

# Recycled materials for plastic timber production in Brazil

## Plastic Timber

**ABSTRACT:** *Plastics are present in various products and become a problem for disposal. With time consuming degradation, some take more than a hundred years to decompose and are responsible for many problems, such as flooding and pollution of rivers. One solution to this problem is the plastic waste recycling. In late 2010 Brazil sanctioned the Solid Waste Federal Law (12.305/2010). By 2014 Brazil must eliminate garbage dumps and improve the conditions of landfills, which not always treat the leachate and gases from the decomposition of waste. As an alternative to recycling waste plastics there is plastic timber. Plastic timber is a result of various residues recycling, such as raw organic fibers discarded by industry and high density polyethylene plastics. The objective of this research involves the steps of recycling of various materials for the composition of plastic timber, which products can be obtained from the process and their applications in Brazilian Architecture. Sustainability is present in entire process, from the materials collection, throughout the recycling process and also on social demands. Among plastic wood characteristics that most influences its choice is its impermeability, its impact resistance, it is immune to termites' action, does not release barbs, it is resistant to chemicals and moisture, has high durability and it is a product that meets Brazilian health standards.*

**Keywords:** *architecture; sustainability; recycling; plastic timber*

### INTRODUCTION

Plastics are present in various products and become a problem for disposal. With slow degradation, some lead more than a hundred years to decompose, are responsible for many problems, such as flooding and pollution of rivers.

One solution to this problem, present in various cities around the world, is the recycling of plastic waste. At the end of 2010 Solid Waste Federal Law (12.305/2010) was sanctioned in Brazil, [3]. By 2014 the country must eliminate dumpsites and improve the conditions of landfills, which do not always treat the leachate and gases from the decomposition of waste. As an alternative to recycling waste plastics is the plastic timber. It is a result of recycling of various residues such as raw organic fibers and plastics discarded by industries and high density polyethylene.

### OBJECTIVE

The main objective of this research was to study the stages of materials recycling for the composition of plastic timber and its applications in Brazilian architecture.

The provisions of Brazilian Solid Waste Federal Law were analyzed, which deals with the responsibility of manufacturers through reverse logistics, and an extensive literature review in the sustainability and materials area was also made.

### SELECTIVE WASTE COLLECTION AND REVERSE LOGISTICS

The biggest problem nowadays is urban improper disposal of Municipal Solid Waste (MSW). According to Brazilian Solid Waste Federal Law, 12305 of August 5th, 2010 [3], which established the national policy on solid waste, solid wastes are "material, substance or

object resulting from human activities in society" and it included solid-state materials, semi-solid, gaseous or liquid in containers that "make impracticable its launch in public sewers or watercourses, or require for that technically or economically solutions unviable by the best available technology."

Thus, the MSW is composed of different materials discarded by society and disposed in landfills and dumps. Due to population growth in urban centers and the increasing industrialization and the consequent disposal of products before the end of its life cycle the improper disposal of waste, more and more disorders have been caused as a major cause of pollution of soil, groundwater and watercourses.

The MSW generation in Brazil increased 7.7% from 2008 to 2009, with 88.15% of the volume of waste produced in 2009, ABRELPE [2]. Upon being dumped on urban roads, besides the degradation of spaces, waste contributes to the occurrence of floods, since clogs culverts and galleries, and favors the accumulation of animals that can transmit diseases.

Searching for an alternative to disposal of municipal solid waste and the extraction of raw materials that could be avoided, selective waste collection becomes a necessity and a means of reducing the volume of waste in landfills, as well as the number of landfills existing. Furthermore, it allows a triage of the best materials without being soiled or contaminated by other, facilitating recycling thereof.

Selective waste collection can be done in three ways, the first separating the wet waste (organic) of dry waste (recyclable), the second separating into recyclable waste, organic waste and non-recyclable, the third separating the different categories: plastics, glass, metals, paper, organic and non-recyclable. Once

separated, the materials are taken to recycling or to composting centers, according to their procedure.

In Brazil, in 2009, according to data from ABRELPE [2], 56.6% of the municipalities had some initiative that aimed the selective waste collection.

A tendency to be requested to industries is the reverse logistics: waste generated in the production of a product or disposal of a used product must be used as raw material for the generation of another, and so on. Thus, companies work together and reduce the amount of waste generated, besides the manufacturer of a product to be responsible for the fate given to it after its use.

## PLASTIC TIMBER

"Composite materials are produced by mixing or combining two or more constituents that differ in form and chemical composition and which are essentially insoluble in each other", CORRÊA [4]. Through the needs to reuse and recycling of solid urban waste, plastic timber composite was created, as a way of extending the useful life of plastics, reducing contamination of rivers and dumps and reducing the demand for timber and consequently reducing cutting of trees, MOLINA *et alii*, [7].

