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The works must be unpublished and refer to issues of international architecture, technological innovation in architecture, industrial design, business design techniques, multimedia design, advertising design, web system design, residential architecture and other topics related to Engineering Sciences and Technology.

Presentation of the Content

In Issue 11 is presented an article *Energy efficiency in mass-built housing and demonstrative bioclimatic models in a hot-dry climate zone, by* ROMERO-MORENO, Ramona, BOJÓRQUEZ-MORALES, Gonzalo, LUNA-LEÓN, Aníbal and REYES-BARAJAS, Karmina, with adscription at Universidad Autónoma de Baja California, in the next article *Design of ecological masonry piece for non-structural walls*, by MENDOZA-GONZÁLEZ, Felipe, CÓRDOVA-ESCOBEDO, Jesús Fausto, TREJO-MOLINA, Francisco de Jesús and SALMERON-ORTIZ, Mario Raúl, with adscription at Universidad Veracruzana, in the next section *Diagnosis of the pathologies of a bridge, section: Champotón Bridge*, by BARRERA-LAO, Francisco Javier, CANUL TURRIZA, Román Alejandro, CRUZ-Y-CRUZ, Andrea del Rosario and GUTIÉRREZ-GONZÁLEZ, Julio Antonio with adscription at Universidad Autónoma de Campeche, in the next section *Innovation and development of self-sustained wooden residues blocks "Madeblock" for homes and buildings*, by LANDAZURI-AGUILERA, Yara & RUIZ-PEREZ, Roberto, with adscription at Tecnológico Nacional de México, Campus Delicias.

Content

Energy efficiency in mass-built housing and demonstrative bioclimatic models in a hot-dry climate zone

Eficiencia energética en vivienda de construcción en serie y en modelos demostrativos bioclimáticos en zona de clima cálido seco

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Abstract

The residential sector is one of the biggest consumers of electric energy, especially in zones with extreme dry-hot climates such as Mexicali. The implementation of NOM-020-ENER-2011 energy efficiency standards for the envelope of the dwelling is essential to provide thermal comfort with a lower energy consumption. The goal of this article is to evaluate the application of energy efficiency standards in three housing models: The first one was a prototype of mass-built housing (commercial model) and the remaining were demonstrative dwelling prototypes built with bioclimatic criteria. The analysis was made with the digital calculation tools provided by the Secretary of Energy and the National Commission for the Efficient Use of Energy. The results showed that for the commercial dwelling to reach the energy efficiency standards, it is required to diminish the overall heat transfer coefficient. Therefore, it was achievable to improve the energetic efficiency by including the bioclimatic housing criteria. Although important efforts have been made to optimize the housing design, they have not been effective enough to improve the energy efficiency of the mass-built housing.

Energy efficiency standards, Mass-built housing, Hot-dry climate

Resumen

El sector residencial es uno de los mayores consumidores de energía eléctrica sobre todo en zonas de clima cálido seco extremoso como Mexicali. La implementación de normas de eficiencia energética para la envolvente de la vivienda NOM-020-ENER-2011 es indispensable para generar condiciones de confort térmico con un menor consumo de energía. El objetivo del artículo fue evaluar la aplicación de las normas de eficiencia energética en tres modelos de vivienda: el primero fue un prototipo de vivienda de construcción en serie (modelo comercial) y los restantes, fueron prototipos demostrativos de vivienda construida con criterios bioclimáticos El análisis fue realizado con la herramienta de cálculo digital proporcionada por la Secretaria de Energía y la Comisión Nacional para el Uso Eficiente de la Energía. Los resultados mostraron que para que la vivienda comercial cumpla con los estándares de eficiencia energética requiere disminuir el coeficiente global de transferencia de calor. Se observó que fue factible mejorar la eficiencia energética al incluir criterios de los modelos bioclimáticos de vivienda. Aunque se han hecho esfuerzos importantes, para optimizar el diseño de la vivienda, no han resultado lo suficientemente efectivos para mejorar la eficiencia energética de la vivienda de construcción en serie.

Normas de eficiencia energética, Vivienda de construcción en serie, Clima cálido seco

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Introduction

Energy efficiency in the residential sector is part of the policies to cushion the impact of climate change and its impact on electricity consumption. The residential sector is one of the main consumers of electricity. Globally, this sector is responsible for 22% of total consumption and 19% of CO_2 emissions (Global Alliance for Buildings and Construction, et al., 2019). In Mexico, in 2016, the electricity consumption of the residential sector represented 26.8% of the total electricity consumption (Secretaria de Energía, 2017). In areas with an extreme hot climate, such as Mexicali, electricity consumption in the residential sector represents 43.9% of total consumption (National Institute of Statistics and Geography, 2016). In hot areas, electricity consumption is increased by the use of environmental conditioning systems to maintain conditions of thermal comfort in the hot season.

The housing envelope is the filter of the impact of weather conditions; greater energy efficiency of the same implies greater savings in the use of energy. Laws, codes, regulations and / or standards have been developed in different countries to improve the energy efficiency of buildings and in particular the residential sector. In Spain, there is the Technical Code for Buildings which contains regulations for energy saving (Ministerio de Fomento, 2019). In the United States there are various energy efficiency codes and standards, such as the California Energy Code (California Building Standards Commission, 2019) and the ASHRAE 90.2 standard for the energy efficient design of low-rise residential buildings (American Society of Heating, Refrigeration and Air Conditioning Engineers, 2018), among others.

In Mexico, the public policy to promote energy efficiency in buildings is regulated for non-residential buildings in NOM-008-ENER-2001 (Official Gazette of the Federation DOF, 2001) and the official standard for the envelope of buildings for residential use by NOM-020-ENER-2011 (NOM-020) (DOF, 2011). In this sense, both standards seek to optimize the design of the enclosure, from the point of view of thermal and energy performance.

Obtaining as benefits, among others, energy savings due to the reduction of the capacity of the cooling equipment, since the generalized use of these equipment affects the peak demand of the national electricity system. The building envelope becomes an element of interaction between the exterior and interior environment of the house. With this, there may be envelopes that favor the increase or decrease of the heat gain to the interior, and with this the impact on the conditions of thermal comfort, especially in areas of hot dry climate.

Energy efficiency standards for housing in Mexico

NOM-020 becomes the instrument to determine the energy efficiency of buildings for residential use, applies to new homes or extensions, came into force in 2011, although it is not mandatory; the houses can be of the isolated single-family type (one house per lot) or collective (condominium, multi-family).

NOM-020 is focused on the analysis of the envelope (ceilings, walls, windows and doors). Basically, it estimates the heat gains by conduction and radiation through the envelope, from the comparison of a reference home (VR) and the projected home (VP) –proposal that is evaluated. The characteristics of the VP are defined in the executive project or in the built house, as the case may be; the main requirements are: construction areas and systems by orientation of walls and ceilings, as well as the characteristics and areas of windows and doors by orientation. Regarding VR, it maintains a relationship with VP in areas and orientation, based on considering 90% opaque part in walls and 10% transparent part and in ceilings with 100% opaque part.

In both cases (VP and VR), it is required to have the thermophysical properties of the materials, to estimate the global heat transfer coefficient of the different construction systems of walls and ceilings; the equivalent temperature values for heavy walls, light walls and windows by orientation (north, east, south and west); Average solar gain factors for windows based on their orientation and for skylights and domes.

With the above, an "energy budget" is obtained that seeks to limit the heat gain of the PV. If the PV has a heat gain equal to or less than the VR, this means that the projected home passes compliance with the standard and shows the corresponding energy savings (DOF, 2011).

The version of NOM-020 published in 2011 was modified in 2016 (DOF, 2016), since it was not possible to comply with it, with the common construction systems for serial construction housing. Adjustments were made to the global heat transfer coefficients, equivalent temperature and solar radiation gain; the values are regionalized by state and cities of the country. Table 1 shows those corresponding to the city of Mexicali, Baja California.

Global heat transfer coefficient (W / m^2 °C)					
Levels	Up to three levels	Walls and ceilings	0.625		
	More than three levels	Ceiling	0.625		
		Wall	0.714		
Equivalent temperature (°C)					
Driving	Inside	25			
	Bottom surface	34			
	Ceiling	50			
		Orientation			
	Walls	N	S	E	O
	Massive	36	40	37	39
	Light	41	45	43	46
	Window	30	32	32	33
	Skylights	29			
Solar gain coefficient (W / m^2)					
Radiation	Window	70	159	131	165
	Skylights	322			

Table 1 Global heat transfer coefficient, average equivalent temperature and solar gain factor., NOM-020-ENER-2011, Mexicali, Baja California
Source: Elaboration based on DOF, 2016

Therefore, the objective of this article is to determine the impact of the application of energy efficiency standards NOM-020 in series construction housing in a context of hot dry climate, such as Mexicali; with the purpose of knowing to what extent they comply with energy efficiency regulations or if modifications are required to existing construction systems; and includes the proposal of two demonstration models of housing designed with bioclimatic criteria

The article consists of three parts. In the first, the introductory section is shown and the main guidelines of NOM-020 are specified. In the second, about the method, the case studies, the criteria used, and the evaluation tool are described.

In the third, the results of the application of NOM-020 in the different case studies, the requirements for compliance with it, and the conclusions are presented.

Methodology

Serial construction housing for low-income families, called affordable housing, was evaluated; Three housing models were used: one was the commercial housing model (MC) and two were bioclimatic housing models (BM1 and BM2), these are demonstrative housing prototypes, products of the research project “Thermal comfort and energy saving in economic housing in Mexico: regions with a hot, dry and humid climate ”(Universidad Autónoma de Baja California, *et al*, 2013). The case studies have the main facade to the north, one of the side facades is built at the property limit, they have a corridor that connects the front with the rear of each house. The dimensions of each lot are 6.86 x 17.50 m, with a surface area of 120 m^2. The homes have a common space (living room-kitchen), one or two bedrooms and a bathroom (Figure 1 and 2).

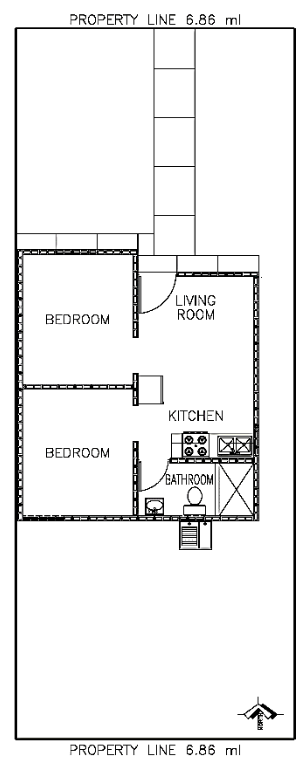

Figure 1 Architectural plan, Commercial model (MC), Fracc. Places of Puebla, Mexicali
Source: Own elaboration, AutoCad

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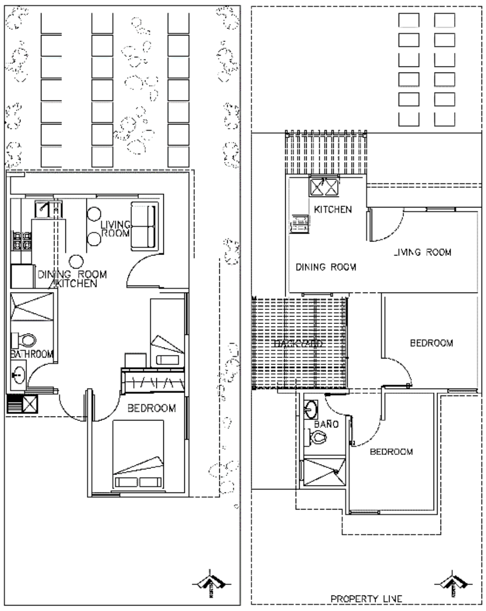

BM1 BM2

Figure 2 Architectural plan, Bioclimatic Models BM1 and BM2, Fracc. Places of Puebla, Mexicali
Source: Own elaboration, AutoCad

The MC and BM1 models have a surface area of 38 m^2 and the BM2, 43.8 m^2. Table 2 shows the wall and ceiling surfaces of each of the housing models.

