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POLYMERS REINFORCED WITH NANOMATERIAL FOR USE IN SHALLOW FOUNDATIONS: DEGRADABILITY TEST

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Abstract. *The present article worked with the degradability of biopolymers in membranes and plates reinforced to fibers used as a new technology for biodegradable forms used in shallow foundations in civil construction with the purpose of replacing the wood forms that need to be removed from the soil after concrete drying. The two biodegradable polymers used as polylactic acid (PLA) and poly(3-hydroxybutyrate-co-valerate) (PHB). They are highly biodegradable polymers, so it had used them to test their degradability in foundation centric rigid spread footing form reinforced to use as a biodegradable form for the concrete foundation since it will be used to make ecological shapes that will not need to be removed from the footing form that is made. The work was developed in three stages, the first to produce the Simulated Soil according to ASTM12-G-160-03. The second stage was the production of the three different combinations of the polymers. One plate was the product to PLA pure, the other was with PHB pure and the last with both polymer reinforced with eucalyptus nanocellulose added to PLA and PHB plates. The third step consisted of the degradability test in the simulated soil and in the real soil. The degradability control was done with the raw cotton cloth placed under a layer of simulated soil, for fifty days. After that, the cotton was taken for tensile strength test in Dynamometer, according to NBR13 11912/1991. In the test was verified that there was loss of at least 50% of tensile strength, the soil was considered appropriate for use. Regarding the degradability of the forms used for the foundations, all forms reached the degradability point recommended by the standards within a period of 180 days.*

Keywords: PHB, construction, biodegradable materials, cost reduction, shallow foundation, PLA

1. INTRODUCTION

During the last decade, construction has been one of the most important areas of economic growth in developing countries. However, new technologies do not grow at the same speed that construction industries need. The issue of minimizing spending, shortening construction time and improving service quality are important for improving competitiveness and increasing profits in the construction industry. One of the most important part of a construction is the concrete foundation, it is responsible for the transfer of the load of the structure to the soil on which is resting. The classification of the footing is showed in Figure 1 (GOMES et al., 2014).

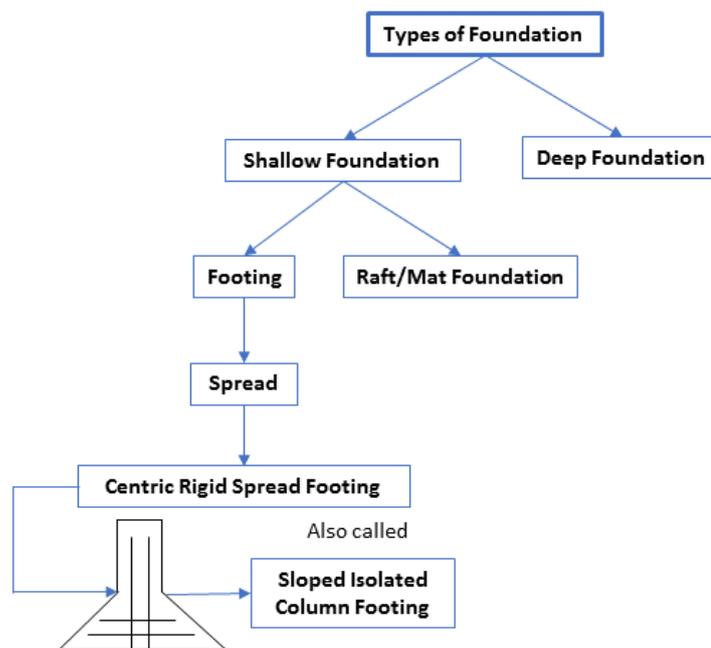


Figure 1. Types of foundations
Source: own elaboration

The foundation of a construction is responsible for about 25% of the value of the work. For the construction of centric rigid spread footing, is necessary to build forms that could hold the concrete. The materials used are wood and nails and need a workmanship to assemble it and to disassemble it, these questions consume great time of the official destined to this work. The price of materials to building the forms and the time expended after 24 hours to take the forms of makes the work more expensive. Thus, this research used the simulated soil as an initial part of the work to verify the degradability of the material used to make ecological forms (CHRISTEN; ADEY; WALLBAUM, 2016).

