

## Construction elements for ecological houses

### Elementos constructivos para casas ecológicas

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#### Abstract

This research was carried out to learn about the use of reject plastic "PET" (Polyethylene Terephthalate), coming from plastic containers and other plastic waste, to make mortars that can be used for the manufacture of construction elements. The plastic waste is ground up and put into a combination of cement and a chemical additive that improves the strength of the mortar. Many bricks and tiles were made from this combination; many of them have presented less unit weight, acceptable absorption and good resistance in accordance with the required standards. The following investigation allows the use of three, recycling, reduction and reuse of R, which is an excellent lemma to put into practice.

**Constructive elements of recycled plastic, Environmental pollution, Social houses**

#### Resumen

Esta investigación se llevó a cabo para conocer el uso del plástico de desecho "PET" (tereftalato de polietileno), procedente de envases de plástico y otros residuos plásticos, para hacer morteros que puedan utilizarse para la fabricación de elementos de construcción. Los residuos de plástico se trituran y se introducen en una combinación de cemento y un aditivo químico que mejora la resistencia del mortero. Con esta combinación se han fabricado ladrillos y tejas, muchos de los cuales han presentado un menor peso unitario, una absorción aceptable y una buena resistencia de acuerdo con las normas exigidas. La siguiente investigación permite el uso de tres, el reciclaje, la reducción y la reutilización de R, que es un excelente lema para poner en práctica.

**Elementos constructivos del plástico reciclado, Contaminación ambiental, Casas sociales**

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## Introduction

Every day we dispose of large amounts of polymers in the form of plastic bottles, cartons and yogurt containers. Experts estimate that 25% of polymer waste cannot be recycled, for three main reasons: it contains mixtures of different types of polymers; it is not economically profitable; and it is a very messy process.

These plastic bottles are the most rebellious when it comes to transforming. Outdoors they lose their tonicity, fragment and disperse. Buried, they last longer. Most are made of polyethylene terephthalate (PET), a tough material to crack because it is immune to different types of microorganisms.

In the present investigation, disposable bottles were used, made up of PET and plastics from candy packaging, BOPP (Bioriented Polypropylene) and PVC (Polyvinyl Chloride).

The construction elements that were designed with these materials are bricks and tiles.

The use of recycled materials in construction reduces environmental pollution, contrary to what usually happens when natural raw materials are used.

It can be said that it is a "clean and cleansing" technology, because the manufacturing procedures do not pollute the environment, and because waste is used as raw material.

In the case of PET containers, there are other recycling procedures in the world for various applications, but more complex than the one used in this research.

In this case, it is not necessary to remove labels or lids prior to the grinding process, small amounts of soil or dirt are admissible in the containers, and the material will not be melted.

## Background

Today's recycling process is crucial to dealing with the growing volume of waste we produce, but researchers are looking for alternative solutions.

A group that has partners from Spain, Latvia and Lithuania assures that it is ready to launch an ecological solution for the management of plastic waste on the market. The SANDPLAST project, funded by the EUREKA programme, has developed a technology to produce concrete construction materials using polymer waste and inert fillers.

Valdis Leitlands has helped design this technique within the project and is convinced of its commercial potential and has therefore founded Partneris LV, a spin-off company that aims to create new construction materials from polymeric waste. His company has joined forces with Uniland Concrete, which has the capacity to produce two million cubic meters of ready-mix concrete a year, to help him test products created using this technique and find markets. Lithuanian partners also participate in the project.

The waste we produce is infinite and the manufacture of classic brick is a true ecological disaster, because it is made with humus that takes thousands of years to form and in open-air kilns, as was the case in Babylon.

In other words, on the one hand we bury the garbage and, on the other, we devastate the fertile land. We propose a technology that helps alleviate both problems, but is also cheaper, very efficient from the point of view of insulation and easy to manufacture." Source- article in the Argentine newspaper La Nación.

## Problem statement

Falta of proposals to consolidate this type of mix using recycled plastic as raw material. Polymers are polluting products of the environment and do not have biodegradable properties, but rather last over time, constituting a problem for the environment.

## Objectives

### *General Objective*

Make mixtures of cement and plastic aggregates for the manufacture of bricks and tiles usable in ecological-social constructions.

*Specific objectives*

- Contribute to the reduction of contamination by plastic containers (polyethylene-terephthalate).
- Determine and evaluate the dynamics of the mix.
- Determine and evaluate resistance by laboratory tests.

**Hypothesis**

With the addition of recycled plastics, PET, BOPP, in traditional mortars, it is a matter of obtaining a construction material with characteristics like conventional ones, providing lower specific weight and reaching the resistance required by the standard. In this way we contribute to recycling and non-pollution by plastic waste.