Surfaces		Areas (m^2) Walls (opaque)	Sale-Nas	Doors (opaque)	Total
Business model (MC)					
Vertical	N	14.03	2.08	1.92	18.03
	S	16.77	1.24	-	18.01
	E	19.19	0.61	-	19.80
	O	19.78	-	-	19.78
Horizontal	T				38.00
	P				38.00
Bioclimatic model (MB1)					
Vertical	N	15.28	2.14	-	17.41
	S	13.18	1.37	1.81	16.34
	E	23.09	2.58	2.18	27.85
	O	27.22	-	-	27.22
Hori	T				38.00
	P				38.00
Bioclimatic model (BM2)					
Vertical	N	18.70	2.49	2.15	23.34
	S	18.77	2.81	-	21.58
	E	20.54	-	-	20.54
	O	28.24	1.31	2.15	31.70
H	T				43.80
	P				43.80
Symbology: N = north, S = south, E = east, O = west, H = horizontal, T = ceiling, P = floor.					

Table 2 Surfaces by orientation, ceiling and floor; Models MC, BM1 and BM2, Mexicali, B.C.
Source: Elaboration from executive plans of the projects

The construction systems of the three housing models are shown in Table 3, and the global heat transfer coefficients of each of them are included.

	Ceiling	U (W/m^2 ºC)	Walls	U W/m^2 ºC
MC	Vault joist	0.345	Common concrete block 0.12 m	2.992
MB1	Wooden structure	0.2506	Common concrete block 0.12 m	2.992
			Common concrete block 0.12 m, polystyrene thermal insulation 0.0254 m (1 ”)	0.956
MB2	CCA-6 panels thickness 0.175 m	0.5549	Block 0.15x0.40 x0.40 m, CCA-4 type “O” and “U”	0.8624

Table 3 Construction systems and global heat transfer coefficient (U), case studies
Source: Elaboration from the CATEDI Program, Luna

All homes have a reinforced concrete floor 0.10 m f’c = 240 kg / cm^2 (U = 3.18 W / m^2 ºC); single glass windows and aluminum hoses (U = 7.24 W / m^2 ºC); and drum type wooden doors (U = 2.78 W / m^2 ºC).

The bioclimatic criteria of BM1 are: a) roof with a lightened wooden structure, exterior sheet and interior insulation, which functions as a double roof with ventilated attic; b) 0.12 m concrete block wall in north and south walls; plus thermal insulation 0.0254 m (1 ”) in east and west walls; c) location of windows that promote cross ventilation; d) window shading elements with roof extension; e) use of light colors on exterior walls.

The bioclimatic techniques of the BM2 are: a) roof made of panels of autoclaved cellular concrete (CCA), type CCA-6; b) CCA walls, type CCA-4; c) use of natural ventilation and lighting; d) use of outdoor patios; e) use of solar protection on walls; f) interior heights greater than 2.40 m.

For each case study, a base case was established, which is the one that matches the real home built. Modifications were proposed to the design of the housing envelope, to improve energy performance (Table 4).

Key	Considerations
	Business model (MC)
Base case	Joist and vault ceiling 0.20 m, concrete block wall 0.12 m, windows without shade
A	Base case + 0.0254 m (1 ") polystyrene thermal insulation on south wall
B	Base case + 0.0254 m (1 ") polystyrene thermal insulation on west wall
C	Base case + 0.0254 m (1 ") polystyrene thermal insulation on south and west walls
D	Base case + 0.0254 m (1 ") polystyrene thermal insulation on south, west and east walls.
E	Joist and vault ceiling 0.20 m, CCA-4 autoclaved cellular concrete block wall,
	Bioclimatic model 1 (BM1)
Base case	Wooden roof with lateral ventilation on two sides and 0.508 m (2 ") polystyrene thermal insulation and exterior covered with galvanized sheet. 0.12 m concrete block walls in north and south orientation. 0.12 m concrete block walls + 0.0254 m (1 ") polystyrene thermal insulation in east and west orientation. Shadowless windows
A	Base case + 0.0254 m (1 ") polystyrene thermal insulation on south wall
F	CCA-6 autoclaved aerated concrete panel ceiling, 0.17 m, CCA-4 autoclaved aerated concrete block wall, Shadeless windows
G	Joist and vault ceiling 0.20, concrete block wall 0.12, windows without shade
	Bioclimatic model 2 (BM2)
Base case	CCA-6 autoclaved cellular concrete panel ceiling, CCA-4 autoclaved cellular concrete block wall, windows without shade
H	CCA-6 autoclaved cellular concrete panel ceiling, CCA-4 autoclaved cellular concrete block wall, windows with shade

Table 4 Study cases. Source: self made

The evaluation of the case studies was carried out with the NOM-ENER-2011 calculation tool prepared for the Secretary of Energy and the National Commission for the Efficient Use of Energy (Danish Energy Agency, 2017; CONUEE, 2017). Screens of the assessment tool are shown in Figure 3.

Figure 3 NOM-020-ENER- 2011 Calculation Tool, SENER-CONUEE
Source: https://www.gob.mx/conuee/acciones-y-programas/herramienta-calculo-nom-020-ener-2001

Results

The results are presented by type of home, the base case and the modifications made to comply with NOM-020 are considered.

Table 5 shows the heat gain of the commercial model (joist and vault ceiling, and concrete block walls). It is observed that the MC, without insulation in ceilings and walls, has 50% more heat gain than the value allowed to approve compliance with NOM-020.

Thus, even when you have a joist and vault ceiling, it is not enough to achieve compliance with NOM-020, nor with the partial isolation of any of the orientations (south, west or east), isolation is required. of the 3 orientations mentioned (Case D) or the change for a construction system with a higher thermal resistance (Case E).

Model de vivienda	Heat gain (W) Conduction	Radiation	Total	NOM-020 compliance Yes or no	Energy Saving (%)
Reference Housing					
	1397.94	1001.4	2402.31		
Projected Housing					
Base case	3200.90	405.03	3605.93	No	-50.1
A	2790.34	405.03	3195.37	No	-33.0
B	2677.44	405.03	3082.47	No	-28.3
C	2267.78	405.03	2672.81	No	-11.3
D	1681.80	405.03	2086.83	Si	13.1
E	1282.55	405.03	1688.58	Si	29.7

Table 5 Heat gain, Commercial model (MC), NOM-020-ENER-2011, Mexicali
Source: Elaboration based on the application of NOM-020

In the case of the bioclimatic housing demonstration model (BM1) built with a wooden roof (ventilated attic) and concrete block walls, according to Table 6, it is observed that even when it has a roof with thermal resistance (thermal insulation of polystyrene 0.0508 m) and east and east walls with thermal insulation of polystyrene 0.0254 m (1”), does not meet the approval of NOM-020.

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Housing model	Conduction	Heat gain (W) Radiation	Total	NOM-020 compliance Yes or no	Energy Saving (%)
Reference housing					
Ref	1557.98	1225.2	2783.13		
Projected Housing					
Base case	2347.71	738.90	3086.61	No	-10.9
A	2026.02	738.90	2764.92	Si	0.70
F	1759.56	738.90	2498.46	Si	10.20

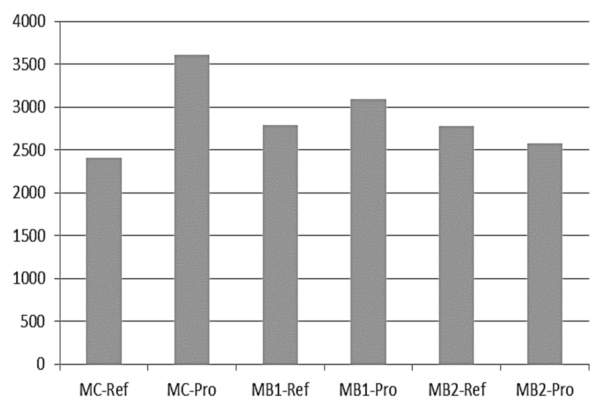
Table 6 Heat gain, Bioclimatic Model (BM1), NOM-020-ENER-2011, Mexicali
Source: Elaboration based on the application of NOM-020

To comply with NOM-020, it is required that the south, east and west walls be insulated, which implies increasing the surfaces with thermal insulation or substituting construction systems with higher thermal resistance. Table 7 shows the application of NOM-020 in a bioclimatic house built with autoclaved cellular concrete system. This system did allow the approval of NOM-020.

Housing model	Conduction	Heat gain (W) Radiation	Total	NOM-020 compliance Yes or no	Energy Saving (%)
Reference housing					
	1610.97	1165.6	2777.52		
Projected housing					
Base case	1817.99	756.80	2574.79	Si	7.3

Table 7 Heat gain, Bioclimatic Model (BM2), NOM-020-ENER-2011, Mexicali
Source: Elaboration based on the application of NOM-020

In Graphic 1, the total heat gains of the reference and projected housing of each of the study cases are shown; and Table 8 shows the energy efficiency per square meter (m^2) of the case studies.



Symbols: MC-Ref = Reference commercial-housing model; MC-Pro = Projected commercial-housing model. BM1-Ref = Bioclimatic model 1 - reference house; BM1-Pro = Bioclimatic model 1 - projected house .; BM2-Ref = Bioclimatic model 2 - reference house; BM2-Pro = Bioclimatic model 2 - projected house

Graphic 1 Total heat gain (W) of the MC, BM1 and BM2 models, NOM-020-ENER-2011, Mexicali

The models built or homes projected showed that the MC had a heat gain of 3605 W, the BM1 of 3086.61 W and the BM2 of 2574.79 W; it is observed that the bias of the bioclimatic models is 16% and 29% lower than the commercial model.

Housing (W / m^2) Business model MC		Bioclimatic model BM1		Bioclimatic model BM2	
Ref	Proj	Ref	Proj	Ref	Proj
63.22	94.89	73.24	81.23	63.13	58.52
Symbology: Ref = Reference, Proj = Projected					

Table 8 Energy efficiency per m^2, case studies, Mexicali
Source: Our elaboration

The above shows that the commercial construction system is the one with the highest heat gain, therefore it turns out to be the least efficient; a better thermal performance per m^2 was shown by the construction systems of the bioclimatic models.

Conclusions

For the climatic conditions of Mexicali, it is concluded that:

- Current construction systems are not sufficient to comply with NOM-020, they represent 50% more heat gain than allowed by the standard.

- It is required to apply thermal insulation measures at least in 3 (south, east and west) of the 4 basic orientations, which implies additional investment costs to have a home that passes the conditions of the standard.

- The modifications made in 2016 are not yet sufficient to achieve energy savings and maintain conditions of thermal comfort, it is necessary to readjust the global heat transfer coefficients used as a reference in hot dry climates.

- The digital evaluation tool of NOM-020-ENER-2011 resulted in an accessible and relevant instrument for its application, significantly facilitating the evaluation of projects.

