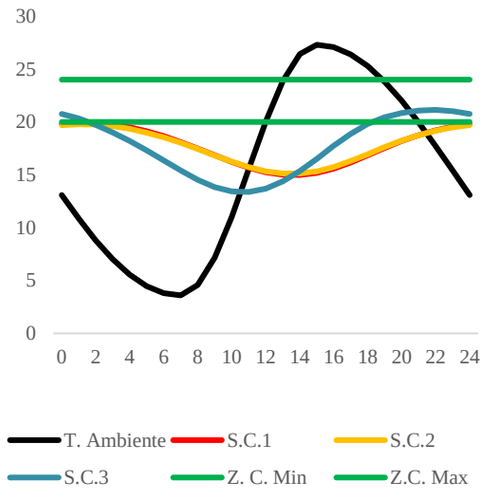


Graphic 4 Interior temperature behavior of the construction systems of the North Wall (cold month)
Source: Ener-Habitat



Graphic 5 Indoor temperature behavior of the construction systems south wall (cold month)
Source: Ener-Habitat

In the cold month (January) the comfort zone within the dwelling is from a range of 20 ° C to 24 ° C. It can be seen that no building system analyzed in this simulation enters the comfort zone (graph 4), it should be noted that the wooden and brick construction system recovered plastic have more stability and the temperature change within the home is moderate with respect to concrete. In Figure 5 the S.C.1 and S.C.2 enter the comfort zone from the hours of 23 hours until 3 a.m. and S.C.3 enters the comfort zone at 6:00 p.m. until 2 a.m.

Conclusions

The recovered plastic brick is an efficient material for the construction of decent housing due to the decrease factor (0.17 - 0.20) which is very close to that of the wood, with a more accessible price up to 30 % compared to traditional materials. It has the characteristics that make it safe for building structures, and this alternative construction system can be successfully replicated in the city of Tijuana according to the analysis of the Ener-Habit program.

The manufacture is made with non-biodegradable waste materials, thus preventing them from ending up in the sea. In addition to motivating society to want to implement it in their homes and contribute to the preservation of ecosystems. By implementing this alternative construction system will recover plastic debris polluting the environment, reducing the emission of CO2, generator of climate change and the greenhouse effect, in addition this plastic brick does not need to consume water and any other material from natural resources for its elaboration.

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