Ecological Roofing Tiles Made With Rubber And Plastic Wastes

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Abstract

The general objective of this research work was to contribute to the environmental decontamination. Its specific objective was to develop sustainable roofing tiles from the ecological, technical and economical points of view.
These roofing tiles are made from recycled materials such as plastics from industry, and rubber from tires into disuse.
In this way this technology contributes in the decontamination of the environment, since it uses waste materials that are buried in municipal land without any use, or accumulated and burned in landfills, causing pollution.
The procedure used was the thermo-molding compaction.
The available amounts of plastic waste are abundant. According to data provided in 2012 by the Ministry of Health and Environment of Argentina, Argentina produces 1,639 tons / year.
The available amounts of rubber tires are also abundant. According to data provided in 2012 by the National Institute of Industrial Technology -INTI, Argentina generates more than 100,000 tons / year.
Plastics and rubber are non bio-degradables materials, so nature can not absorb them as other waste.
One purpose of this research work was to provide an alternative to other traditional building technologies that consume non-renewable resources, or produce negative environmental impact.
The main technical advantages of these roofing tiles respect to other traditional such as ceramic or concrete tiles are their excellent resistance to hail and freezing, high flexural resistance, low specific weight, and low water absorption.

Introduction

The start point of this research work is the problem of environmental pollution.
The human produce large quantities of waste. Some of this waste may be "absorbed", by recycling food waste as fertilizer for crops, for example. Other part of the waste is not bio-degradable, as in the case of plastics, and the nature can not absorb it.
Most part of the waste is accumulated, buried or incinerated in legal or illegal landfills, irrationally wasting resources and causing a negative impact in the environment.
Open dumps create pollution in water, soil, air and food. They produce landscape deteroration, loss of property value, and health consequences. Frequently human feed animals in the dumps, mainly pigs, and after that, acquire illnesses from eating contaminated meat .
The dumps are also places of a hazardous work for collectors.

Waste combustion is justified to prolong the life of the dump and control of disease vectors, but produces air pollution with carcinogenic gases.

According to data provided by the Ministry of Environment and Sustainable Development (SAyDS) under the Ministry of Health and Environment of Argentina, Argentina produced 12.325 million tons of trash per year [1]. On average, the Argentines produce 1 kg. of waste per person per day. Plastics make up 13.3% of total waste (by weight) in Argentina. This equates to 30% of the total volume [2].

The bags of low density polyethylene (LDPE) newly transformed than 150 years in contact with natural agents.

According to data provided by the National Institute of Industrial Technology, Argentina produces 100,000 ton per year of rubber residue [3].

The problem generated by the tires in landfills is the large volume they occupy and the long degradation time (600 years or so), creating a habitat for the proliferation of dengue-carrying mosquitoes and rodents.

Decreasing waste production, recycling materials and adequate disposal of waste that cannot be recycled are viewed as the best possible solutions to this problem.

Recycling is also the best way to reduce extraction of raw materials.

In our country there is little awareness of the need for recycling:

"*Almost 30% of the residues are difficult or impossible to recover (for its intrinsic characteristics, mixing state, size, etc..), But we still have the 70% likely some type of recovery. About 10% of the waste is recovered by an informal system*" [4].

Research Objectives

General: Collaboration in environmental decontamination. Collaboration in solving the housing shortage in our country.

Specific: Development of components for cover, environmentally friendly, with technical aptitude, and low cost, suitable for social housing.

Background

There are numerous precedents worldwide about the use of plastic and rubber particles in building elements, in recent years. These served as the starting point and ongoing consultation material of this research. However, it should be noted that there are differences between them and the constructive elements that were developed in this research, in terms of: dosage, constituent materials, production processes, design, physical and chemical properties, applications, and cost. They include:

- The tiles made of a mixture of plastics (PVC, CPVC, PVDC, ABS, ASA and EVA), patented in Europe [5].
- The tiles developed in Brazil with long life packaging, consisting of a sheet of cardboard and plastics [6].
- The ceiling plates made with nylon fibers which simulate tiles, developed in USA [7].
- The Tejalar tiles produced by the factory Recypack in La Rioja, Argentina, consisting of sheets of cardboard and plastics from beverage packaging. Information provided by the manufacturer.
- The colonial style tiled wall plates arched sections made from scrap tires, heated to straighten the edges, patented by Garcia [8].
- The roofing components in European patent made with polyethylene, polypropylene, rubber and various aggregates [9].

- The mixture of bitumen from disused tires with recycled polyethylene, for the execution of roofing and waterproofing, developed in Spain [10].

Experimental method

The technique for the production of components was to bind particles of plastic and rubber using a thermoforming process by compacting with an extruder and pressing equipment.
Subsequent experiments were carried out with the manufacture of test specimens, changing variables at a time (dosage of materials, particle sizes, constituent materials, processing procedures applied temperature, mechanical stress, and morphological design components). Laboratory tests were performed, and results were evaluated. Adjustments were made based on partial findings.