- NOM-020 analyzes the impact of heat gain on the enclosure, gives priority to the criterion of thermal resistance; it does not allow to include the effects of shaded or ventilated ceilings or walls and construction systems greater than 5 layers, although it does consider shading in windows.

Finally, it will be important to have public policy elements that favor the inclusion of bioclimatic design criteria, which allow better thermal performance of the housing envelope, as well as to reduce electrical consumption while maintaining conditions of thermal comfort for the population.

Acknowledgment

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Design of ecological masonry piece for non-structural walls

Diseño de pieza de mampostería ecológica para muros no estructurales

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Abstract

In the research work in the methodological aspect, the tongue and groove Block was designed (geometry) in AutoCad, based on the NMX-C-038-ONNCCE-2004 standard; It was included in the material with which the Block was manufactured, crushed polypropylene plastic (PP) to reuse materials that are polluting, and in this way an ecological Block was made, later it was manufactured complying with the NMX-X-159 standard. ONNCCE-2004 the steel mold for the Block. For the analysis and results, a press was used to test the compression pieces established by the NMX-C-441-ONNCCE-2013 Standard for non-structural blocks. In the laboratory, the initial water absorption test was carried out with the NMX-C-037-ONNCCE-2005 in three pieces of blocks, in addition, the MATLAB software was used to obtain the effort-time graphs of the pieces of block with the different dosages of recycled plastic material. The research concludes that the reuse of polypropylene plastic to make blocks will help reduce environmental pollution. The results of the compression tests were satisfactory for non-structural blocks. The initial maximum water absorption tests to which the blocks were subjected, comply for exterior and interior walls.

Masonry, Ecological, Assemble

Resumen

En el trabajo de investigación en el aspecto metodológico se diseñó (la geometría) en AutoCad del Block machihembrado, con base en la normativa NMX-C-038-ONNCCE-2004; se incluyó en el material con el que se fabricó el Block, plástico de polipropileno (PP) triturado para reutilizar materiales que son contaminantes, y de esta manera se hizo un Block ecológico, posteriormente se elaboró cumpliendo con la norma NMX-X-159-ONNCCE-2004 el molde de acero para el Block. Para los análisis y resultados, se utilizó una prensa para ensayar las piezas a compresión que establece la Norma NMX-C-441-ONNCCE-2013 para blocks no estructurales. En el laboratorio se realizó la prueba de absorción inicial de agua con la NMX-C-037-ONNCCE-2005 en tres piezas de block, adicionalmente se utilizó el software MATLAB para obtener la gráfica esfuerzo – tiempo, de las piezas de block con las diferentes dosificaciones de material de plástico reciclado. En la investigación se concluye que la reutilización del plástico de polipropileno para fabricar los blocks, ayudara a disminuir la contaminación del medio ambiente. Los resultados de los ensayos a la compresión fueron satisfactorios para blocks no estructurales. Las pruebas de absorción máxima inicial de agua a la que se sometieron los blocks, cumplen para muros exteriores e interiores.

Mampostería, Ecológica, Machihembrado

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Introduction

For many years the structural or non-structural walls in buildings have been made of solid block, hollow block of concrete, hollow block of annealed clay, adobe, etc., which must be joined together with mortar made with mortar-sand-water or cement-sand-water, this makes that at the time of joining a block with another generates an increase in time and cost due to the preparation of mortar to join these pieces.

Also, more time is required to join the mortar with the blocks, as well as its leveling and accommodation, when building the masonry walls.

This research will present another way of building non-structural walls, which will be made with ecological block masonry and in turn these will be assembled, which aims to reduce time and costs, in which part of this significant reduction will also get a contribution to the environment by using recycled material such as plastic, which is the largest pollutant worldwide, environmental pollution by plastics is causing irreparable damage to our planet, and increasingly increases, the Greenpeace (2020) states that "The total production of plastic in 2015 reached 380 million tons. To date, some 8.3 billion tons of plastic have been manufactured since production began around 1950," so instead of this plastic being deposited in sanitary landfills or contaminating city streets, fields, rivers or seas, it will be used for construction purposes.

The different types of masonry are described, including the ecological and tongue-and-groove masonry that exist today. Beginning the investigation with the design of the piece in its dimensions and shape, once defined the block was manufactured the steel mold, and blocks were developed to determine that dosage in the mixture met the resistance, to define the dosage are manufactured 8 blocks, of these, 5 are tested to simple compression, and 3 are made the test of maximum initial absorption, the blocks tested to compression is obtained in MATLAB the graph of effort and time.

Types of masonry, ecological bricks and tongue and groove

Hollow mortar block

They are those that have a net area of at least 50 percent of the gross area; the most common being 40x20x20 cm, the thickness of their exterior walls is not less than 15 mm. The hollow brick is a type of brick that has the characteristic of having passing holes in its interior in a longitudinal sense. For hollow pieces with two to four cells, the minimum thickness of the interior walls must be 13 mm (cgservicios, n.d.).

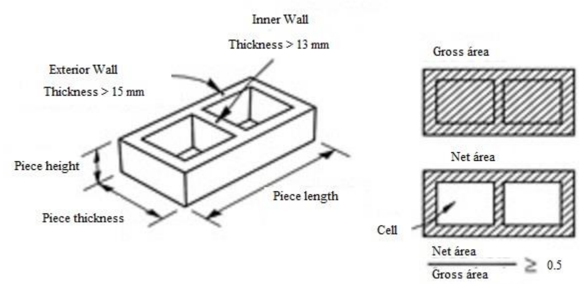

Figure 1 Hollow block
Source: NTC-For design and construction of masonry structures

Multi-perforated parts

For this piece its perforations must be of the same dimensions and with uniform distribution, the minimum thickness of the interior walls will be ≥ 7 mm, and as for the exterior ones ≥15mm. Multi-perforated pieces are understood to be those with more than seven perforations. (cgservicios, n.d.).

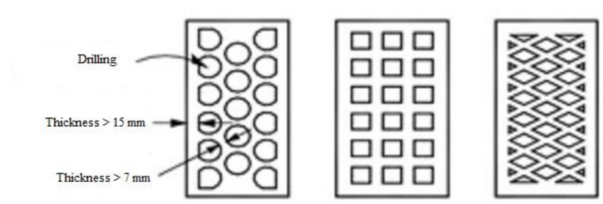

Figure 2 Multi-drilled block
Source: NTC-For design and construction of masonry structures

Normal or solid block

The traditional brick is solid of dense aggregate and responds to the formats DIN (29x14x5cm) or metric (24x11,5x5cm), although it can have some perforations.

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It is considered solid those that have in their most unfavorable cross section a net area of at least 75 percent of the gross area, and whose exterior walls are not less than 20 mm thick (cgservicios, n.d.).

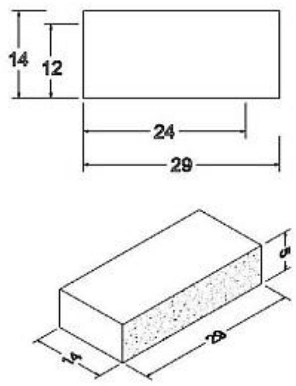

Figure 3 Normal or solid block
Source: Construmatica

Red annealed clay partition.

The red brick is a ceramic piece, usually rectangular in shape, obtained by molding, drying and firing at high temperatures, from a clay paste, the dimensions of the wall are usually around 24 x12 x6 cm. The use of the annealed partition is very extensive in all masonry work: the red partition is found in walls, walls and houses. (Materials for construction, n.d.).

Figure 4 Red annealed clay partition
Fountain: Construrama.com

Ecological brick based on construction waste

At the UNAM Engineering Institute, an ecological brick was created through a sustainable process; construction waste is used as raw material and solar energy is used for drying, instead of the traditional brick kiln firing. (Gazette, 2016)

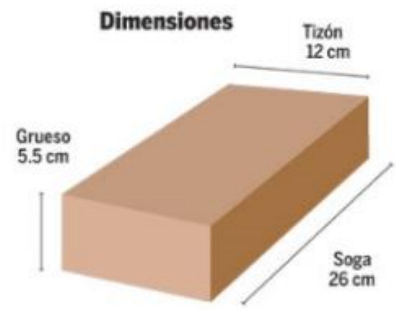

Figure 5 Dimensions
Source: UNAM Gazette, January 11, 2016

Ecological brick based on plastic waste (pet) and concrete

The manufacturing process of these bricks begins with the crushing of the plastics and then mixing it with portland cement as a binder to give cohesion to the mixture, and a chemical additive that improves the adhesion of the plastic particles. This mixture is placed in molds as if it were a prefabricated concrete piece and is left to set. (Science and Cement, 2015).

Figure 6 PET bricks and concrete
Source: Science and Cement, September 28th, 2015

Ecological brick based on plastic waste (pet)

These bricks can be manufactured with the help of a machine that can recycle all types of plastic following a series of steps, to finally compress the plastic paste to produce a 10 kilogram brick. (Ecologiaverde, 2017).

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Figure 7 PET bricks
Source: Ecologiaverde, November 22nd, 2017

Ecological brick based on concrete and rice husks

It is necessary to replace part of the sand aggregates with rice husks, in order to take advantage of the agro-industrial waste produced in high volumes in the places where the rice plant is planted and processed, since they generate environmental pollution in order to prevent such waste from being deposited in the rivers or burned causing pollution. This type is made with the combination of sand, rice husk, cement and water, similar to the conventional block. (Wordpress, 2016)

Figure 8 Rice husk-based bricks
Fountain: WordPress, October 2016

Ecological brick based on coal ash

The ash generated in coal-fired power stations is used, a waste with a high environmental impact and a high cost associated with its disposal. The method developed by "Calstar" (an American company) allows the transformation of such ashes into bricks with only 10 hours of cooking at a maximum temperature of 212 degrees, as opposed to the 24 hours and 2,000 degrees required by the raw materials usually used to produce this construction material. (Ecoticias, 2009).

Figure 9 Bricks based on coal ash
Source: Ecoticias, September 25, 2009

Ecological brick based on hemp

The block is made of industrial hemp fibres, natural hydraulic lime and a mixture of minerals. The components are mixed, solid blocks are pressed and air-dried, so the energy consumption in production is very low. Measures from 30 x 14,5 x 10,5 centimeters. (Elmundo, 2008).

Figure 10 Hemp-based bricks
Source: The World, March 19th, 2008

Ecological brick made from peanut shells

Previously and currently, peanut shells have been a contaminating residue that if stored in large quantities generates a radiation process that absorbs the soil, returning it sterile after a certain time. "Because of this, the ecoladrillos were created, which are made from a mixture of peanut shells, cement, lime and sand; having many benefits besides the already mentioned of reducing waste". (Expoknews, 2015)

Figure 11 Peanut shell-based bricks
Fountain: Expoknews, January 13, 2015

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Adobe brick

This brick is made without "firing", which results from a mass of mud (clay and sand), if needed, straw is added to the mixture, a brick-shaped mold is made and it is left to dry. These bricks can be used to build walls and arches. (Ecured, 2018).

Figure 12 Adobe bricks
Source: ecocosas.com, July 16, 2012

Tongue and groove block.

The tongue and groove block is a block with a system of inputs (female) and outputs (male) which makes your construction method easier, saving time and costs.

If tongue and groove building blocks are used, it is not necessary to be a professional mason to build plumbed walls. The blocks can be made from a variety of materials, including charcoal, slag, and pumice. Each block has a shoulder at the top and an undercut groove at the bottom. Steel rods can be inserted through the holes to reinforce the wall. In order to form a seal around the blocks, mortar is injected into the holes in the blocks. Only a thin line between the blocks is visible on the wall surface. For this type of block there can be as many types as desired, provided they have adequate resistance.

