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Reuse of demolition material from the construction industry: In a block

Reutilización del material producto de demolición de la construcción: En un block

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Abstract

The present research project talks about the importance of the reuse of the material product of construction demolition. Whose objective is to elaborate a block through the reuse of the material product of demolition of the construction, with the purpose of diminishing considerably the waste of the rubble in clandestine garbage dumps. The research methodology developed consists of four phases to follow, within them there is a section of the separation of materials of the so-called rubble by type; followed by implementing the process of separation of reusable material to select the materials to be used for recycling and production of the block to replace the gravel and sand; and through the experimental method to perform tests type (4) and finish with the mechanical-physical tests the best type of block that can be used in the field of construction. Finally is to decrease the percentage of the amount of demolition debris as a replacement of aggregate in a final product such as a block, and to demonstrate that there is a real possibility of reuse in the world of construction materials.

Demolition, Reuse, Material, Aggregate

Resumen

El presente proyecto de investigación habla de la importancia que debe tener la reutilización del material producto de demolición de la construcción. Cuyo objetivo elaborar un block a través de la reutilización del material producto de demolición de la construcción, con el fin de disminuir considerablemente la tira del escombro en basureros clandestinos. La metodología de investigación elaborada consta de cuatro fases a seguir, dentro de ellas hay un apartado de la separación de materiales del denominado escombro por tipo; seguido de implementar el proceso de separación del material reutilizable para seleccionar los materiales que se ocuparan para el reciclado y elaboración del block en sustitución de la grava y arena; y por medio del método experimental realizar pruebas tipo (4) y terminar con las pruebas de mecánica – físicas el mejor tipo de block que se pueda utilizar en el ámbito de la construcción. Finalmente es disminuir el porcentaje de la cantidad de escombro de la demolición como sustitución de agregado en un producto final como un Block, y demostrar que existe una posibilidad real de reutilización en el mundo de los materiales de construcción.

Demolición, Reutilizar, Material, Agregado

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Introduction

The excessive extraction of natural resources from the environment is creating serious damage to our planet, causing deterioration, little or no regeneration of them, Ochoa (2014) "refers that there are very few control measures, mitigation and policies that force people to live in a healthier environment, that despite research generated by government institutions dedicated to this ecological field". Hence, over time it has become a problem in the field of construction considering two aspects; a) the huge exploitation of supply mines for construction material and b) clandestine dumps of debris, this derived from the demolition of construction, the latter arise every day throughout the Mexican Republic, despite the creation of standards that regulate this problem, such is the case of NOM-161-SEMARNAT-2011, it is considered as an obligation for builders who generate more than 80 m3 of waste in each of their works, the formulation and development of the respective management plan. (CMIC, 2013)

In Mexico City, in the municipality of Miguel Hidalgo, the Integral Recycling Center for Construction and Demolition Waste (CIREC-MH) is being built. This center will specialize in processes focused on the use of construction and demolition waste. In the municipality of Miguel Hidalgo (AMH) it is estimated that 750,000 tons of rubble are generated each year, most of which ends up in clandestine dumps, contaminating ravines, rivers and protected natural areas (AMH, 2021). (AMH, 2021).

In this sense, this research project aims to develop a block, reusing materials derived from demolition debris, which can be applied in other material or materials that can be used in the field of construction. Therefore, for the realization, execution and application of this research work, a methodology with four phases was elaborated, including the use of the experimental method, manipulating variables and carrying out controlled tests to reach the adequate resistance of the final product (block). Finally, the optimal final product is obtained for the use of this material, the block, in the field of construction and will serve as another alternative for the mitigation of solid waste pollution (debris) and above all the economy in the construction process.

Methodology to be developed

For the development and fulfillment of the general objective of this research, the principles of the experimental method, exposed by Claude (1865, as cited in Murillo, n.d.), are taken up again.), "Experimental research is based on the determinism of phenomena, which will have to be distributed under the same conditions until constant relationships can be established between them" among others; without forgetting the manipulation of study variables, to control the increase or decrease of these variables and their effect on the observed behaviors, together with this and without leaving aside the cabinet and field research for data collection (survey), hence the methodology to be used in this project is developed, which consists of 4 phases for the development of a product for the construction of a block (see Figure 1.)