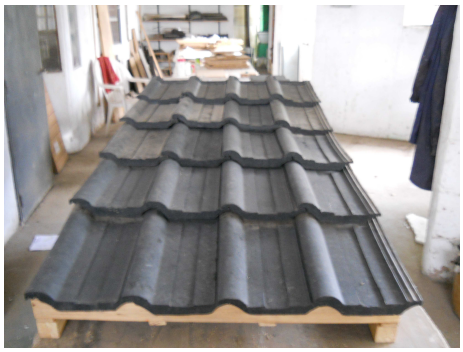

Figure 1. Prototype of roofing tiles.

Technical properties of the components

The technical properties of the tile composed of low density polyethylene and rubber, were established by tests on the following laboratories:
- CINTEMAC Laboratory, National Technological University Cordoba Regional Faculty.
- Structures Laboratory FCEFyN National University of Cordoba.
- Laboratory of the National Institute of Industrial Technology, INTI, Buenos Aires.

GEOMETRIC CHARACTERISTICS (average values): Length: 408.80 mm. Width: 230,45 mm. Weight: 1.29 kg. The test was performed under IRAM Norm 12528-1.
FROST RESISTANCE: The test was performed under IRAM Norm 11632-2 for concrete tiles. No damage or chipping surface observed after conducting the test.
WATER PERMEABILITY: The test was performed under Iram Norm 11632-1 for concrete tiles. Meets the Standard, which states that they should not discard water droplets on the underside of the tiles during the test duration. The tests were conducted within 7 days after the end of the thaw test.
AIR PERMEABILITY: The tes was performed under Swiss Norm SIA 262/2003. Permeability: 0.0010 KT [10-16m2]. It is classified as very low permeability material.
WATER ABSORPTION: Percentage of water absorption: 0.42% (average value). The test was performed under IRAM Norm 12528-03 for ceramic tiles. Meets the Standard, which states that the tiles immersed in water for 24 hours should not absorb an amount of water greater than 15% of their dry mass.
IMPACT RESISTANCE: The test was performed under Iram Norm 12528-2 for ceramic tiles. Result: Satisfactory. Meets the Standard, which states that after performing the test, the tile should not break or introduce surface defects such as blistering, chipping, craters, damage deburring, or surface cracking.
FLEXURAL RESISTANCE: The test was performed under Norma Iram 12528-2 for ceramic tiles. Meets the Standard, which states that none of the tested tiles should break under a load less than or

equal to 1200 N. These tiles resist more than traditional such as ceramics or concrete, with greater deformation (they are more flexible).
AGING RESISTANCE: The test was performed in a chamber under ASTM Norm D 4329:99 and ASTM Norm G 154:04. Result: This formulation is resistant to the action of UV light and moisture.

Conclusions

On the technical side, the main advantages of the developed component (tile made from recycled rubber and plastic) over other traditional such as ceramic tile and concrete, are a higher flexural resistance, a lower specific weight, a lower water absorption, a lower air permeability, and an excellent resistance to hail.
In the ecological aspects, this technology works for the decontamination of the environment, by using recycled plastic and rubber.

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References

[1] Government of Buenos Aires, Ministry of Environment and Public Space. Annual report of management of municipal solid waste. Law 1,854. Buenos Aires, Argentina. 2008, p.7.
[2] CEAMSE. Periodicals. 1992, Argentina.
[3] INTI. Argentina begins to recycle used tires. Weekly Tech News No. 18. Digital publication July 26, 2010.
[4] Environment Agency Cordoba. Cordoba Clean Program. 2001, Publication of the Government of Córdoba, Argentina.
[5] C. Zhang. Plastic roof tiles. WO2001CA00243 European Patent number 20,010,227. Date: September 20, 2001.
[6] J. Fiorelli, J. Morceli , R. Vaz and A. Days. Avaliação telha thermal efficiency gives recycled longa embalagens à base life. Revista Brasileira de Engenharia Agrícola e Ambiental. Campina Grande Vol.13 no.2 March / April 2009.
[7] F. Bacon. Roofing materials made with nylon fiber composites. Patent E.E.U.U. number: 20050170141, Date: August 4, 2005.
[8] E. Garcia. Roof or wall tiles made from recycled rubber tires. Patent E.E.U.U. No.: 5,675,954, date: March 7, 1996.
[9] B. Boor. Composite roofing materials structure. European Patent No. WO 2009152213 (A1). Date: December 17, 2009.
[10] F. Navarro, P. Partal, F. Martinez-Boza and C. Gallegos. Novel recycled polyethylene / ground tire rubber / bitumen blends for use in roofing applications: Thermo-mechanical properties. Polymer Testing Volume 29, Issue 5, August 2010, Pages 588-595.