Figure 13 *Tongue and groove block*
Fountain: Architecture Link

Methodology

Type of Geometry

The design of the masonry piece is started with the help of the program "AutoCAD", with which it is intended to produce a block with a different geometry and aggregates to the pieces that are on the market.

Different investigations were carried out on existing pieces, of which we have those already mentioned in the ecological bricks, and on tongue and groove block".

According to the information obtained, we began to design the piece with the (NMX-C-038-ONNCE-2004, 2004).

The conventional measures are chosen for a common block, which are 40 cm long, 15 cm wide, and 20 cm high, with the difference that this piece is added outputs and inputs (male-female) for its tongue and groove design, the inputs and side outputs have 2 cm radius located from the lateral centers, throughout the thickness or height of the block, the left side inward and right outward, as the bottom and top have 4 cm in diameter and 1. The upper part is 5 cm high and the lower part is 1.5 cm inwards.

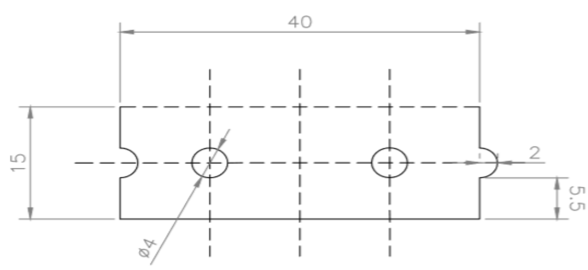

Figure 14 Geometry of the ecological tongue and groove block for non-structural walls

Figure 15 Eco-friendly masonry piece for non-structural walls

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Shredding or cutting of polypropylene (PP) plastic

Polypropylene plastic from yogurt containers, sorbets and bottle caps is shredded to obtain smaller parts of it, to favor mixing with the concrete, and to have better adhesion.

Figure 16 Crushed plastic (PP)

Mould making

A special steel mold is elaborated with the measures designed to manufacture the pieces, since it will not be of the conventional ones because it has a different geometry, this mold will have a thickness of the plates adapted so that it is not deformed at the time of casting the concrete mixture, the (NMX-C-159-ONNCCE-2004, 2004) indicates that "The molds and the accessories to elaborate the concrete specimens must be of steel, fused iron, or any other nonabsorbent and nonreactive material with the portland cement or other hydraulic cementants" (p. 6).

Manufacture of ecological masonry parts for non-structural walls

To make our piece of masonry will need the appropriate tools, equipment and materials for this, whose measures will be 40 cm long with 15 cm wide and 20 cm high, with 14 days old, the blocks were made in the laboratory of soil mechanics and concrete at the University of Veracruz, Coatzacoalcos Campus.

Team:

- Mold for the masonry piece.
- Compacting rod.
- Rubber hammer for compacting.
- Wooden hammer for compacting.
- Racer.

Auxiliary tools:

- Pala.
- Container.
- Spoon.
- Water Meter.

Materials:

- Gravilla.
- CPC 20R cement.
- Agua.
- Recycled crushed plastic.
- Accepted to descend.

According to the specifications provided by the CEMEX company, for non-structural blocks with approximately 40 kg/cm2 of resistance, and measures of 40x20x15 cm the dosage is:

- One 50kg cement bundle.
- 19 cans of 19 kg aggregate (gravel).

For the production of 23 to 25 pieces.

The dosage for a block of masonry with the measures described above is made, and it is obtained that for a piece you need: 15.5 kg of gravel, 2.64 kg of cement and 1 to 1.2 liters of water, approximately.

To determine the dosage for the ecological masonry piece, three proportions of recycled plastic (PP) will be used, until a resistance for non-structural masonry is achieved, one with 25% plastic and 75% stone aggregate, another with 15% recycled material and 85% stone aggregate, and a last one with 10% plastic and 90% gravel.

Material	25%PP (kg)	15%PP (kg)	10%PP (kg)
Gravel	11.55	13.09	13.86
Plastic (PP)	3.85	2.31	1.54
Cement	2.13	2.13	2.13
Water	1-1.1 L	1-1.1 L	1-1.1 L

Table 1 Non-structural ecological block dosage

The procedure for making the blocks is explained briefly below, before pouring the mixture into the mold, this should be applied inside, oil with a brush to prevent the masonry piece is stuck to the steel mold when removed; The materials are mixed starting with the gravel and the crushed plastic, then the cement is added and it is homogenized again, and at last water is added gradually, it is mixed until it is a little thick for a better workability in the mold, the mixture will stop adding water until when taking it with the hand and squeezing it it does not disintegrate, the concrete is poured little by little with the help of a bucket so as not to drop it abruptly, this procedure is done in two equal layers, the standard for the elaboration and curing of specimens (NMX-C-159-ONNCCE-2004, 2004) is taken as a reference "for pieces with a surface area of 320 mm or more, a 16mm rod will be used and a penetration per layer of one for every 10 cm2 of surface will be done".

Since the piece will be 600 cm2, a penetration of 60 times will have to be done in the whole layer to eliminate the air holes, as well as it will have to be hit around the mold with a neoprene hammer about 25 times, later the compaction will be completed with a wooden mallet to tamp each layer. Afterwards, the piece is covered, leaving a weight on it, and it is left to dry for 20-30 minutes, in order to properly unmold it. Finally, the mold is unscrewed since it is dismountable and all its faces are removed to take out the masonry piece. This procedure will be done six times to manufacture six blocks to which the compression test will be done.

Two pieces for each one of the plastic dosages (PP), and they will be tested at 14 days of age, to determine which of the dosages complies with the resistance for non-structural blocks.

Simple compressive strength test

We start the test with the pieces with 25% of plastic.

First, a grout is placed on the top and bottom of the specimen, so that the sulfur that will serve to head the block does not remain adhered to it when it is removed due to the not 100% smooth surface, this in order to be able to reuse the sulfur. Later the sulfur is heated to make the pitch of the element, the universal pitcher is prepared based on the NMX-C-036-ONNCCE-2004-"INDUSTRY OF THE CONSTRUCTION-BLOCKS OR BRICKS, TABICONS AND ADOQUINES-RESISTANCE TO THE COMPRESSION-METHOD OF TEST", is not placed as it is commonly done, since the longest length of the header brackets is 40 cm, and our piece due to its protrusions measures 43cm, so an arrangement is made according to the size of our piece. Once the sulphur and the pitching plates are ready, the sulphur is poured into the base of the plates and without letting more than 10 seconds pass (so that the sulphur does not dry out) the block is placed to achieve a uniform pitch. It is worth mentioning that when this procedure is carried out the blocks should not have the upper projections so that our test can be carried out successfully, once the pitch is carried out in the upper and lower part of the block, the sulphur is left to set for approximately 30 minutes.

The block is placed in the press to perform the compression test. The 6 pieces will be tested at 14 days of age, once the results are obtained, the dosage of the elements that manage to be in the range of non-structural blocks will be chosen.

Figure 17 Testing the ecological piece to simple understanding

The chosen dosage that obtained the best result to the compression was with 10% of shredded plastic.

Block	Plastic (PP) (%)	Resistance f'c (kg/cm^2)
1	25	22.18
2	25	19.21
3	15	25.85
4	15	23.65
5	10	44.93
6	10	42.62

Table 2 Compressive strength of the blocks

Manufacturing 5 blocks with 10% PP to comply with the standard "NMX - C - 441 - ONNCCE - 2013 - INDUSTRIA DE LA CONSTRUCCIÓN-MAMPOSTERIA-BLOQUES, TABIQUES O LADRILLOS Y TABICONES PARA USO NO ESTRUCTURAL-ESPECIFICACIONES Y METODOS DE ENSAYO"

Initial maximum absorption test

Once our dosage of the ecological blocks is obtained (10% PP), we proceed to make another batch of 3 pieces, of measures, 40 cm long, 15 cm wide and 20 cm high, with 14 days of age, made in the laboratory of soil mechanics and concrete of the Universidad Veracruzana Campus Coatzacoalcos. For the test of maximum initial absorption according to the "NMX - C - 037 - ONNCCE - 2005 - "INDUSTRIA DE LA CONSTRUCCION-BLOQUES, LADRILLOS O TABIQUES Y TABICONES - DETERMINACON DE LA ABSOCION DE AGUA Y ABSORCIÓN INICIAL DE AGUA", section 2.7 Determination of water absorption and initial water absorption.

A metal container with a minimum interior depth of 1.3 cm must be used. Two supports are placed on this container so that the block is placed on them and in this way the lower face is in contact with the water, as well as the sides of the piece. The blocks must be submerged in the water up to 5 mm high on the lower face of the piece. The blocks must be left submerged for a period of 10 minutes, counting the time from the moment the piece touches the water surface. It is important to note that during this time the water must be kept at a constant level, so water will be added gradually as the water level in the container decreases.

After 10 minutes the block will be removed, removing the excess water from the saturated surfaces with a damp cloth, without letting this time pass 10 seconds. The block will be weighed again without letting more than 2 minutes pass after having removed the water from the piece, and the algorithm is used to calculate the maximum initial absorption in g/min.

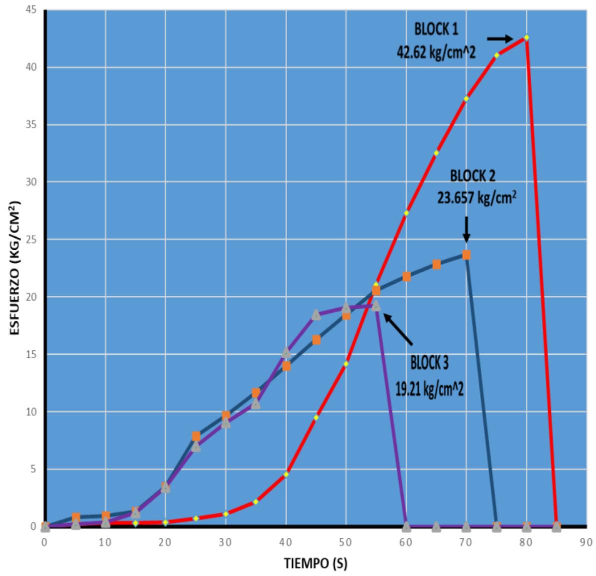
Figure 18 Maximum initial absorption test of the ecological part

Graphic (effort - time)

In the Table are presented the blocks with dosage of the three proportions of crushed plastic, the graph was made with the program MATLAB.

Time (s)	Effort block 1 (10%PP)	Effort block 2 (15%PP)	Effort block 3 (25%PP)
0	0	0	0
5	0.217	0.833	0.217
10	0.333	0.917	0.367
15	0.333	1.3	1.21
20	0.35	3.517	3.41
25	0.70	7.867	7.01
30	1.10	9.65	9.05
35	2.15	11.65	10.75
40	4.533	13.983	15.183
45	9.50	16.283	18.433
50	14.15	18.43	19.05
55	21.083	20.583	19.21
60	27.317	21.817	0
65	32.517	22.85	0
70	37.233	23.657	0
75	41.033	0	0
80	42.62	0	0
85	0	0	0

Table 3 Resistances (effort-time) 10, 15, 25% Polypropylene



Graphic 1 Resistances (effort-time) 10, 15, 25% Polypropylene

The graphic shows the simple compression tests, performed with the three percentages of shredded plastic, these load parameters were taken every 5s, the block #1 has a compressive strength of 42.62 kg/cm^2, the #2 with a result of 23.657 kg/cm^2, and the #3 with a strength of 19.21 kg/cm^2.