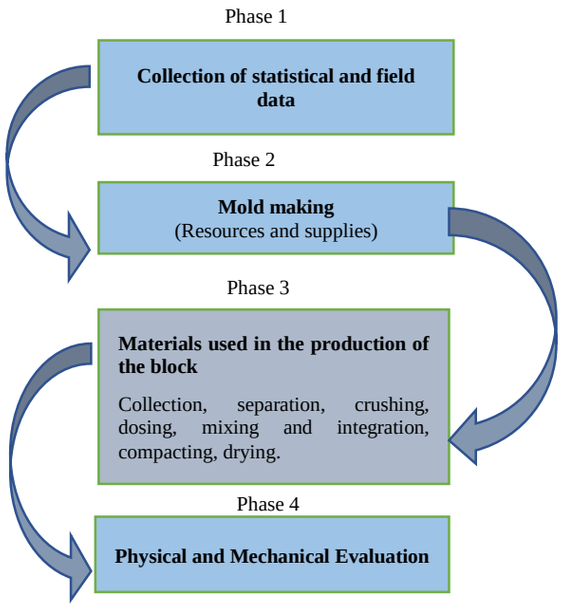

Figure 1 Methodological Scheme
Source. Own Elaboration, 2021

Description of phases of the methodological scheme

Phase 1 - We proceeded with the search for statistical information in reliable sources, search for the sample equation, as well as the breakdown by variable; preparation of the data collection instrument (questionnaire) and the field work outlines (application).

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Phase 2 - Once phase one was completed, we continued with the quotation and purchase of inputs for the manufacture of the mold (review the NMX-C-441-ONNCCE-2005) according to current regulations and human resource fees.

Phase 3 - In this phase the process for the elaboration of the block is made, with the description of each of the steps to follow: separation of the recycled materials from the demolition of the construction, crushing, dosing, mixing, compacting, and drying, all according to the process and development of the 4 types of blocks.

Phase 4 - Finally, the resistance test of the concrete laboratory of the Tecnológico de Estudios Superiores de Villa Guerrero is carried out.

During the field work, 68 surveys were applied, whose objective was to know what approval the population has on the subject of recycling rubble to produce recycled gravel and sand and substitute it as part of the aggregates of a block. These surveys are directed mainly to people directly involved in the construction of buildings, masons, architects, architecture students, as well as 10% of the population that represents the potential comparators of the product to be obtained.

Results

Mold

Under the Mexican Construction Industry Standards, the block is elaborated to obtain a quality product that can be implemented in the market. Following the methodology described above and developing each one of the phases, considering the aggregates of each one of the types made of the block, as it was proceeded, starting with the elaboration of the mold with the specific and appropriate characteristics under the current regulations where the nominal size of the molds of 20 x 40 x 12 is considered, being this the most common in the local market and that is within the ranges mentioned by the NMX-C-441-ONNCCE-2005 standard in the specifications section.

Subsequently, a lid with sills is made to support and keep the rectangle fixed during the production of the block. PTR is added to the lid in the central part to leave the space without concrete so it can be hollow, this is thicker in the part fixed to the base and smaller in the final part to facilitate the detachment of the material used in the block (see figure 2), and finally, handles were added to the sides of the mold to make its detachment easier.

Figure 2 Final Mold
Source. Own Elaboration, 2021

Collection, classification, crushing

We proceeded to visit construction sites to collect material from demolition, having the raw material, we separated the material according to its classification; On one side were placed the components of the block and on the other side those of the concrete, this is done because the block (recycled) often brings pieces of concrete and vice versa and even steel depending on where the concrete is obtained, the tool for crushing was a pot, hammer and hammer, to obtain a residue of smaller size and this can be better compacted when mixed with other elements, and form a homogeneous mixture.