The tests were carried out in the soil mechanics laboratory, and the project was divided in three stages, the first one it was controlled soil, the second it was the reinforced polymers with nanomaterial and thirdly it was the degradability of the footing shape plates. The controlled soil is the initial part of the research whose function is to test the degradability of the polymers. The lactic polyacid (LPA) is among the biodegradable polymers, which presents the greatest potential for substitution of petroleum-based polymers in the packaging industry. However, one of its main limitations is in the low dimensional thermal stability (PEREIRA and MORALES, 2014).

Poly-3-hydroxybutyrate-PHB is made by fermentation, decomposition of bacteria into the garbage: after collection of bacteria, they are multiplied in the laboratory, after all this process are separated and formed PHB granules that resemble PP (polypropylene). The objective of this research was to test the degradability of the PHB and LPA biopolymer reinforced with nanocellulose for use in shallow foundations.

2. SHALLOW FOUNDATIONS, SIMULATED SOIL AND POLYMERS

2.1 Shallow foundations

In the shallow foundation called footing, the load is transmitted solely by the base, which results in the direct foundation. According to Bastos (2016) the foundation is responsible for transmitting all kinds of actions to the ground. The soil generally has a much lower resistance than the concrete, for this reason that a planned structural element with the function of transmitting the actions to the ground is needed.

2.2 Simulated Soil

The Simulated Soil was made through the composition of soil and horse manure with conditions of temperature and wettability according to current norm, for fifty days, after that time was inserted, for test, a raw cotton fabric was inserted in the simulated soil for test of degradability. After the 15 days the cotton was taken for tensile strength test in Dynamometer, following the norm of NBR 11912/1991. When verifying that there has been a loss of at least 50% of the tensile strength, the soil will be considered suitable for use and the degradation tests of the study polymers will be initiated. One blank line must be included above and below each equation (GOMES et al., 2014).

2.3. Biopolymer Poly (lactic acid) – PLA and Biopolymer (polyhydroxybutyrate) - PHB

Poly Lactic Acid or Poly Lactate - PLA is a biocompatible and biodegradable aliphatic, thermoplastic, semicrystalline or amorphous polyester, produced via polymerization of lactic acid. The PLA comes from the rest of the milk. PHB polyhydroxybutyrate comes from the fermentation of bacteria from stereoselective reactions, where 100% of PHB is obtained (KIZILTAS et al., 2016).

It is a polymer having properties that resemble Polypropylene (PP). If compared, it is more brittle, with lower thermal stabilities and with a narrower processability, which can result in degradation during processing (Brognoli, 2000; Pachekoski, Dalmolin and Agnelli, 2013).

3. METHODOLOGY

Poly(3-hydroxybutyrate-co-valerate) (PHB/HV), containing 30% hydroxyvalerate units and having MW 800,000, and Poly Lactic acid (PLA) were purchased from Aldrich. The Simulated Soil was composed of 2,0 kg of horse manure, 2,0 kg of sifted sand and 2,0 kg of sifted soil, homogenized in a 1,50 liter of water concrete mixer for approximately 40 minutes at 10-minutes intervals. Its moisture content and temperature were evaluated at four different points daily. The Figure 2 showed the process.

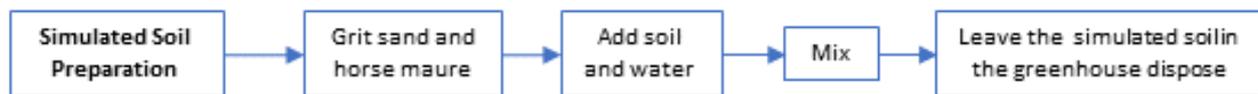


Figure 2. Simulated soil preparation

Source: own elaboration

All measurements were measured and tabulated, which were recorded for further analysis. The soil samples were weighed, photographed and finally placed in an oven at 80 ° C, considering that the ideal temperature according to ASTM12 G-160-03 varies between 20 and 90 ° C with a 30% variability.