Results

The 5 blocks that were made with 10% PP, were subjected to compression in the press at 15 days of age, obtaining the following results.

Part	P (kg)	A (cm^2)	Resistance f'c (kg/cm^2)
1	26080	600	43.46
2	25850	600	43.08
3	24700	600	41.16
4	24390	600	40.65
5	23090	600	38.48

Table 4 *Resistances of the 5 pieces*

The resistance f'c of each piece is calculated with the following equation

$$f'c = P/A \quad (1)$$

Where:

P is the load at which the part fails in kg

A is the area of the section that receives the load in cm^2

And for the average resistance, the equation

$$f'c\ average = \frac{\Sigma f'c}{\text{Nº Parts}} \quad (2)$$

$$f'c\ average = 41.36\ kg/cm^2$$

Adequate resistance for non-structural walls, according to the standard "NMX-C-441-ONNCCE-2013-INDUSTRY OF CONSTRUCTION-MAMPORY - BLOCKS, STUDS OR BRICKS AND SHEETS FOR NON-STRUCTURAL USE - SPECIFICATIONS AND TESTING METHODS", which indicates that the average resistance is 35 kg/cm2, and the minimum individual resistance is 28 kg/cm2.

At 3 blocks with 10% PP, they were tested at initial water absorption, with an age of 14 days, obtaining the following results.

Part	Weight seco P0(g)	Wet weight P1(g)
1	19,163	19,232
2	18,286	18,358
3	19,486	19,528

Table 5 Dry and wet weights of the 3 pieces

The maximum initial absorption in g/min is calculated by applying the following algorithm

$$Cb = \frac{100M}{S\sqrt{t}} = \frac{100(P1-P0)}{S\sqrt{10}} \quad (3)$$

Where:

Cb is the initial maximum absorption in g/min

M is the weight of water absorbed by the block during the test in grams

S is the surface of the submerged face in cm^2

t is the dive time in minutes.

Part #1

$$Cb = \frac{100M}{S\sqrt{t}} = \frac{100(19{,}232g - 19{,}163g)}{600\ cm^2\sqrt{10}\ min}$$

$$Cb = 3.63\ \text{g/min}$$

Part #2

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$$Cb = \frac{100M}{S\sqrt{t}} = \frac{100(18{,}358g - 18{,}286g)}{600\ cm^2\sqrt{10}\ min}$$

$$Cb = 3.79\ g/\text{min}$$

Part #3

$$Cb = \frac{100M}{S\sqrt{t}} = \frac{100(19{,}528g - 19{,}486g)}{600\ cm^2\sqrt{10}\ min}$$

$$Cb = 2.21\ g/\text{min}$$

The results of the blocks for non-structural use comply with the NMX-C-441-ONNCCE-2013-BUILDING INDUSTRY - MAMPOSTERY - BLOCKS, STOPS OR BRICKS AND TABICONES FOR NON-STRUCTURAL USE - SPECIFICATIONS AND TESTING METHODS, which are acceptable for exterior walls as they do not exceed 5 g/min, as well as for interior walls or with 7 tolerance coating. 5 g/min, then the average absorption of the parts was determined.

$$Cbprom = \frac{\Sigma Cb}{\text{Nº Parts}} \quad (4)$$

$$Cbprom = \frac{3.63 + 3.79 + 2.21}{3} = 3.21 g/min$$

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Conclusions

In the research, different types of dosages were made, 25% (3.85 kg), 15% (2.31 kg), and finally 10% equivalent to 1.54 kg of Plastic in the masonry piece, which were tested for their resistance to compression, giving satisfactory results with an aggregate of 10% PP, with an average resistance of 41.36 kg/cm2 in the test of 5 pieces, so they comply with the NMX-C-441-ONNCCE-2013 for non-structural blocks.

With that same 10% PP dosage, three more pieces were manufactured, which were subjected to the initial maximum absorption test, leaving the blocks submerged for 5mm for 10min, at the end of the test the calculations show favorable results, an average is obtained to determine the initial maximum absorption, with a result of 3.21g/min, therefore they comply with the NMX-C-441-ONNCCE-2013.

It is concluded that the ecological masonry piece with its strength is suitable for use only as non-structural blocks.

It will also be acceptable for use in the construction of interior walls and exterior walls that will be exposed to the weather.

The ecological masonry pieces will make a great contribution to the environment, since for example, if a 4x3m wall is built, 150 blocks of 40cm long x 20cm high will be needed. If 1.54 kg of plastic is used to make an ecological block, 231 kg of polypropylene plastic will be needed to build the wall, thus reusing the plastic that could contaminate the environment.

The design of the ecological masonry piece can be improved if the upper projections and lower circular entrances are modified, by a prismatic geometry, as well as in the sides (projection and entrance) of the block, to increase the moment of inertia in those sections, achieving a greater coupling between the pieces.

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Diagnosis of the pathologies of a bridge, section: Champotón Bridge

Diagnóstico de las patologías de un puente, tramo: Puente Champotón

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Abstract

Objective: The present work seeks to expose the current pathological samples in the Champotón bridge, using its own methodology. Methods: It consists of an initial determination on the investigations in the structure and finishes. A non-destructive study of the property was carried out, through an eminently field study, in a qualitative, quantitative, descriptive and longitudinal way, first carrying out a visual inspection, preparing a photographic record, determining a diagnosis that would allow us to information on the object of study, an analysis of the deteriorations found, make a catalog of bridge factories to know the types of design materials, an own evaluation and finally, the most appropriate maintenance plans and proposed criteria were updated with their symbols correspondent. Conclusions. When carrying out a detailed visual inspection of the existing pathologies of the bridge, it is concluded that it requires constant routine maintenance and the pathologies found demand a short-term preventive rehabilitation, in order to prevent further progress and generate probable damages.

Approach, Concrete structure, Scour

Resumen

Objetivo: El presente trabajo busca exponer las muestras patológicas actuales en el puente Champotón, ubicado en la localidad del mismo nombre, mediante una metodología propia. Métodos: Consiste en una determinación inicial sobre las investigaciones en la estructura y acabados. Se realizó un estudio no destructivo del inmueble, a través de un estudio eminentemente de campo, en forma cualitativa, cuantitativa, descriptiva y longitudinal, efectuando primeramente una inspección visual, elaborando para ello, un registro fotográfico, determinación de un diagnóstico que nos permitiera obtener información del objeto de estudio, un análisis de los deterioros encontrados, efectuar un catálogo de fábricas del puente para conocer los tipos de materiales de diseño, una evaluación propia y por último, se actualizaron los planos y criterios propuestos de mantenimiento más adecuados con su simbología correspondiente. Conclusiones. Se pudo realizar una inspección visual detallada de las patologías existentes en el puente Champotón, que incluyó toda la información recolectada en trabajo de campo, a partir del cual, el puente requiere un mantenimiento rutinario constante y las patologías encontradas requieren una rehabilitación preventiva a corto plazo, con el fin de evitar que sigan avanzando y genere probables afectaciones

Aproche, Estructura de hormigón, Socavación

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Introduction

Bridges, such as the Champotón bridge (see figure 1), are structures built in order to allow the passage, above all, of vehicles with different capacities through areas of difficult access and safely, they are built of different materials, either be it in steel, concrete or wood.

Figure 1 Photograph of the Champotón Bridge. Panoramic view of the bridge, from the north-south point
Source: own (2019)

The continuous use of these bridges, climatic factors, settlement movements, seismic movements and the age of their structures, are the cause of pathologies that appear over time that affect their physical state and their operating condition, generating insecurity for Those who make use of these, therefore, require inspections for a continuous scheduled periodic maintenance that allows to evaluate their physical condition and thus determine if they require any type of intervention to keep them in good condition and thus fulfill the function for which they have been built.

In this regard, Moldovan, Lonut, Figuereido, Eloi and Barata Marques, Manuel (2013), affirm that the maintenance of bridge structures is a challenge, even more so when they are in service conditions, additionally, due to the great variety structural systems, which currently range from reinforced or prestressed concrete bridges, as well as composite, steel, cable-stayed, suspended and masonry arch bridges, makes each of these types of structures behave differently, suffering different types of deterioration and therefore, generate different maintenance needs.

Therefore, visual inspections become one of the best alternatives to evaluate the conditions of the bridges, as Masoumi, F.; Akgül, F. and Mehrabzadeh, A. (2013) “visual inspections are one of the most important parts of a bridge management system, they are carried out using non-destructive evaluation methods, which can be used as a tool for verification of the structural conditions of the bridges”. Similarly, Adnan, Azlan (2006), presents a non-destructive test method to evaluate the condition of bridges in comparison with the visual inspection that is constantly used; In this, it is stated that although the condition classifications are all qualitative in nature and are defined mainly as sets of visual indicators in routine inspection, non-destructive tests are more quantitative and have great potential to determine damages within the structure that are not visible. For the purpose of this study, the priority was to determine the strength of the bridge through non-destructive tests and thus establish the correlation between the visual inspection qualification and the results of these tests, through an intelligent classification system that combines both the Non-destructive test data such as the visual inspection qualification, generating more efficient and detailed results, in accordance with the above, the visual inspection and evaluation of bridges, is a highly relevant task that requires meticulous and methodical processes. In addition, interest in investigating the status of pedestrian bridges, and the way to keep them in good condition for use, is not only an issue of relevance in the country, internationally there are also investigations on the subject, one of these it is, for example, the one carried out in Spain by the authors Rodríguez, Soledad; et al, (2014), taking into account that in this country a considerable amount of bridges are built in wood and their service time had exceeded their useful life, being necessary an evaluation of the structural state of the same, for this reason the Researchers developed a methodology for inspection, evaluation and diagnosis of the state of bridges, through visual inspection, detection of rotting through the use of equipment, estimation of mechanical properties and static load tests and dynamic analysis to determine the natural frequencies of vibration.

The foregoing makes it possible to understand that conducting pathology evaluations on pedestrian bridges is a task that can be carried out relatively easily and efficiently, without the need to use complicated methodologies, but rather, through visual inspections, with formats For the recording of detailed information and supported by photographic records, effective diagnoses of the state of the elements that make up the bridge structures can be made, since as stated by Bader, James (2018) "they are particularly useful methods for evaluating bridges in service, since these can remain intact and open to traffic during the inspection and evaluation period ".

General Background

History

The town of Champotón (its etymology comes from the Mayan language Chakán sabana and Putum, which is a modification of the Petén region or region, meaning "region or region of the savannah"), was founded by the Itzáes, one of the most important lineages of the Mayans when they left Chichén-Itzá, around the year 700 of our era and returned to their native Chichén-Itzá 280 years later. In 1194, when the Confederation of Mazapán was dissolved, which was an alliance between the main Mayan cities, Champotón became the capital of the Chakán-Putún chiefdom or region of the savannah. The first Spanish explorers arrived and found a fatal defeat against the "aborigines", for this place was always named by them with the name of "Costa Bahía de la Mala Pelea". In 1538, Francisco de Montejo El Mozo, founded the Villa de San Pedro Champotón. The municipality of Champotón was thus declared on December 7, 1915, forming one of the 8 (eight) free municipalities of the new state of Campeche, on December 7, 1957 the title of city was granted to its municipal seat.