For the production of plastic timber it is necessary the use of thermoplastics, natural fibers and an adhesive (usually urea-formaldehyde), optionally a colorant may be added to the mixture. After triage of the materials they are crushed and placed in appropriate machinery for the production of profiles.

The machinery, through processes with controlled pressure and high temperature, creates a mass and from an extrusion process, the pasta passes through a profile chosen by the manufacturer creating plastic timber boards. These are products with the look of wood materials, but with the lightness of plastic. Due the fact that natural fibers are present in the composition the product's name carries that designation. Various shades of color are used and the pieces have enough similarity to actual pieces of timber species well known in Brazil. Depending on how the product was manufactured its inner part may or may not dye.

This material is already used in the United States, can be cut, nailed, screwed and fastened from the use of epoxy resins. It does not loose barbs, does not cracks, is resistant to corrosion, is immune to pests, termites and rodents and can be cleaned with soap and water, Figure 1.



Figure 1: Plastic timber wall – image courtesy of Ecoblock company

## PLASTIC TIMBER PROFILES

During this research it was possible to establish that recycling is a broad subject and of great importance to sustainable development. With the sanctioning of the Solid Waste Federal Law in Brazil in 2010, [3], a major concern of companies and general population regarding the disposal of waste was observed; a trend that needs to be strengthened and encouraged by the government because residents often separate their trash and during the collection the different materials are mixed in the truck. Several initiatives of disposal of these wastes are emerging.

To complement the process of literature review a visit to a plastic timber factory in the metropolitan region of Belo Horizonte was conducted, in order to better understand the production process, from the capture of waste for the production to its sale.

The peculiarity of this plant is given in the way of plastic timber production, unique in Brazil: in its process there is no separation or triage of plastic residues by types or compositions. The only caution adopted by the company is to place some magnets in the conveyor belt, which carry the residues to the machinery, in order to remove any metallic parts that may have been mixed. The raw material is purchased from companies that would send waste to landfills. Thus, the production of any waste, be it liquid or gaseous, is zero. In other companies the plastic timber production processes need neat plastic material, being necessary in that case, cleaning and subsequent triage of the residues, which often plastics are still processed, creating granules according to the chemical composition of plastics, before being processed again for the plastic timber production. This process generates more waste because water is used to clean the plastic residues and in triage some parts end up being discarded because they are contaminated or in a more advanced decomposition process.

Vegetable fibers used at this company, in particular, are coconut fiber or sugar cane bagasse; the choice

between both is given by the purchase market availability. After arriving at the factory they are dried and crushed prior to being added to the mix in the machine. After mixing the components, may be added dyes, depending on the customer's choice. Then the mass of plastics and fibers passes through an extrusion process where 3 meters tablets are created, according to the selected profile. In the factory the colors produced are kaki, cumaru and gray.

After leaving the machine the profiles have some barbs and imperfections. Then, after being produced, the boards go to carpentry, where they are separated by color and finishes are given, removing the barbs and cutting thicknesses according to the requests. After leaving the machinery profile has a standard dimension, Figure 2.

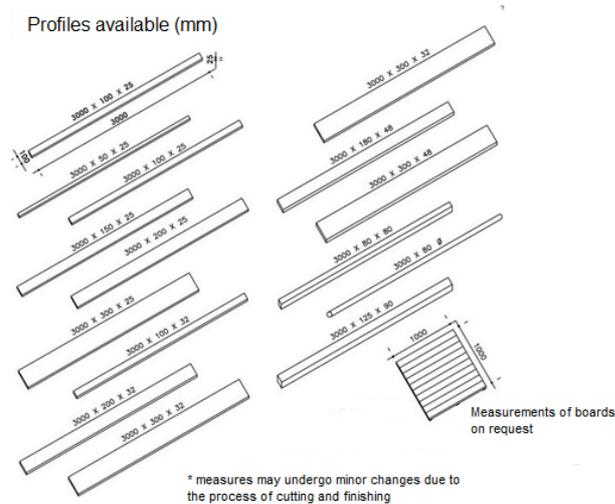


Figure 2: Plastic timber profiles – image courtesy of Ecoblock company

In the production of 700 kg of plastic timber are used approximately 233,000 plastic bags and it is prevented the cutting a grown tree. When the customer avoids the cutting of 70 trees the company sends a certificate of environmental commitment to this buyer, as an environmental incentive.

