Journal of Physics:
Conference Series

PURPOSE-LED PUBLISHING™

PAPER • **OPEN ACCESS**

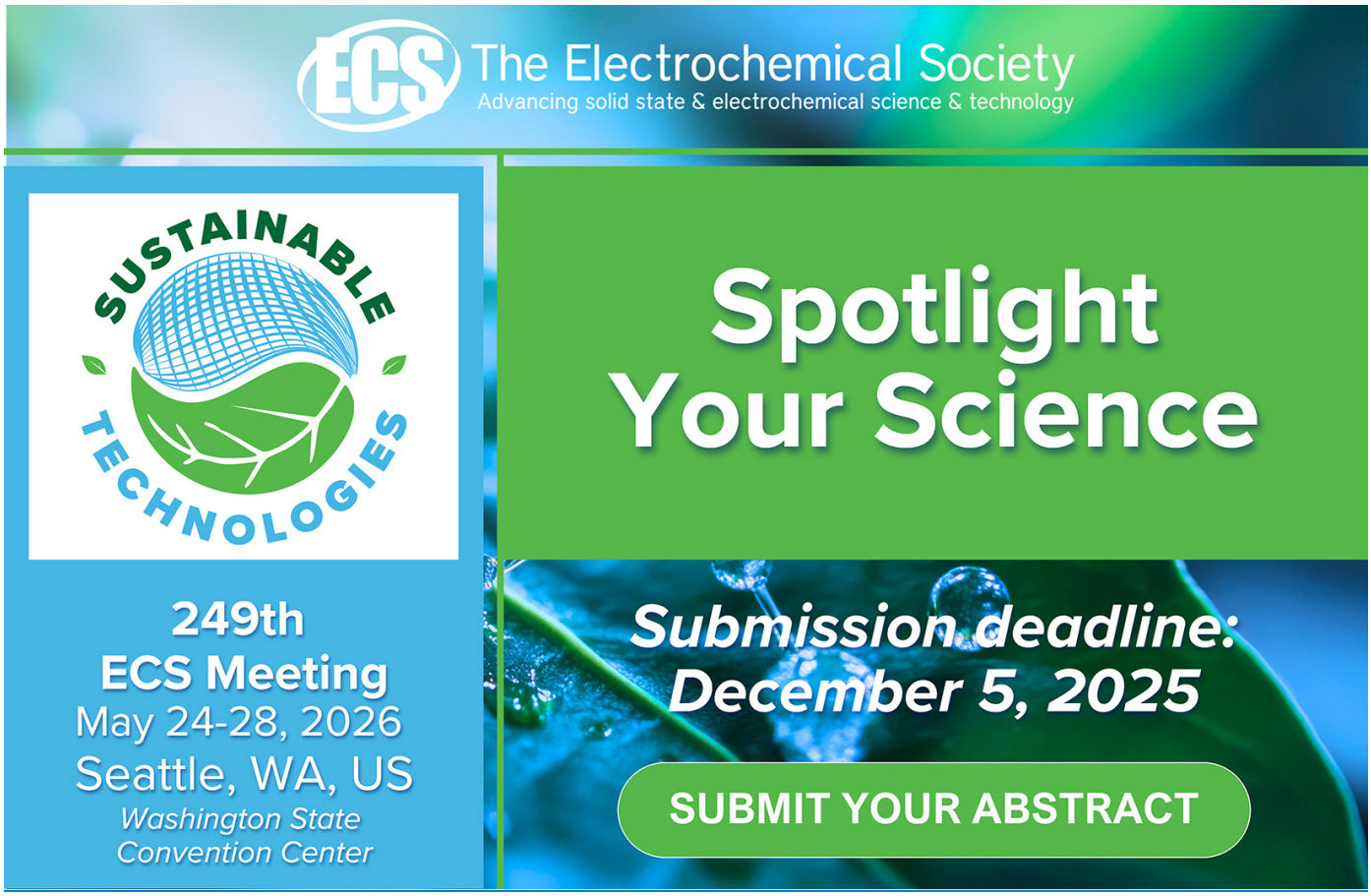
Permeable polymeric panels made from processed plastic

To cite this article: H Y Jaramillo 2019 *J. Phys.: Conf. Ser.* **1257** 012022

View the article online for updates and enhancements.