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Mixing and integration of aggregates

This process is carried out under the NMX-C-441-ONNCCE-2005 standard, which indicates a minimum compressive strength of 3.0 N/mm2 (30 Kg/cm^2) for concrete blocks, although according to this, the values may be lower if the local construction regulations allow it.

Once the mixture is made, it is transported to the steel mold (20*40*12), this previously treated with oil burned, so that the mixture does not stick to the mold, then the filling in small quantities so that with the help of a piece of way it is compacted little by little until its capacity. The compaction process reduces the volume of concrete mix and aggregates to a practical minimum volume; therefore, the technique used is tamping, to comply with the process. Once done, the types are placed on a flat surface, in this case a wooden base was used to facilitate the transfer to the area where they will be kept until it sets, the time given is from one to three days, this will vary depending on the ambient temperature.

Physical and mechanical evaluation of the types of blocks

At this point, the results of each of the types of blocks are described according to the Mexican standards, taking into account that each type has a different dosage, taking as a reference the resistance table provided by the cement companies (100 Kg/cm^2), since it is the one indicated for walls and it falls within the resistance range requested by the Mexican standard, as shown in Table 1 of Dosages in volume (Kg).

Dosing Symbology			
Material	Cement Kg	Recycled concrete Kg	Recycled Tepojal Kg
I	1	3	4
II	1.5	3	4
III	2	3	4
IV	2.5	3	4

Table 1 Material dosages for each type of block
Source. Own Elaboration, 2022

Type of block	Aggregate Materials			Final Result
	Cement (kg)	Recycled Concrete (Kg)	Recycled Tepoojal (Kg)	
I	1	3	4	
II	1.5	3	4	
III	2	3	4	
IV	2.5	3	4	

Table 2 Results of Types blocks with different dosages
Source. Own Elaboration, 2022

Dimensions

According to the regulations, the 4 types (block) are within the standard dimensions (20 x 40 x 12) since a standard mold is used for all of them.

Dimensions			
Block	Height	Large (cm)	width (cm)
1	20	40	12
2	20	40	12
3	20	40	12
4	20	40	12

Table 3 Result of the dimensions obtained by type
Source. Own Elaboration, 2022

Compressive strength

According to Cemex (2019), the results of compressive strength tests are used primarily to determine that the concrete mix supplied meets the specified strength (f'c) requirements for a given structure. The strength of the block types is shown in Table 4 below.

ISSN 2414-4932

Compressive strength		
Block	Resistance failures Individual N/mm^2 (Kgf/cm^2)	Minimal resistance Individual N/mm^2 (Kgf/cm^2)
1	19	39
2	46	46
3	89	89
4	92	92

Table 4 Compression results obtained by type
Source. Own Elaboration, 2022

The following formula is used for this compression section.

$$R = \frac{F}{A}$$

R: Is the compressive strength in MPa (Kgf/cm^2).
F: Is the maximum load in N (Kgf)
A: Is the cross-sectional area of the specimen (cm^2)

According to the standards and the established in the tables, the 4 block types comply with a compression established within the parameter.

Water absorption

The results of each type block (4) are attached in table 5; taking into account the following calculations to obtain the total absorption in 24 hours, with the following expression:

$$A = \frac{Msss - Ms}{Msss - Pa} * 1000$$

Where:

A: Is the value of absorbed water referred to the apparent volume of the specimen in dm^3/m^3.
Ms: Is the dry mass of the specimen in kg.
Msss: is the saturated mass of the wet specimen in kg.
Pa: Saturated and superficially dry mass in kg.

Maximum water absorption in % in 24 H		
Block	Weight of dry specimen (kg)	Individual water maximum
1	9.17	24.95
2	9.576	25.13
3	10.274	26.36
4	10.484	27.25

Table 5 Absorption results obtained by type of Block
Source. Own Elaboration, 2022

Unit price

The following tables show the total amount per unit of measurement of each work concept, such as materials, labor, machinery and tools involved in the process of making the different types of blocks, in order to determine the total cost of the block (see tables 6, 7, 8 and 9).