**Justification**

These plastic bottles are the most rebellious when it comes to transforming. Outdoors they lose their tonicity, fragment and disperse over a very long period of time (100-1000 years). Most are made of polyethylene terephthalate (PET), a tough material to crack as it is immune to different types of microorganisms.

The construction elements that will be designed with these materials will be bricks and tiles, helping to control the environmental pollution produced by PET bottles, BOP and other plastic materials that do not degrade easily, providing an economic technology, fast learning, minimum equipment and good living conditions, one of the factors that most reduces productive activity in the rural sectors of the department of Chuquisaca and of Bolivia in general is the backwardness of the towns due to the lack of initiatives that allow for short-term solutions, as is the case of the mixtures of cement and plastic, which in addition to controlling environmental pollution are cheaper and offer a more aesthetic panorama.

**Materials and methodology**

The materials used are:

- Recycled plastics.

- Cement.
- Water.
- Sand.
- Chemical additives (Sika FF-86).
- Metal models.
- Concrete mixer.
- Sieves
- Other materials:
  - Pallas.
  - Compactor rod.
  - Demonstrate through laboratory tests resistance and durability mechanisms for each of the construction prototypes.
  - Demonstrate through tests the resistance to tensile and compressive stresses.
  - The final test must allow validating the application of mixtures with polymers, for the use of mechanisms that do not harm health or the environment.

**Pressmen**

Performance of standardized tests in laboratories, to establish physical properties.

- Mill (crusher)

**Methodology**

This research work was carried out using a methodology with high experimental content. For the manufacture of the cement-plastic mixtures, a granulometry was used for the sand and another for the plastic particles with a fineness modulus of 4.25 in the case of bricks and tiles.

*Activities*

- Revision of information.
- Perform conceptual design.

- Carry out the experimental engineering design.
- Demonstrate through tests the influence of the hardness and the dynamics of the mixtures.

Comparative economic evaluation of the construction elements developed. The dosage of the mortar is 1:4 for both the brick and the tile, the chemical additive is added to the mixing water, in a percentage of 0.5% of the weight of the cement. To remove the percentage of moisture from the aggregates (sand). First, we proceeded with drying in the sun, continuously removing the samples to be used.

Once the drying of the samples was concluded, the respective sieving was carried out to obtain the granulometry required by the standard. The PET was crushed with a mill designed for this purpose.

The PET particles were mixed with cement in a concrete mixer, then water with incorporated chemical additives (sika ff86) was added.

When this mixture acquired a uniform consistency, it was poured into a metal mold.

The compaction of the mixture and the position of the bricks and tiles was carried out.

The control specimens were made together.

They were left outdoors for a day and then moved to a container for curing with water, in which they remained for seven days.

The test pieces broke after 28 days in a laboratory, which gave us a compressive strength required by the standard.

LI remove the bricks and tiles after 7 days of curing and store them until they are 28 days old.

Composición Granulométrica (Norma Iram1627)			
Tamiz	Peso Retenido (g)	% Retenido	% Ret. Acumulados
4 = 4.75 mm	2.5	0.278	0.278
8 = 2.40 mm	97.0	10.790	11.068
16 = 1.20 mm	191.5	21.301	32.370
30 = 0.59 mm	297.0	33.037	65.410
50 = 0.29 mm	236.0	26.250	91.660
1 100 = 0.15 mm	56.0	6.220	97.880
Mf = 2.99			

**Table 1** Resistance and stability tests (emptying)

## Dosage

### Flake aggregate replacement percentages

15% of the weight of sand was replaced in its place, 1 kg of PET flakes, the incorporation of plastic in the composition of the mixture produced changes in the characteristics of the mortar, not gradually proportional to the increase in the % of incorporated flakes, but appreciable modifications were observed for percentages specific for PET aggregate.

Sika fluidifying additives (Sika ff86) added to the mixtures were used, according to the usual dosages. A weight ratio of one part of cement per four of aggregates (1:4) was adopted. The PET flakes were added in different percentages according to the portion of sand that you want to replace

### Preparation of mortars

Two specimens were moulded for each mixture or proposed dosage, one containing fluidizer and the other that did not, of which two were analysed at the age of 7 days and 2 at the age of 28 days, for compressive strength tests in both cases. The method of mixing, filling molds and compaction was carried out as indicated by the standard. In all cases it was determined previously, in the fresh state, and the fluidity

The study proceeded as follows:

All kinds of plastics were used for its preparation, which were crushed in a mill designed for this purpose, and then mixed with the cement and a chemical additive in the water, which improves the adhesiveness of the plastic particles with the cement.

The slow biodegradability of plastic is a problem on many occasions, in this case it becomes a great ally of this material.