You may also like

- Effect of recycled coarse aggregates enhanced by CO_2 on the mechanical properties of recycled aggregate concrete
Surong Luo, Wenda Wu and Kaiyun Wu
- Cyclability Improvement of Recycled Graphite Materials in Lithium-Ion Batteries Via Conductive Polymer Coating
Qiusu Miao, Tianyu Zhu, Xiuyu Jin et al.
- Direct Recycling and Upcycling of Spent Graphite Anodes
Jinyun (Jared) Liao, Andrew Park, Bruce E. Koel et al.



This content was downloaded from IP address 8.243.64.131 on 20/10/2025 at 15:08

IOP Conf. Series: Journal of Physics: Conf. Series **1257** (2019) 012022 doi:10.1088/1742-6596/1257/1/012022

Permeable polymeric panels made from processed plastic

H Y Jaramillo[1]
[1] Grupo de Investigación en Construcción Geotecnia y Medio Ambiente, Universidad Francisco de Paula Santander, Ocaña, Colombia

E-mail: hyjaramillo@ufpso.edu.co

Abstract: The construction industry has been constantly looking for new materials and systems that go hand in hand with the technical and economic environmental commitment. Currently, it is easy to find different proposals resulting from the recycling and re-signification of solid waste, as is the case of polymer materials, which form a large part of the city's solid waste, which has generated that little by little the sustainable and environmental issue becomes part of the integral solution of the diverse construction projects. For this reason, this research proposes the creation of a panel composed of a recycled polymer matrix, articulated with each other and that can be used as a dividing element of architectural spaces. The elaboration of this panel is made from the reuse of plastic bottles of polyethylene terephthalate (PET), initially the different recycling companies in the region were identified, from which, the processed material was obtained and with the addition of the plastic resins in the laboratory, a compact and low density polymer matrix was obtained, with which test pieces were made and subjected to compression tests, reaching a maximum resistance of 4.3 and 36kN.

1. Introduction

Technical innovation is associated with social innovation through the daily relationships that are established within a social structure, where there are reciprocal links between academia and society, it is of great importance to analyse the impact and economic relevance of the creation of a recycled plastic panel because this material generates great impact in the construction industry from a sustainable approach. In addition to being a resistant, low-density material, plastic is also a malleable material capable of taking on almost any shape. MacArthur et al. (2016) mention that the demand for plastic increases considerably each year, and it is estimated that the annual demand will double in the next 20 years, exceeding 600 million tons [1]. This is a situation that has caused a series of serious environmental problems, because since the 1950s, worldwide plastic production has increased by 25,000% [2] this is an alarming rate of growth and the final disposal of these wastes has become a major problem for which several countries aim at recycling as the solution to the problem [3-8].

From the exposed problem, the re-signification of plastic is sought for the elaboration of polymeric panels that could be used in the construction of architectural spaces, thus allowing the reuse of this material to contribute to the reduction of waste. Traditional construction methods have gradually adopted new technologies to adopt comfortable spaces under the philosophy of sustainability.

A broader perception of sustainable construction is described by the President of Green Construction of Spain, who states that "Sustainable Construction can be defined as that which, having special respect for and commitment to the environment, involves the efficient use of energy and water, resources and materials that are not harmful to the environment, is healthier and is aimed at reducing environmental impacts [9]. Likewise, the Colombia Green Building Council in 2011 defines as advantages of this type

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

of construction" the implementation of sustainable systems that generates strong benefits by lowering on average, 30% energy savings, 35% carbon, between 30% and 50% water and between 50% and 90% of waste costs, this without taking into account the improvement in health and productivity of those who inhabit them [10].

Several researches have been carried out around the world using plastic and mainly researches have been carried out on "Wood plastic composite" (WPC), structural advantages have been identified in roofing systems, walls, insulation, floors and columns [11-12], these advantages are sought with the elaboration of the panels. Likewise, prolonging the useful life of the plastic reduces the potential environmental impact [13].

Reuse and recycling allow a new trend from technical and technological innovation transforming aesthetics, and contributing to environmental, technical and economic aspects; becoming an alternative not only economic and environmental, but also contributing to the alteration of the linear process and returning the material to another cycle, which allows incursion into sustainable construction, ensuring the safety and bioclimatic comfort of architectural space to be created with recycled polymeric panels.