Composite				
Materials	Unit	Quantity	Price	Amount
Cement	Kg	2	$3.80	$ 7.60
Recycled Concrete	kg	3	$0.05	$ 0.15
Recycled Tepojal	kg	3	$0.12	$ 0.48
Water	Lt	2	$0.0073640	$ 0.01
		Total	$3.98	$8.24

Table 6 Cost of materials
Source. Own Elaboration, 2022

Composite					
Category	Activity	Quantity	Unit	Hourly wage	Price per piece
1 master blockmaker	Block production	1000	Pza.	$500.00	$0.50
1 Pawn	Demolition of reinforced concrete	0.5	M3	$300.00	$1.28
1 Pawn	Demolition of partition walls	12	M2	$300.00	$0.10
				Total	$1.88

Table 7 Labor cost
Source. Own Elaboration, 2022

Composite				
Tool / Machinery	Unit	Quantity	Price	Amount
Steel Moid	Pza	1	$2,480.00	$0.03
Small tool	%M0	0.05	$1,100.00	$0.55
Safety equipment	%M0	0.02	$1,100.00	$ 0.22
		Total	$4,680.00	$0.80

Table 8 Cost of tools and machinery
Source. Own Elaboration, 2022

Unit price per block with demolition product materials			
Concept	Unit	Quantity	Amount
Materials (cement, Concrete, tepojal, water)	Pza	1	$8.24
Team (master block maker and 2 pawn)	Day	1	$1.88
Tool (Steel mold, small tool, safety equipment)	%M0	1	$0.80
		Total Cost per piece	$10.92

Table 9 Block cost per unit
Source. Own Elaboration, 2022

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Discussion of the elaboration process

At the beginning of the elaboration of each of the types of blocks made, the qualities of each of them were observed, type I. is determined with quality problems, due to the reuse of materials from demolition, the resistance of the cement is affected, causing crumbling in the corners, although it kept intact its rectangular shape, at the same time in the compression test it had a failure at half of what is established by the Mexican Standard, so it is discarded for its probable elaboration in the market.

Subsequently, for type II, it was decided to increase the resistance by increasing the amount of cement to ½ kg, this provided a more stable shape, there was no crumbling, and in the compression test the result was at a medium point according to what was established in the NM, but it was still not the quality that was sought.

In the same way, for type III, the resistance was increased by dosing with ½ kg more cement, the results obtained were adequate according to the NM, having a stable block without crumbling and exceeding the resistance in the compression test, which makes it suitable for its manufacture.

Even so, type IV was carried out. Like the previous ones, the resistance was increased with ½ kg more cement than type III, and as a result a block of very good physical quality was obtained and even of great resistance, reaching a structural block, but the amount of materials used for this type IV, the dosage is very excessive and it will be reflected in the definition of the unit price.

Conclusions

Finally, the results of the investigation show the feasibility of recycling material from demolition and based on the Mexican regulations for this type of product (block), it is possible to produce a block of non-structural use for the construction field, adequate and at a good price in the market; due to its characteristics it is determined that it is durable and competent with those of the market, aesthetically attractive, and above all easy to make.

In this way, regarding the reuse of the demolition product or rubble, its reduction is possible because for each block produced, approximately 4 kg of concrete and 3 kg of shingle can be recovered, which results in a saving of 60% of aggregates.

However, it is important to emphasize that the price increase of the raw material is increasing, since when substituting the common materials (sand and tepojal) by the recycled ones the resistance of the cement lowers, in the market for each block 1 kg of cement is used and in our block 2 kg will be used, that when obtaining a price per unit makes that both the commercial block that is in the market and the one elaborated with recycled material, are sold for a similar or equal price.

The new technologies seek to replace them by other artificial or natural materials that supply with benefit their usefulness and, also, are the least harmful to the environment so this new block in a very viable and safe alternative.

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