Orography

The topographic relief is flat with small undulations that favor the formation of part of the valleys, such as Yohaltún and Edzná, the latter extending to the municipality of Campeche. The average altitude is 27 meters above sea level, from the town of Seybaplaya the Sierra Alta starts, which, on its way along the coast, forms a large cliff with a point known as "El Morro". From Seybaplaya there is also a mountain range called Sierra Seybaplaya in the direction of the Chenes region where there is a flat pronunciation called Meseta de Zoh Laguna; From north to south, the municipality of Champotón has small hills no greater than 30 meters high, in the central part is the plain of the Edzná Valley.

Hydrography

The Champotón river is located in the municipality, which is navigable with boats of up to 15 tons, from Canasayab to the town of Champotón, in an extension of 35 kilometers, that is, most of the 47 kilometers that measure its total length. Its basin is 6,080 square kilometers and its annual runoff amounts to 885 million cubic meters. We also find the Nayarit d Castellot and Noch lagoons; among the aguadas we have that of Xbacab, Chuiná and Hool.

Weather

In a strip of 30 kilometers that starts from the coast of the municipality of Champotón, towards the north (part of Campeche and the north center of Calakmul), the climate is warm subhumid with an average annual temperature of 26 ° C. In the south, east and southeast of the municipality, there is the most humid variant of sub-humid climates, with a rain regime in the months of June to September; warm winds from the east and southeast predominate; the maximum temperatures are those of the month of May of around 40 ° C and the minimum ones are those of the month of January with 10 ° to 14 ° C.

Macro and Micro Location

The Champotón bridge is located in the southwest of Mexico, in the municipality of Champotón, Campeche state (see Figure 2); It is located in the Yucatan Peninsula, southeast of the Mexican Republic. In the northern part it borders the municipality of Campeche and Hopelchén, to the east with the municipality of Calakmul, in the south with Escárcega and Carmen, to the east with the municipality of Calakmul and to the west with the municipality of Carmen and the Gulf of Mexico . As for the total territorial area that covers Champotón, it has approx. 6,876.26 square kilometers. (INEGI, 2016), with a population density of 12.07 inhabitants / km2. Politically the state of Campeche is currently divided into thirteen municipalities: Calkiní, Calakmul, Campeche, Candelaria, Dzitbalché, Escárcega, Hecelchakán, Tenabo, Hopelchén, Champotón, Carmen, Palizada and Seybaplaya.

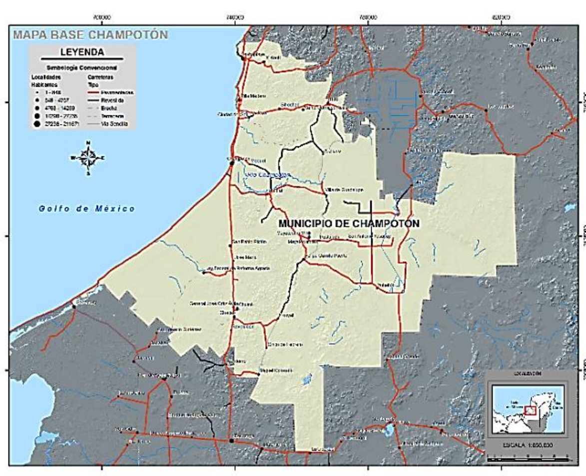

Figure 2 Macro location of the municipality of Champotón
Source: Google Maps (2017). Satelital image

With a population of 83,021 inhabitants according to the 2010 Population and Housing Census (INEGI, 2010), which represents 10.7% of the state's total. Champotón has a warm-humid climate, with an average temperature of 26 degrees Celsius. Geographically, it is located between meridians 89 ° 32 'and 91 ° 08' west longitude and between parallels 17 ° 49 'and 19 ° 41' north latitude, it is located to the Northwest 387 kms from the city of Villahermosa; 177 km southwest of Mérida and 1,127 km southeast of Mexico City, the municipal seat of Champotón is located with 37.2% of the population, with respect to the entire municipality.

The city has a maximum altitude of 100 meters. above sea level, with an average height of 27 meters. above mean sea level. The study area, the Champotón bridge, is located on federal highway 180 called Gulf Highway, it is located after the Campeche-Champotón-Hool junction, between the gas station and the Boca del Río spa, both are located at the entrance of the location. (See figure 3).

Figure 3 Micro satellite location of the Champotón bridge
Source: Google Earth (2019). Satelital image

Theoretical framework

According to Ribeiro (2014) and Metha (2008), concrete pathologies can be divided into three main groups: physical, chemical and biological causes: the physical causes of concrete deterioration can be divided into two categories: surface wear (or weight loss) caused by abrasion, erosion and cavitation and cracking at the rate of normal temperature and humidity gradients, salt crystallization pressures in the pores, structural loading and exposure to extreme temperatures, such as freezing or fire. The chemical causes of concrete deterioration are generally due to the presence of chemical substances, which can occur due to: 1) hydrolysis and leaching of the components of the cement paste by pure water, 2) ionic changes between aggressive fluids and the paste of cement, 3) reactions causing expandable products, such as expansion by sulfates, alkali-aggregate reaction and corrosion of concrete reinforcement. Biological causes are mainly related to the presence of microorganisms, which promote aggressive corrosive environments to concrete paste and steel, through oxidizing sulfur or sulfide bacteria, which accelerate the deterioration of these structures.

Enright, Michael P. and. Frangopol, Dan M, (2000) mention for example in their study, that they focus on the reported damage of concrete bridges, especially to bridges located in the state of Colorado (USA), a study on the degradation mechanisms that presents and is applied for various concrete bridges based on information from literature and field studies conducted by the Colorado Department of Transportation. The results showed that the most common source of corrosion damage is water leaking through the board joints. This study generates a significant contribution due to the fact that it refers to the damages presented in a reinforced concrete bridge and the different deterioration mechanisms.

Problem Statement

Bridges are mostly necessary structures for the movement of vehicles, depending on the type of bridge, its structure behaves in a particular way, suffering different types of deterioration, due to factors such as traffic volume, maximum load weights, as well as exposure to aggressive environmental environments, such as the effects of chlorides, either in a marine environment or de-icing salts, alkali-silica reaction, carbonation and corrosion protection, which requires different maintenance needs at higher frequency.

The Champotón bridge, was originally built of reinforced concrete in 1968 to free the river, had a special design privileged for this type of construction due to the characteristics of the topography of the land in the area where it is located, it is a road called type A2 (two-lane road), in some cases of the section, access to the site was used through an asphalt layer and in another section, it consisted of the placement of reinforced and precast concrete elements, mainly beams to bridge the existing gaps between piers and then a reinforced concrete slab was built on these beams to finally place an asphalt layer as a bearing surface.

The bridge currently has a length of 213m, which includes two approaches, four beams of five inches each, three concrete slabs with a thickness of 10 cm, two traffic lanes on both sides of 4 meters wide crown, with six meters of a ltura It was maintained by the Secretary of Communications and Transportation (SCT) in November 2016, due to the fact that the bridge had a landslide due to the erosion that was generated by the current of the river, the footings were reinforced, the reinforcement used more than 1650 square meters of stone, and it was finished in the following month. However, the bridge presents certain visible pathologies that must be studied further: drains in poor condition, reinforcement exposed by corrosive processes, undercuts, damage to construction joints, cracks, erosions, rusted materials, paint in an advanced state of deterioration, missing of railings, loose and destroyed sheets, cracked, fissured and / or worn pavements (mainly caused by increased loads, materials with poor quality, buckling, concrete with a lack of vibrating and curing, concreting during extreme ambient temperatures, landslide, failures in the foundations, rooting of trees and shrubs), repair with different materials different from the original ones, require constant maintenance.

The section under study is developed on flat terrain and according to data provided by the General Directorate for Road Conservation, the condition of the bridge's rolling surface and the road is classified from fair to poor, which generates low traffic speeds. increases in vehicle operating costs and high maintenance and road rehabilitation costs.

Justification

Offer

The boardwalk of the City of Champotón, including the Champotón bridge, is part of Route 180, currently operating with 2 traffic lanes in a crown width of 7.0 meters, a length of 5.10 kms, a central median of 4.00 meters wide from the beginning to the Moch-Cohuó Park with a length of 2.47 kilometers and 3.20 meters wide sidewalks, the maximum speed allowed is 40 km/hr, in the lane from south to north there are shops, restaurants, health establishments, truck station, public market, banking institutions, freezers, cemetery, service station 6979 (gas station) and a park, in the lane from north to south there are riverside fishermen's docks with landing maneuvers for marine species, craft school, street trade, foreign bus stop and one lane in each direction is used for public parking.

Demand

According to road data published by the SCT in the passage through the city of Champotón (see Table No. 1), 4,615 vehicles circulate daily until 2012, we can note that the vehicular composition of these are 76% are cars, 8% are buses and 16% trucks:

	2008	2009	2010	2011	2012
Total	4037	4174	4316	4416	4615

Table 1 Total road data published in the passage through the city of Champotón
Source: Ministry of Communications and Transportation (2019)

Interaction and current situation without project. Low traffic speeds are generated on the current route with an average travel time by car of 24 minutes, by bus of 27 minutes and by truck of cargo 32 minutes, increases in vehicle operating costs and high maintenance costs (around 2 million pesos annually) and routine rehabilitation of the current road (around 5 million pesos every 5 years), rebuilding it every 8 years with a total investment of approximately 50 million pesos, at current costs.

Optimization

Given that for the current total length it is 5.10 km, it generates a vehicular flow with TPDA = 4.615, with an average rolling speed of 43.6 km / hr, on flat terrain and an average growth of the order of 3%, the main assumptions They are: Extension to 3 meters of the road width of the boardwalk (1.5 meters per side), including the bridge, reducing the width of sidewalks to 1.20 meters and the central median to 1.0 meters in a section of 2.47 km that goes from Parque Moch Cohuo to the Gas Station, passing by the Champotón bridge. (located at the exit to Escarcega), with road signs.

Methodology

In most cases, in addition to the detailed inspection in the field, it is necessary to carry out tests aimed at providing information related to the strength and rupture conditions of components of the inspected structure. Following the systematization of Lima (2019), two main components are classified: non-destructive tests and destructive tests.

During non-destructive testing, although it does not always include all of them, we can perform the following tests: Sclerometry; depth of carbonation; Crack control with plaster or glass seals; Ultrasonography; Ganmagraphy; Load Test; Deformation and settlement measurements. For destructive tests, if they allow it to be carried out, we can mention the following tests: Resistance to axial compression in cores removed from the structure; Tensile strength in core removed from the structure; Modulus of deformation of concrete and mortars; Reconstitution of concrete and mortar mix; Specific gravity, permeability and water absorption; Chloride content; Determination of traction in reinforcement samples removed from the structure; Determination of the corrosion potential of reinforcement samples removed from the structure; Compressive strength of individual bricks and blocks; Compressive strength of brick and block prisms.

Consequently, a series of inspections were carried out on the analyzed element and then a photographic report was made of the pathological manifestations presented, which are compared by attributing values of the degree of damage to the structure. In the Champotón Bridge project, the following studies were carried out:

- Historical research and antecedents of the study area.

- Descriptive study of the area.

- Visual inspection of the study area.

- A survey of the infrastructure (materials used and construction systems).

- Inventory of existing elements in the area.

- A diagnosis of the area and changes inherent to the current traffic was carried out.

- Carry out a quantitative and qualitative investigation of alterations and deterioration (state of conservation of the bridge).

- The degree and type of intervention required was evaluated.

- Rising and updating of architectural plans.

- A descriptive study of the environment of the area, to analyze and detail what future activities, contexts and events will be like.

