Green Bricks of Recycled Plastic: Analysis of their Production Process and Efficiency in Non-Load Bearing Structures

Gustavo R. Amaral, Pablo J. Correa, and Gabriel G. Casari.
Universidad Tecnológica Nacional – Facultad Regional Paraná.

Abstract The material footprint in the world is extremely increasing, and plastic waste is a big part of this. The construction and infrastructure industry can promote the reduction of the material footprint by using new technologies to create a construction system, similar to a traditional system, which uses bricks from recycled plastic. In this direction, plastic waste can be used to create a new construction system, where bricks from plastic are the main components. The objective of this paper is to evaluate the production process and efficiency of green bricks, presenting the advantages and disadvantages they bring to construction. As well as this, an example of the implementation of these green bricks in non-load bearing structures is provided.

Index Terms: **green bricks of recycled plastic, bricks of plastic, production process of bricks from plastic, efficiency of bricks form plastic in non-load bearing structures, construction with green bricks.**

I. Introduction

NOWADAYS one of the major 21st century problems results from the inefficient exploitation of natural resources, and their use to make single-use products that are discarded. The UN's Sustainable Development Goals Report mentions that this creates a major material footprint [1] which is an indicator that shows the full amount of raw materials used to satisfy a given country's level of domestic consumption. Material footprint can be avoided by recycling and reusing plastic materials to give them an efficient way of reusing. The best way to use these materials is by introducing them in the construction and infrastructure field.

The construction and infrastructure industry can promote the reduction of the material footprint by using new technologies to create a construction system, similar to a traditional system, which uses bricks from recycled plastic. These serve a dual purpose, namely, reutilizing plastic waste and raising awareness about the need of taking care of natural resources. Both aims are achieved through introducing green bricks of recycled plastic in construction. These bricks are the best way to do these two things.

The aim of this paper is to analyze the production process and efficiency of green bricks of recycled plastic in non-load bearing structures. To fulfill this aim, this paper has been divided into three sections. First, there is a description of the green bricks production process, analyzing the steps in the process before the production of the brick (recycling), followed by the production of the brick itself and ended by the post-recycling stage. Then, there is an analysis of green brick efficiency in terms of the advantages and disadvantages in non-load bearing structures. Finally, an implementation example on these structures is presented, introducing a project that uses this brick as an important part of the structure building.

II. Green Brick Production Process

A. Before the production of the brick: Recycling

Plastic is a regular resource that people are in contact with every day at home, in school, at work, and in markets. The

Gustavo R. Amaral is a Civil Engineering student at UTN FRP: gustavoamaral@frp.utn.edu.ar. Pablo J. Correa is a Civil Engineering student at UTN FRP: pablojoaquincorrea@frp.utn.edu.ar. Gabriel G. Casari is a Civil Engineering student at UTN FRP: gustavocasari@alu.frp.utn.edu.ar.

The present manuscript is part of the research activities in the Inglés II lesson at Universidad Tecnológica Nacional, Facultad Regional Paraná. Students are asked to research into a topic so as to shed light on a topic of their interest within the National Academy of Engineering's Grand Challenges or the United Nations' Sustainable Development Goals frameworks. If sources have not been well paraphrased or credited, it might be due to students' developing intercultural communicative competence rather than a conscious intention to plagiarize a text. Should the reader have any questions regarding this work, please contact Graciela Yugdar Tófalo, Senior Lecturer, at gyugdar@frp.utn.edu.ar

first problem is generated when people discard it, which becomes solid waste, and this is what people call plastic garbage.

In the last decades, the constant use of plastic for everyday purposes has rapidly increased the material footprint in every part of the world [Fig 1,3]. Every year, more than 420 million tons of plastic are manufactured across the globe [2].

Figure 1. Illustration of plastics waste in the river [3]

It is an important problem that has this solution: recycling. For recycling to occur, awareness of the problems derived from plastic waste is necessary. In addition, people should aspire to a healthy waste-free future, or at least decrease the current material footprint levels.

The recycling process can be approached in several ways by requesting people to separate the waste in homes, to a major level of efficiency in the manufacturing process or some countries. In Nigeria, for example, there is a working modality where the government or industries pay money to citizens to gather waste plastic around the cities [4].