Under the principles of sustainability, the adequacy of living spaces is sought, which harmonize architectural spaces with the incorporation of dividing elements with functional characteristics and contribute to the solution of waste disposal; the manufacturing of polymeric panels.

2. Methodology

For the development of this research, a mixed qualitative and quantitative methodology will be adopted. Initially the precedent will be set on the national and international context, with respect to the advances in the elaboration of panels in recycled materials.

Subsequently, an identification of the physical properties and the various uses of the materials to be implemented in the development of this research proposal will be carried out.

From the quantitative and experimental part, technical answers are sought from the bioclimatic, sustainable and economic point of view. Therefore, during this research a previous selection of the polymers and resins that will be used as binders will have to be carried out, allowing the determination of the amount of material generated in Ocaña Norte de Santander.

Within the economic analysis, a comparative study of the costs of panels made of fibre cement such as the Super Boart, which is one of the most used in the construction industry in recent times, and recycled polymeric panels should be carried out, which will allow to define their economic viability.

In the same way, the technical part must be identified, allowing tests such as compression test, bending and wear unit, which allows a comparative analysis with materials such as concrete in order to demonstrate its functionality and strength as a compound.

And in its final phase its economic impact and social impact will be determined, which validates this research in terms of its application and relevance in the construction trade.

3. Results

Within the identification of the easy to handle thermoplastic material and with adequate resistance for the creation of the polymeric panel, it is determined that it is necessary to classify the plastic with respect to its origin, which can be:

- Naturals: which are obtained directly from raw materials such as vegetables (cellulose, cellophane) or animals (such as casein, one of the main proteins in cow's milk).
- Synthetic or artificial: which are produced from compounds derived from oil, natural gas or coal.

By defining plastics as such, it can be determined in accordance with the plastic guide according to [14], where the physical and chemical properties of the plastic are specified, allowing it to be named in the first instance as polymers “and establishing its conformation by long macromolecular chains that contain in their structure carbon and hydrogen. They are mainly obtained by chemical reactions between different raw materials of synthetic or natural origin. Depending on the structure that forms carbon when associated with hydrogen, oxygen and nitrogen, the physical properties and molecular structure change.

They are divided into thermoplastics, materials that soften when heated and harden when cooled, and thermosets, which take on a permanent form when heat and pressure are applied to them".

In the first stage it was determined which would be the most suitable type of plastic to use in the manufacture of polymer panels, and since synthetic plastics also called artificial are widely used in everyday life, are easier to obtain, and from the literature review and visits to plastic recycling companies in the region of Santander and the city of Medellin, it was determined that the polymer with which the recycled polymeric panel can be developed is polyethylene terephthalate (PET), which is the most widely used material worldwide, this material belongs to the family of polyesters, which has a great multiplicity of applications, since it is frequently used to make fibers, injection molded parts, containers and containers for carbonated beverages and food, as well as for pharmaceuticals and cosmetics.

Bearing in mind that the Ministerio de Ambiente, Vivienda y Desarrollo Territorial determines the composition of PET based on crude oil, gas and air. One kilogram of PET is 64% oil, 23% liquid derivatives of natural gas and 13% air. Paraxylene is extracted from crude oil and oxidized with air to obtain terephthalic acid. Ethylene, which is obtained primarily from natural gas derivatives, is oxidized with air to form ethylene glycol. The combination of terephthalic acid and ethylene glycol results in PET, which is identified in all containers with the number 1 [14].

The plastic that will be used for the development of the investigation comes from the recycling company Resplasander, located in via Girón, Bucaramanga. This company has an industrialized process for the treatment of the plastic that arrives, and in Figures 1, and Figure 2 where the initial process to which the plastic bottles are submitted when arriving at the company is observed.



Figure 1. Plastic material classification.



Figure 2. Plastic material storage.

After this first stage, the process is done in a more technical way, making use of equipment that transports the material as shown in Figure 3, to be later crushed. Then, it is necessary to wash the material to remove any residue or contaminating agent as shown in Figure 4. Finally, the plastic is separated by color and size.