Finally, once the inspections have been carried out, the intervention priority for bridge maintenance is established and they are classified according to their needs, that is, if routine maintenance is required or, on the contrary, a specialized structural diagnosis is required due to situations that are out of the normal behavior of the structures.

Goals

Overall objective

Prepare a pathological inspection and evaluation of the Champotón bridge, in order to obtain the current conditions in which they are found, through the application of a visual inspection of the study area and non-destructive methods.

Specific objectives:

- Identify the main characteristics of the bridge, through a documentary review, which serves as a background for the inspection and evaluation of the pathology.

- Analyze, through a visual inspection, the physical characteristics of the Champotón bridge, to determine the degree of deterioration of the property at the moment.

Posed hypotheses

Central hypothesis

With a better quality of infrastructure that is provided for a good, safe and stable service to citizens, it is necessary to have databases that report the detailed status on a monthly, quarterly, semi-annual or annual basis, by government entities , to keep a strict repair control, and thus accidents can be avoided

Secondary hypotheses

- The more time passes without intervening the property in major conservation, the greater the degree of deterioration of it.

- The greater the use of the property due to the use of vehicular traffic, the greater the deterioration that occurs in the structure.

- The level of humidity caused by the bridge being in direct contact with sea water and atmospheric factors will increase the structural degree of deterioration of the bridge.

Results

Situation with project. Market. Through a field study carried out at the entrance to the city of Champotón, it was recorded that ADT in 2012 was 4,615 vehicles, of which 45% went to Cd del Carmen and 55% to Escárcega; and those arriving from Cd del Carmen is 54% and from Escárcega 46%, with this, it is justified to relieve 75% of the vehicular flow.

Conclusions

- It was possible to carry out a detailed visual inspection of the existing pathologies in the Champotón bridge, which included all the information collected in field work, from which, the bridge requires constant routine maintenance and the pathologies found require preventive rehabilitation to short term, in order to prevent them from continuing to advance and generate probable damages.

- It could be determined that the Champotón bridge presents a series of pathologies that minimally affect the elements that make up its structure, however, due to atmospheric agents and its daily service operation, it has generated deterioration, in addition, it is present in the study, related to acts of vandalism, dumping of garbage and substances that little by little affect a constant deterioration and the presence of pathologies.

- The main causes, as a result of the visual inspection, it can be concluded that they are related to corrosion, wear and lack of coatings in different parts of the electrical wiring elements, which generate the presence of plant material, organic agents, contamination of the concrete of the structure and pavements, among others.

- The Champotón bridge does not present critical conditions that warrant a meticulous intervention according to its pathologies found in the inspections, which shows adequate preventive maintenance of this type of structures.

- Elements with less structural damage were obtained, since the beams and the pier system presented non-significant failures and do not represent any risk of collapse or functionality of the bridge.

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Innovation and development of self-sustained wooden residues blocks "Madeblock" for homes and buildings

Innovación y desarrollo de block de residuos de madera autosustentable "Madeblock" para viviendas y edificios

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Abstract

The south-central region of Chihuahua State has 150 transformation industries of timber forest resources, these industries dedicate to produce different types of timber furniture, which generates a huge amount of organic scraps that are deposited mostly in the intermunicipal landfill that covers 5 municipalities. Within the field research, it was detected that only one of all companies produces 20 tons of scrap per week. Hence, it is considered ground-breaking developing a model to produce sawdust blocks destined to build sustainable houses and buildings. In order to frame this research, it was also analyzed the problem of September 19th, 2017 earthquakes, presented in the following states of the Mexican Republic, Oaxaca, Chiapas, Puebla, Morelos and Mexico City, where 111,668 houses and buildings had a partial damage and 60,302 had a total damage, in other words, there were 171,990 affected houses and buildings. The prototype's construction was developed by performing destructives and mechanical resistance tests, inside the testing laboratory of a social enterprise, La Cosa in Delicias City, a town of Chihuahua State, which is accredited by the EMA (Entidad Mexicana de Acreditación).

Innovation, Sawdust Block, Sustainable Environment

Resumen

La región centro sur de Chihuahua, cuenta con 150 industrias de transformación de recursos forestales maderables, que se dedican a fabricar diferentes muebles de madera, generando gran cantidad de residuos orgánicos, que son depositados en su gran mayoría en el relleno sanitario intermunicipal, que comprenden cinco municipios. Dentro de la investigación de campo, se detectó que únicamente una de estas empresas produce 20 toneladas de scrap por semana, es por esta razón que se considera muy novedoso desarrollar un modelo para fabricar blocks de aserrín, que con ellos se puede construir viviendas y edificios con este tipo de materiales. También para realizar esta investigación, se analizó la problemática presentada en los sismos del 19 de septiembre del 2017, en los siguientes estados de la República Mexicana, Oaxaca, Chiapas, Puebla, Morelos y Cd. de México, donde se identificaron 111, 668 viviendas y edificios que tuvieron un daño parcial y 60,302 con daño total lo que da un total de 171 mil 990 viviendas y edificios afectados. La construcción del prototipo se desarrolló realizando pruebas destructivas y de resistencia mecánica en el laboratorio de pruebas con razón social, La Cosa en Cd. Delicias Chihuahua, mismo que se encuentra acreditado ante la EMA.

Innovación, Block de Aserrín, Medio Ambiente Sustentable

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Introduction

Delicias City, a town of Chihuahua State, is known as an important region that develops the timber industry, Mexico's pioneer in timber forest resources transformation. Despite there are 150 factories involved in timber furniture fabrication, only one company of all produces 20 tons of sawdust. This research describes the reuse of this material, with the purpose of building prototypes elaborated with the thrown away scrap, and consequently, generate a decrease in environmental contamination. Therefore, the need of creating this input for the construction industry appears, optimizing the process and so on avoiding the concentration of the scrap sent to the intermunicipal landfill of Chihuahua State south-central region. To collocate the prototype in constructions, epoxy resin will be used as adhesive, to attach the block in the house and buildings walls. This objective is supported by the relevance of testing its properties and mechanical resistance, allowing to develop more sustainable and comfortable constructions. The purpose is to construct a sawdust block able to be used as a material in the construction of more sustainable houses, with a stable temperature and comfortable to its owners, because the wood's properties allows to keep isolated a place, according to the given use, thereby it may result in the construction of a more economical construction way to a conventional house.

Justificaction

This project exposes the reasons why it is important to develop this type of research, since there is already developed an environmentally sustainable block, which has the mechanical resistance properties tested on a laboratory certified by the EMA (Entidad Mexicana de Acreditación). Its resistance supports up to 58 kg/cm^2, accrediting harness tests and behaving as a lightweight block prototype in contrast to its special weight for seismic zones. It was also analyzed the problem of September 19th, 2017 earthquakes, presented in the following Mexico states, Oaxaca, Chiapas, Puebla, Morelos and Mexico City, where 111,668 houses and buildings had a partial damage and 60,302 had a total damage, in other words, there were 171,990 affected houses and buildings.

The prototype's construction was developed by performing destructives and mechanical resistance tests, inside the testing laboratory of a social enterprise, La Cosa in Delicias City, a town of Chihuahua State, which is accredited by the EMA (Entidad Mexicana de Acreditación).

The importance of this project is to focus on how to reduce this type of contamination, due to it is a serious problem, eminently presented in the last years and currently affecting in a direct way the environment. As mentioned before, sawdust coming from those manufacturing process represents a huge number of tons, hence, this research stablishes reuse alternatives, so that the contaminant effect decreases. This block prototype's innovation, build from sawdust and other adhesives, has proven to be a durable and resistant material, on account of that, combined with the adhesives is formed a compound strong enough to construct buildings able to support great mechanical stress, not only under high or low climatic conditions, as strong winds, but also to any other phenomena of non-extreme magnitude. Creativity is based on the thermic and mechanical properties of the block, proved on deformation stress test performed on the laboratory.

General objective

To reuse the scrap thrown away by the companies that produce different types of timber in the south-central region of Chihuahua State, and convert it into input for the construction industry, through the analysis of destructive mechanical resistance tests, in the laboratory La Cosa located in Delicias City and accredited by the EMA (Entidad Mexicana de Acreditación). Furthermore, developing different material engineering tests, in order to exploit the scrap derived from the manufacturing process performed by the furniture companies, and to transform it into a more lightweight and environmentally sustainable block.

Problem statement

The huge number of timber scrap coming from the furniture companies is only used by brickworks as an energizer in the brick firing process or deposited in the intermunicipal landfill, located in the south-central region of Chihuahua State. Within the field research, it was detected that only one of all companies produces 20 tons of scrap per week. Hence, it is considered ground-breaking developing a model to produce sawdust blocks, in other words, use the scrap produced from the furniture manufacturing as an input to the construction industry.

Theorical framework

According to CANACINTRA (Cámara Nacional de la Industria y la Transformación, 2018) data, Delicias City has 150 furniture industries, therefore the amount of this sector's produced scrap reaches a large percentage. As mentioned by Monroy, A. (2018), in the problem of pollution we find a large number of industries that generate non-hazardous waste that occupy large volumes without providing any benefit. For this reason, it is required to know the amount and types of scrap generated by these industries, in favor of recognizing which of those are potentially valuable; acknowledging that natural degradation of the furniture industry scrap is almost null. So that it is considered ground-breaking having a way to produce construction blocks from sawdust scrap of furniture industries located in Delicias City; according to Martínez, and García, M., & Martínez, E. (2004), it is considered a viable business with multiple benefits as of the possible profits, the growth of the regional economy and the decrease of its impact on the environment. It was also analyzed the problem of September 19th, 2017 earthquakes, presented in the following Mexico states, Oaxaca, Chiapas, Puebla, Morelos and Mexico City, where 111,668 houses and buildings had a partial damage and 60,302 had a total damage, in other words, there were 171,990 affected houses and buildings (Secretaría de Desarrollo Territorial Urbano, 2018). The prototype's construction was developed by performing destructives and mechanical resistance tests, inside the testing laboratory of a social enterprise, La Cosa in Delicias City, a town of Chihuahua State.

Innovation description

It is developed a new paradigm in the daily production of a concrete block, replacing this component for sawdust and an adhesive binder. Sawdust is an eco-friendly material, as easy to obtain that furniture manufactures give it to any people who can pick it up. By constructing the Madeblock, sawdust will be reused, because it meets the laboratory mechanical resistance tests, has a low economical cost and specially, it has the correct properties that in case of an earthquake it would reduce the accident risks of losing a live by falling into a person, due to its lightweight in contrast to a normal concrete block.

Madeblock originates from two principal benefits, the first is to optimize the sawdust by giving an added value and the second is to take care of the environment.

Competitive advantages:

- There is no other product elaborated with the same components.
- It has a lower cost than a traditional block.
- It is more lightweight than other blocks.
- By impacting against a person, it hurts less.
- It is eco-friendly.
- A use is given to the timber scrap.
- Its construction is profitable.
- It reduces the installation time.
- It has a mechanical resistance of 58 kg/cm^2.

Production methods

The fabrication procedure is explained, according with W. NIEBEL, Benjamin, (1998), by an illustration of a flow process diagram, because it is a graphic representation of the operations, transporting, inspections, delays and storages sequences occurring during the process.

The flowchart below includes information considered desirable to the analysis, for instance, the necessary time and traveled distance, are especially useful to bring out hidden cost, as traveled distance, temporal storages, delays, etc.

The following points are elemental in the flow process diagram and must have special attention:

- Material handling.
- Plant and equipment distribution.
- Delay times.
- Storage times.

Figure 1 shows the sawdust block's production process, named as Madeblock.