B. Production of the brick

Plastics are durable, lightweight, and inexpensive materials. They can readily be molded into various products which find use in a plethora of applications [2]. The reuse of these plastics in the form of recycled plastic allows taking advantage of these properties in new products. One of these applications is green bricks, which are made from plastic waste and whose collection depends on the plastic needed.

There are six common types of plastics. Following are some typical products that are made of different plastics [2]:

- **PS (Polystyrene)** – Example: foam hot drink cups, plastic cutlery, containers, and yogurt cups.
- **PP (Polypropylene**) – Example: lunch boxes, take-out food containers, ice cream containers.
- **LDPE (Low-density polyethylene)** – Example: garbage bins and bags.
- **PVC (Plasticized Polyvinyl chloride or polyvinyl chloride)**—Example: cordial, juice, or squeeze bottles.
- **HD-PE (High-density polyethylene)** – Example: shampoo containers or milk bottles.
- **PET (Polyethylene terephthalate)** – Example: fruit juice and soft drink bottles.

All the materials are classified by their proprieties and microscopical characteristics [5], such as:

- **Polyethylene terephthalate (PET):** Clarity, strength/toughness, grease resistance, and heat.
- **High-density polyethylene (HD-PE):** low-temperature resistance; high resistance to tension-compression and traction; waterproof; inert to content; low reactivity; and non-toxic.
- **Plasticized Polyvinyl chloride or polyvinyl chloride (PVC):** versatility, ease mix, force and hardness, grease and oil resistance, resistance to the chemicals, clarity, low cost.
- **Low-density polyethylene (LDPE):** Easy to process, resistant to moisture, flexible, easy to seal, and low cost.
- **Polypropylene (PP):** Less density than HD-PE, higher softening temperature, low-temperature resistance.
- **Polystyrene (PS):** Versatility, easy prosecution, clarity, isolation, and low cost.

Due to the PET characteristics that will be presented later in the advantages and disadvantages section, this material is ideal to be used in the production of green bricks.

Manufacturing.

The production process of green bricks is a composition of steps, where the recycled plastic is treated through specific machinery, at a specific temperature, to make it ready for molding. Below is a sequence of five to follow adopted for these green bricks [6]:

- *Collection of plastic materials:* the plastic materials should be collected from factory, school, hospital, street, and industrial waste. Also, household waste is collected too.
- *Batching of plastic:* measurement of materials for making brick is called batching. After the collection of waste materials, the portion of plastic is checked to separate the plastic necessary to produce green bricks, followed by the removal of all organic waste within it. Then, it is transported to the burning process.
- *Burning of waste plastic:* once the batching process is completed, the plastic waste is burned in hermetic machines to melt it and proceed to have fused plastic. These machines work at temperatures from 90 – 110 degrees centigrade to achieve homogenization of the plastic mixture.
- *Molding:* after the burning process, the plastic mixture fused is transported to the molding step. There are molds to create different shapes, i.e., masonry bricks, beams, columns, and bricks for installations.
- *Curing:* the fused plastic needs to stand for a few days in the mold because it needs to solidify before taking it out to conserve its shape. Therefore, it is

kept in the mold for two days, and then it is removed and stored.

III. Green Brick Efficiency Analysis

Green brick's efficiency depends on the plastic properties, which after being melted become a fundamental part of these bricks. Therefore, this is the reason PET is chosen for brick construction as well as for the advantages provided below. However, like all plastic materials, PET presents disadvantages when it is in contact with the environment. Some of these will be listed below:

A. Advantages:

1) Reduction of material footprint:

The use of waste plastic as a construction material generates a positive impact decreasing the material footprint. With this decrease in the material footprint, people can achieve an improvement in quality in the world.

2) Resistance:

PET plastic used for making these bricks apport sufficient resistance for use as a construction material for a single-family home. Resistance arises from the presence of plastic fibers inside the brick that generates stress support on the structures avoiding fissures of the building.

3) Low weight:

The blocks are light due to the low specific weight of the raw materials, which benefits the building process by making the brick a malleable material, bringing efficiency to this construction model. Achieving an easy fast construction, without the need for specialized labor, is one of the major benefits.