From the field visit and the literature review conducted on plastics called PET, it was determined that the thickness of this material varies with respect to the content of the containers, then, water containers have a thickness or caliber between 0.70 mm and 0.78 mm, and for carbonated beverages, thicknesses between 0.78 mm and 0.85 mm are used. Once the material is processed inside the recycling company, it is weighed, packed and ready for distribution; in Figures 5 and 6 this process is shown.



Figure 3. Conveyor belt for crushing.



Figure 4. Crushed material washing area.



Figure 5. Screening and classification area.



Figure 6. Sealing and storage of the processed material.

Plastic is a 100% recyclable material, and after a process of adaptation it is possible to reintegrate it to the productive process, and there are several companies dedicated to its processing, being this a profitable business. Additionally, for the purposes of the research project, it is important to point out that the use of PET for the manufacture of polymeric panels as non-structural dividing walls is based on the Colombian Technical Standard NTC 2446 [15], which specifies the classification and requirements of prefabricated panels in Colombia in chapters 2.1.3 Monolithic panels and chapter 2.1.5 Non-bearing panels, would allow production at an industrial level due to the quantity of raw material available for its production.

In the same way, within this research, compression and bending tests to the polymeric panel have been carried out in the laboratories of Francisco de Paula Santander University in Ocaña.

For the development of this test several specimens with a diameter of 20 cm and a height of 30 cm (Figure 7) were manufactured from the chopped plastic polymer (PET) of low density and a particle size less than 3/8 of an inch, to perform these tests it was necessary to bear in mind the following steps:

1) To perform an exhaustive washing of the material to remove any impurity or contaminant agent.
2) To dry the material by an approximate time of 8 hours guaranteeing that the particles remain dry in their totality, it is possible to put to the sun for this process or to make use of a dryer of low power.
3) In a metallic container or in a wooden mold, the chopped material is put, and the plastic resins are added to it in its two components, which allow the adhesion between the particles. It has to be mixed continuously for an approximate period of 30 min.
4) Once the material has been mixed, it is poured into a cardboard cylinder mold with a diameter of 20 cm and a height of 30cm.
5) Finally, it is left to dry in the mold for approximately 8 hours, after which it is possible to perform compression tests as show in Figures 8.

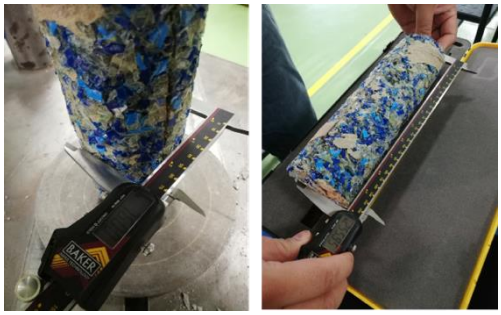


Figure 7. Measurement of PET-based polymer cylinders.



Figure 8. Compression test of PET-based polymer cylinders.

As can be observed in Figure 9 and Table 1, the first series of tests was carried out with the cylinders without coating of the cardboard tubes, and compression resistance values of 4.3 kN were reached,

however with previous tests, it has been evidenced that this value would be raised to 36 kN, a considerable value considering that the specimens are manufactured from plastic polymers using plastic resins as binding agent.

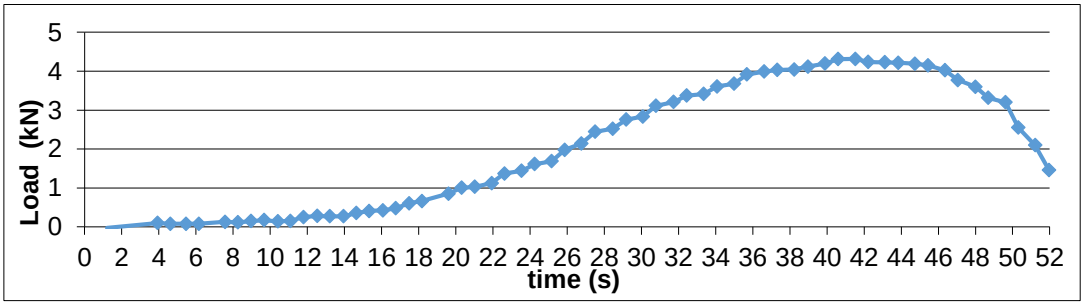


Figure 9. Compression test result of PET-based cylinders.