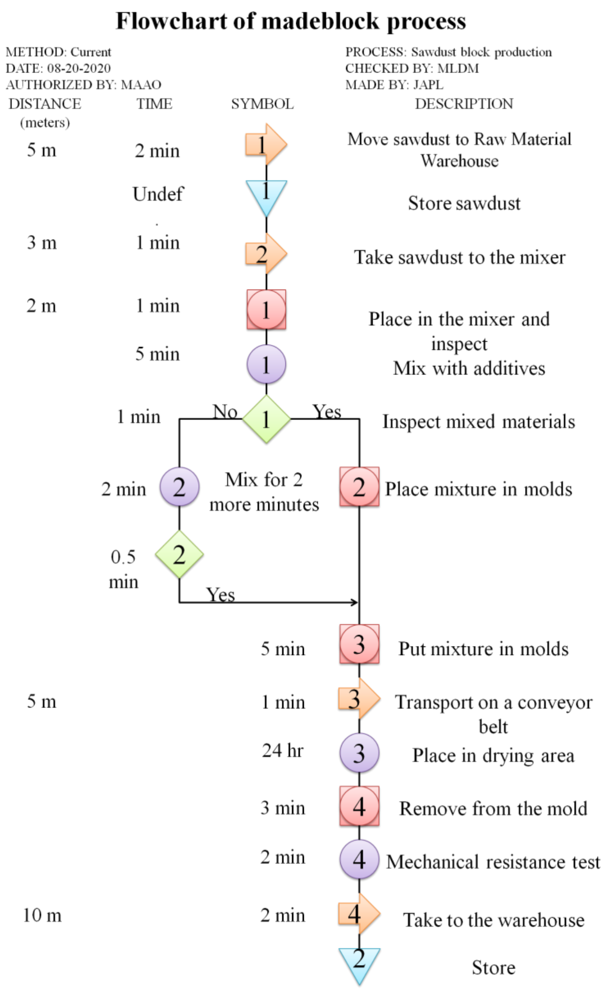

Figure 1 Madeblock Flowchart
Source: Own elaboration

Activity	Symbol	Quantity	Time	Distance
Operation	○	4	9 min	
Inspection	◇	3	1.5 min	
Transport	⇨	4	6 min	28 m
Combined Op.	▢	4	11 min	
Storage	▽	2	Undef.	

Table 1 Summary table
Source: Own elaboration

In brief, Table 1 presented above, shows that in order to produce a set of blocks, four operations were required, using a time of 9 minutes; two inspections in a total time of 1.5 minutes, four transports in 6 minutes and travelling a 27 meters distance, four combined activities in 11 minutes and two storages, one at the beginning and the other one at the end, where the storage time is undefined; totalizing a time of 27.5 minutes of process and a travelled distance of 28 meters. Since storages are undefined, it will depend on marketing and sells the production of Madeblock.

Interview with experts

The furniture producer's union of Delicias City, dependent of CANACINTRA, was visited and it was affirmed that there is a huge amount of scrap tons thrown away and by not being used, it is a contamination source that ends in the landfill. The union indicated that there are currently 150 companies dedicated to the production of furniture along the region, according to the existing database of CANACINTRA (2008), Delicias City produces huge amounts of sawdust after transforming the input (wood); and from an environmental point of view, the saturation of intermunicipal landfill spaces leads to an increase in the contamination. Madeblock can be used in seismic zones so in case of an earthquake, its lightweight property in contrast to traditional concrete blocks can reduce the risk of an accident or losing a life. In this manner, the objective is to use the huge amounts of scrap thrown away by those factories, so that the materials no longer are contaminant trash and are converted into a new product, Madeblock.

Figure 2 shows an example of the block prototype build with sawdust thrown away by furniture producers of the south-central region in Chihuahua State.

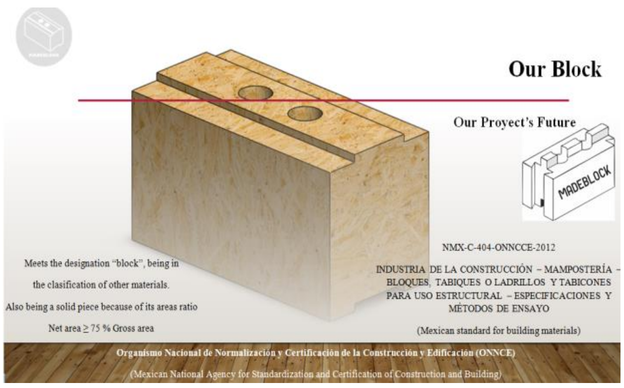

Figure 2 Protytipe developed out of wood residues
Source: Own elaboration

Potencial market

In terms of this research, it is considered as potential market everyone that consumes any type of block, including high resistance block, land block, cement block, thermic block, decorative brick and marbles, among others. The project of sawdust block production and merchandising has a potential market in Delicias City of 39,093 potential customers, according to the INEGI (Instituto Nacional de Estadística y Geografía, 2015). These potential customers are mostly men dedicated to construction; nevertheless, the number of potential customers increases as far as the diffusion of the project is taken, even reaching a national and international market.

Target market

The target market are small, medium and large companies dedicated to the construction industry and the population of the south-central region of Chihuahua State and eventually it will be projected with the view of reaching international and national markets, leaded to any customer willing to change its actual construction product for the proposed product, Madeblock; leaving other used materials as concrete blocks, bricks and other building ways.

Competing technologies

Currently, there is no product fabricated with the same components of Madeblock; thereby, the only competence are lightweight blocks used for unloaded walls and dividing walls, as well as those which have self-assembly system and those produced from industrial scrap of traditional materials mix. Figure 3 shows the possible competitors as national stablished brands, highlighting Block Térmico FARLIC ®, Block ARMO ®, MagPanel IBUILTEC® and Bloqueplás® de Ecoplasso.

Competitive advantages of Madeblock:

- Madeblock does not require materials for its adhesion, meanwhile FARLIC requires traditional materials.

- Madeblock can interconnect with other similar block, meanwhile Magpanel requires specific connectors.

- Madeblock ensures restraint to lateral displacement, meanwhile Bloqueplás requires construction rods.

- Madeblock inputs recollection is easier and more economic than the one from PET of Bloquepás.

- Madeblock is produced from industrial resources, meanwhile the competence exploits natural resources to elaborate the blocks.

- Madeblock production implicates an easier process involving a less amount of energetic resources and polluting emissions into the atmosphere.

Figure 3 Madeblock CANVAN
Source: Own elaboration

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Barriers to entry into the market

Some of the barriers for the product entering and successfully positioning in the market are the high differentiation of the existing products, since in the construction industry there is a considerable block supply, as well as bricks and marbles, among others. Taking into consideration that competitors are already positioned in the costumers' mind, Madeblock requires to invest in marketing, not only money but also time and effort, so it can success in entering the market. Economy of scale represents another barrier to entering the market, because the production volumes have a repercussion in efficiency, therefore when the production amount increases, the production cost decreases. This condition benefits big construction companies and it represents a challenge to compete against those companies. For this reason, it is projected to growth in short term so Madeblock can be produced at large scale and decrease its costs.

Technical and financial pre-feasibility

It is projected a production of 652,800 pieces of sawdust block per year, by involving four employees in its start (hired as general staff), this production requires $ 223,279.62 Mexican Pesos, 40% equity financed corresponding to $ 89,311.84 Mexican Pesos, and 60% debt financed corresponding to $ 133,967.76 Mexican Pesos. The investment distributed as follows: a current investment of $ 85,279.98 Mexican Pesos that represents the opening of the company for the first three months, a fixed investment of $ 99,999.62 Mexican Pesos that includes salaries of the employees (four general staffs and a manager), the local's rent, and basic services, including electricity, drinking water, vigilance, accounting fees, freights for $ 78,500 Mexican Pesos; and a differed investment of $ 38,000 Mexican Pesos that covers the constitutive act and the prepaid rent for one year.

Financial feasibility

The financial viability analysis and assessment, sustained by Baca Urbina, (2001) in project formulation and evaluation, concludes that the business plan is profitable. According to the Net Present Value (NPV) of $ 545,338.38 Mexican Pesos it is possible to start the business and generate an Internal Rate of Return (IRR) of 78.29%, in contrast with the Weighted Average Cost of Capital (WACC) of 19.18%; this satisfies the rule of IRR > WACC. On the whole, it is possible to cover the assessment rate cost and besides generate profit. This project has an approximate number of potential customers of 39,093 in the south-central region of Chihuahua State. Since the nature of a Corporate Social Responsibility (CSR) has interference in the national and international market, Madeblock is projected to reach those markets in short term. The financial feasibility assessment was performed by giving this block a price of $ 1.18 Mexican Pesos.

Intelectual property

Madelock will adopt the patent registry before the IMPI (Instituto Mexicano de la Propiedad Industrial) (2019) belonging to the Secretaría de Economía, because it is considered as a product. According to the search criteria until today there is no record of a similar patent of Madeblock. The simple search was performed in https://siga.impi.gob.mx/newSIGA/content/common/busquedaSimple.jsf by looking for patents, brands and contentious proceedings, including the exact phrase, all words and some of the words, on all information of the published registers. The specialized search was performed in https://siga.impi.gob.mx/newSIGA/content/common/busquedaEspecializada.jsf, which allows to search by exemplar type and date range. The exemplar search was performed in https://siga.impi.gob.mx/newSIGA/content/common/descargaEjemplares.jsf, which allows to search by exemplar type, publication type and exemplar year, and it is possible to download the exemplar in PDF and XML format (only electronic exemplars).

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Additionally, a Corporate Identity Patent will be process to protect the brand and the product’s technical innovation, categories found in industrial property. The patent before the Instituto Mexicano de la Propiedad Industrial (IMPI) will allow to exploit the invention for 20 years.

Results

This research project develops a solution to the problem of huge amount of scrap produced by the furniture manufactures in Delicias City, which contributes to increase environmental contamination. Moreover, it obtains new materials to innovative sustainable buildings, that can be used in houses and households, by also bringing a better resistance to large earthquakes. The research is focused on a universe of 300 regional companies of which comprehends constructors and hardware stores.

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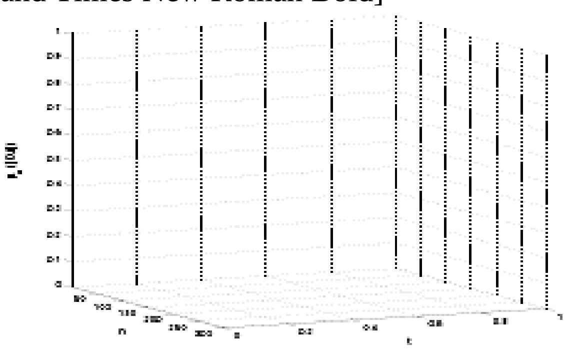

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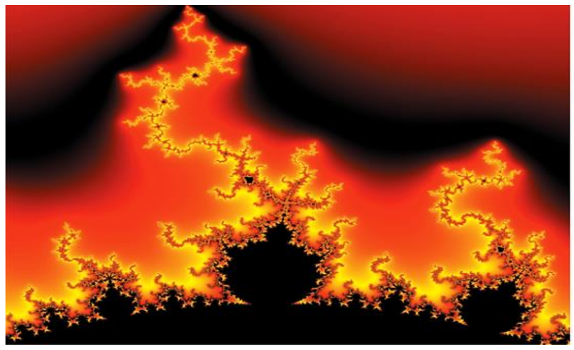

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