4) Insulation and Economy:

Due to the properties that plastic provides, thermal and acoustic insulation, and waterproofing are obtained, which is greater than that of other conventional systems. These properties benefit users economically because less energy consumption is needed to keep the interior of buildings conditioned.

5) Maintenance and Finishing:

Green bricks do not need maintenance due to their plastic material's superficial hardness and corrosion resistance. Besides, the molded process provides a smooth finish to the brick surface, which increases the performance of the construction.

6) Accessibility:

The presence of plastic waste in the bricks benefits vulnerable communities to have a home and cover basic needs since this building material is not as costly as regular ones. As well, it serves as an emergency resource for natural disasters, or houses for work use.

B. Disadvantages:

1) Structural limitation:

Although the resistance is sufficient for its use as a construction material for a single-family home, some limitations do not allow higher buildings. Two-tier structures should not be made.

One of these limitations is lightness: wind force at high altitude becomes very large strong and could knock down a wall made with these bricks.

2) Production:

The machinery is exclusively designed for the production of these bricks, so it can be difficult to obtain. Also, its cost is high and large quantities would have to be produced for it to be cost effective.

3) Unfavorable conditions:

It is not recommended to use this type of bricks outdoors. Aggressive exposure to environmental agents could mean a loss of its properties.

4) Extra costs:

When polymer enters the machine, it must have a maximum of 0.005% moisture content. Then when they have humidity higher than this percentage, a drying process by hot air circulation implies an extra cost in the production.

IV. Green Bricks Implementation

The green bricks made of PET that are developed in this paper, as mentioned earlier in the disadvantages section, are only suitable for non-load bearing structures. This construction method allows the creation of one-story houses because it cannot support loads, it is only suitable for a sector of houses that do not have significant pillars or columns.

An example of this construction model is a project carried out by Conceptos Plásticos, in 2015 in Colombia. It consisted in the construction of a temporal refuge for 42 families, which were stripped of their place of origin due to violence.

Next, there is a sequence of the construction process by which the different parts of the construction can be appreciated, which consists of 3 parts:

1) Foundation and wall survey

2) Column's installation and lifting of walls

3) Non-load bearing structure installation and the roof

[Figure 2,5] shows the finish of a house made with this type of assembly:

Figure 2. Illustration of houses of Conceptos Plásticos [5]

V. Conclusion

This paper shows that the efficiency of this material in the construction and infrastructure field, using it as a part of a new construction system, is as good as the regular building system when it is applied in non-load bearing structures. Its efficiency is proved, and it is positive both in regular constructions for work and habitat purposes and as an emergency resource in contexts of natural disasters.

This new construction system can help society in various factors which are decontamination of cities, reusing materials, socioeconomic support from the government. As well promotes the use of new technologies and new materials that can be able to generate resistant structures and take care of the environment at the same time.

References

[1] United Nations, "The Sustainable Development Goals Report 2020," *Sustainable Development Goals,* vol. I, no. I, pp. 18, 50-51, 2020.

[2] L. Rick, «The ballance small business,» 23 November 2020. [En línea]. Available: https://www.thebalancesmb.com/an-overview-of-plastic-recycling-4018761. [Último acceso: 25 August 2021].

[3] J. C. Gonzalez, «DW,» 21 September 2018. [En línea]. Available: https://www.dw.com/en/global-waste-to-pile-up-by-70-percent-in-2050/a-45588580. [Último acceso: 8 August 2021].

[4] B. N. Obiadi, « The Positive Impact of Plastic Recycling in the Built,» *International Journal of Trend in Scientific Research and Development (IJTSRD),* vol. 4, p. 9, 2020.

[5] D. C. C. Moncayo, Artist, *Análisis de la implementación de ladrillos fabricados a partir de plástico reciclado como material de construcción.* [Art]. Universidad Santo Tomás - Facultad de Ingeriería Civil - Bogotá, 2018.

[6] S. M. a. D. S. R. Rajarapu Bhushaiah, «Study of Plastic Bricks Made From Waste Plastic,» *International Research Journal of Engineering and Technology (IRJET),* vol. 06, nº 04, p. 1122 to 1127, 2019.