Table 1. Tests results.

Cylinder number	1	2	3
Height (mm)	225	225	225
Diameter (mm)	76	76	76
Area (mm^2)	4536	4536	4536
Load (kN)	4.3	4.2	4.3
Real resistance (MPa)	0.95	0.94	0.96
Development (%)	9.51	9.52	9.49

The result is obtained with the cylinder without cardboard covering and when the test is performed with the cardboard cylinders covering the result is 36 kN, a considerable value taking into account that the specimens were manufactured from plastic polymers using plastic resins as binder agent; however, it is important to bear in mind that these panels are not structural, so they will not be subjected to great stresses.

4. Conclusions

By recycling and reusing solid materials such as plastic and other materials, it is observed how they can be transformed into a waste material in elements of innovation and the exploration of new forms that contribute to the construction trade and generates a sustainable and economic commitment for the less favored communities of our region.

The environmental and sustainable commitment of the Francisco de Paula Santander Ocaña University is of great importance. The engineering faculty is developing new proposals of dividing elements that contribute to the reduction of solid waste and become in new architectural and engineering elements. The partial results obtained indicate that the panels have a great potential, although with a low resistance without coating, as indicated by the compression tests. However, these are not structural panels, so the load demand is not very representative.

As a project it can be seen that the development of these polymeric panels stimulates the creativity and the development, allowing the social and technological innovation of new proposals of composition of materials for the service of the community in the construction of new dwellings.

References

[1] MacArthur D E, Waughray D and Stuchtey M R 2016 *The new plastics economy, rethinking the future of plastics* Consulted on: http://www3.weforum.org/docs/WEF_The_New_Plastics_Economy.pdf
[2] Diaz E A 2014 *Evaluación de la factibilidad técnica y económica de una planta de producción de paneles aislantes térmicos a partir de plástico desechado* (Santiago de Chile: Universidad de Chile)
[3] Pattanakul C, Selke S and Lai J M 1991 Properties of recycled high-density polyethylene from milk bottles *Applied Polymer Science* **43(11)** 2147–2150

[4] La Mantia F 2002 *Handbook of plastics recycling* (Shawbury: Rapra Technology)
[5] Jayaraman K and Bhattacharya D 2004 Mechanical performance of wood fibre–waste plastic composite materials *Resources, Conservation and Recycling* **41(4)** 307–319
[6] Kamdem D P J H, Cui W, Freed J and Matuana L M 2004 Properties of wood plastic composites made of recycled HDPE and wood flour from CCA-treated wood removed from service *Composites Part A* **35(3)** 347–355
[7] Talavera F J F, Guzmán J A S, Richter H G, Dueñas R S and Quirarte J R 2007 Effect of production variables on bending properties, water absorption and thickness swelling of bagasse/plastic composite boards *Industrial Crops and Products* **26(1)** 1–7
[8] Zenkiewicz M and Dzwonkowski J 2007 Effects of electron radiation and compatibilizers on impact strength of composites of recycled polymers *Polymer Testing* **26(7)** 903–907
[9] Ramírez A 2002 La construcción sostenible *Física y Sociedad* **13** 30-33
[10] Gamboa C 2011 *Construcción sostenible: elemento clave para la nueva economía verde y responsable* (Bogota: Consejo Colombiano de Construccion Sostenible)
[11] Fu F 2017 Introduction: A perspective natural fibre composites in construction (Ed) Fan M *Advanced high strength natural fibre composites in construction* (Duxford: Woodhead Publishing)
[12] Klyosov A A 2007 *Wood – plastic composites* (New Jersey: John Wiley & Sons Inc)
[13] Mansor M R, Sapuan S M, Zainuddin E S, Nuraini A A and Ariff H 2015 Life cycle assessment of natural fiber polymer composites Hakeem K R, Alothman O Y and Mohammad J (Eds) *Agricultural Biomass Based Potential Materials* (London: Springer)
[14] Ministerio de Ambiente, Vivienda y Desarrollo Territorial 2004 *Sector plastico. Guias ambientales* (Bogota: Ministerio de Ambiente, Vivienda y Desarrollo Territorial)