In order to fulfill with the guidelines of a sustainable company, where the sustainable product tripod must exist, as well as generating profits and social development, the company proves to be effective, especially at the social aspect. The location in a poor neighborhood is considered one of the major reasons for the company's concern: most of the staff consists of surrounding residents. In fulfilling six months of work the company financially assists the person's studies, finishing basic education or early graduate, postgraduate or professional courses. Another assistance given to the employees is the creation of the community garden in the company. At the end of the workday they have their food collected and donated to the employees.

Among the plastic timber characteristics that most influences its choice is impermeability, but it is also impact resistant, immune to termite action, does not release barbs, is resistant to chemicals and moisture, has high durability and is a product that meets Brazilian health standards. Something that is considered one disadvantage is the color variation experienced in the same series, due to the raw materials used in the process, but this is one aspect more of perception and liking of the client, and there are those who like this color variation for appearing aesthetically with the conventional wooden profiles.

The use of plastic timber in humid climate areas, such as in coastal areas, is very suitable because it is resistant, does not require maintenance and can be used in various ways. The most common uses are in decks, pergolas, pool areas and floors, wall coatings, furniture, garden and outdoor areas and facade coatings. Because it is a non-slip material its use on stairs and ramps is gaining strength, beyond its use as coatings in bathrooms and countertops for sinks, Figures 3 and 4.



Figure 3: Plastic timber deck – image courtesy of Ecoblock company



Figure 4: Plastic timber facade coating – image courtesy of Ecoblock company

## MECHANICAL TESTS

The company requested a laboratory to carry out compression tests in longitudinal and perpendicular to the length of the profile directions, flexural strength test, Janka hardness test, water absorption test and density test. The company asked the laboratory the same tests on Angelim, except for water absorption test, in order to compare values. The results of the plastic wood tests showed that the average resistance in longitudinal to the profile's length was 33.82 MPa, while in Angelim it was 45.22 MPa. In perpendicular to the length direction the average strength of the plastic wood was 38.63 MPa, in Angelim, 18.23 MPa. In flexural test plastic wood had resistance of 28.88 MPa and Angelim showed 24.79 MPa. On the Janka Hardness plastic wood showed 6020 N, while Angelim 5786N. In the water absorption test the plastic wood had average rate of absorption of 1.15%. Plastic wood presented average density of 1000kgf/m<sup>3</sup>, while Angelim 710kgf/m<sup>3</sup>.

For comparison purposes other related studies to evaluate the mechanical behavior of the plastic timber were also performed by MOLINA *et alii* [7]. The results were reported from another producer, which utilizes a different composition: sawdust, polyethylene polymers, polypropylene, polystyrene, among others, on the order of 60% to 70%, and aggregates of rice husk in the order of 40% 30%. These components percentages affect the results since each component has its constitutive features. The results showed that the plastic wood sample showed non-linear behavior, with great deformability in bending and even exceeded the limit state of L/200 (according to NBR7190/1997 [1], for conventional wood). It was not observed rupture of the material, which presented residual deformation. In tensile tests brittle rupture was observed, with average value of 18.43 MPa. The average compressive strength in the longitudinal direction of the profiles was 40.00 MPa. The material showed good performance in shear strength with homogenous resistance in the three orthogonal directions of the material. The results were approximately three times greater than the resistance of conifers class C20, therefore the researchers indicated an appropriate use in situations of critical shear requests. The average density was 930kgf/m<sup>3</sup>.

Despite the deformations mentioned above, a product peculiarity is observed after being subjected to a load for a while or improper storage: if the piece is placed on a flat surface, by certain period it will return to its initial format.

## RESEARCH CONTRIBUTIONS

The study, which is still in progress, shows that there are alternatives to the fate of several residues, which previously had no solution. Materials and various applications in construction can be produced with quality.

The Brazilian Federal Law 12305, of August 5th, 2010, [3], which established the national policy on solid waste, came up with this compromise to regulate and control the production of solid waste that increases every day, but also encourages the creation and expansion of new ways of reusing and recycling these materials, gaining prominence, especially the reverse logistics and selective collection concept. There are many selective collection and recycling of waste cases of prominence in Brazil, but in a large country in territory and population aiming to reduce the amount of waste and sustainable materials is still a small initiative.

Some research and new technologies show that it is possible to reverse this situation with small actions and government incentives. The plastic timber comes as an important step in the reuse of waste in a time when sustainability is sought, mainly in construction, which is the largest generator of waste in the world, as a way to create new, high quality and compatible with price products. Proof of this is the use of 233,000 plastic bags in the production of 700 kg of plastic timber.

Because it is still a new material and its use in structures have to be studied manufacturer to manufacturer (because its components and their percentage in the material interfere with the resistances), research and the incentive of plastic timber use should be intensified, requiring motivation through government and private incentives for its development in favor of the many benefits generated for the environment.

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