The PET particles were mixed with cement in a concrete mixer, then water was added with chemical additives incorporated. When the mixture had reached a uniform consistency, it was poured into moulds. consistency, it was poured into metal moulds and compacted. metal moulds and then compacted.

## Results

The construction elements developed have sufficient technical quality for their application.

The physical properties of the same described below were established by carrying out tests in laboratories.

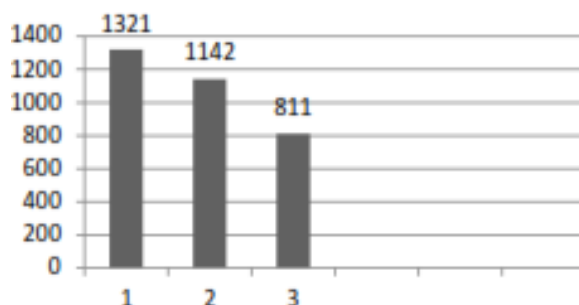


Figure 1 Specific Weights

1. common ground brick 1321 kg/m<sup>3</sup>.
2. bricks with crushed plastic 1142 kg/m<sup>3</sup>.
3. tiles with crushed plastic 811 kg/m<sup>3</sup>  
Mechanical resistance: It is lower than most of the traditional construction components, but enough so that they can be used in houses with an independent structure. The brick with PET has a characteristic resistance of 4 Mpa.

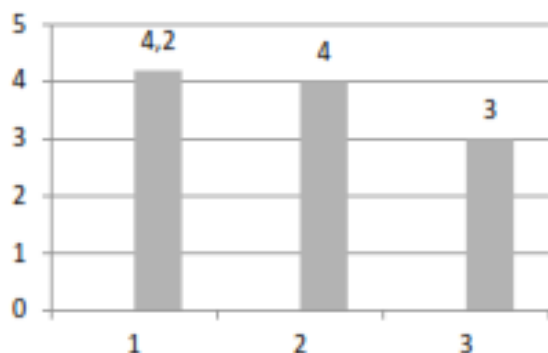


Figure 2 Resistance graph

1. Common ground brick 4.2 MPa
2. Bricks with crushed plastic 4 MPa
3. Tiles with crushed plastic 3 MPa

Due to the difference in unit weight between the aggregate and the flakes, the PET was replaced by an apparent volume equivalent to that of the aggregate to be replaced.

Serie de probetas	% Sustitución de arena por PET	Cemento kg	Arena kg	Escamas de PET kg	Agua cm <sup>3</sup>	Aditivo %
1	15%	1	4	1	900	No Contiene
2	15%	1	4	1	600	2.0 Fluidificante sika

Table 2 Costs

The estimated price of each brick is detailed in the following table:

materiales	unidad	cantidad	precio(unitaio)	parcial(bs)
cemento	kg	1	0,88	0,88
agua	cm <sup>3</sup>	900	0,033	0,030
arena	kg	4	0,016	0,1
aditivo	cm <sup>3</sup>	10	0,04	0,4
plastico	kg	1	0	0
total				1,41

Table 3

Where the price for each brick is 1.41 bs, the elaboration of construction elements with this technology has a cost like that of other traditional construction elements.

The unit production cost of a PET brick is 30% higher than that of a common fired earth brick. The saving is verified in the fact that enclosures can be built with thicknesses less than those of traditional enclosures, due to their good thermal insulation, (which takes up less space on the ground and uses less joining material and is lighter (with which saves on transportation.

The manufacturing technique is very simple, easily reproducible by non-specialized personnel. No large-scale infrastructure is necessary to produce the material, or land for aggregate extraction.

## Discussions and recommendations

It is recommended to subsequently validate the research by adding the plastic additives to the mortar.

In the PET and cement developed by CEVE, it is observed:

- The PET has a specific weight that is 15.5% lower than the common one.
- The PET has a coefficient of thermal conductivity that is 80% lower than that of the common one.
- The PET has a compressive strength that is 50% lower than that of the common one.

- The PET has a percentage of water absorption that is 11.5% lower than that of the common.

### **Conclusions**

In the fresh state, the mortars presented little plasticity and little cohesion for the mixture with flakes. The lack of docility and homogeneity of the mixture, caused a decrease in settlement (after compacting), the reason, in our opinion, was the inadequate granulometry of the PET flakes, provided by the mill.

Doing an analysis of the prices of materials, it is concluded that the tile and the brick are cheaper with a cost of 1.41 Bs, the common brick has a cost of 1.5 Bs for each unit.

PET is recycled through a very simple and cheap process since it does not need to be clean, it can contain dirt, grit, etc. without affecting its good properties. PET containers are milled with labels and lids, and the presence of other types of containers (PP, PVC, etc.) is also accepted.

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