The soil was aged for 2 months until reaching the parameters determined by the standard together with the degradability of the cotton fabric. Continuing the experiments, 16 plates of PHB and PLA polymers duly pressed at a temperature of 170 ° C were measured, measuring 8.0 cm by 16.0 cm with thicknesses ranging from 4.0 to 6.0 mm (figure 3).

All plates were photographed, marked, numbered and recorded for their dimensions and masses. With the objective of constructing a block box and shoes with reinforced concrete in 1/3 ratio and placed outside the building, inside the IFSP, where 6 holes were dug with the following measures: 4 holes of 0.20 x 0.20 x 0.20 cm and 2 holes 0.24 cm x 0.24 cm x 0.20 cm, then a block box and a shoe, made with nano-reinforced polymers reinforced with nanocellulose duly concreted and with a previous date for their deformation, were mounted. After 20 days of their concreting, they were compared, and their degradability was verified next to the soil (figure 4).



a) Wood box simulating a greenhouse with simulated soil



b) Simulated Soil

Figure 3. Simulated soil.

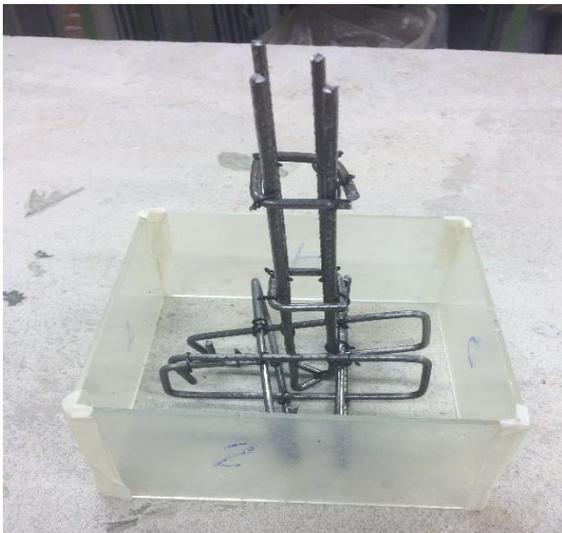
Source: own elaboration



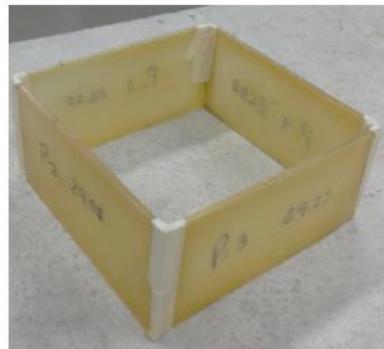
a) Traditional forms shallow foundation with wood



b) Traditional shallow foundation with the rigid structure in iron



c) biopolymer forms for shallow foundation



d) forms and structure of the forms

Figure 4. Shallow foundation.

Source: own elaboration

4. RESULT

It was found that PHB and PLA polymers without reinforcement of nanocellulose maintained their constancy to form perfect films, but the same result was not obtained with mixtures of PHB and PLA polymers reinforced with nanocellulose, which at low temperatures became liquefied, only showing constancy of its form at room temperature. In the weighing and visual verification, it was verified that the plates that were used to construct the boxes of blocks and footings had the degradability of 0.16% in its physical structure in a period of 26 days.

5. CONCLUSIONS

It is concluded that with the use of the PLA and PHB biopolymer plates the time spent with the disassembled forms is reduced, being aware that the plates undergo degradation making the reinforced concrete free of its forms. Over time degraded plaques attach to the soil. One of the plates degraded 0.16% in 20 days, so for 180 days it would have degraded 28.87%, by which it is possible to affirm that in one year the plaque would already be completely degraded. Because of that, it is possible to determine that the bioforms made by PLA and PHB reinforced with nanocellulose fibers for concrete shallow foundation it will be a important development of technology that could increase environmental aspect and could decrease costs and time in the civil construction, because the amount of time used to disassemble the forms will not exist anymore. The other important characteristic of the bioforms it is related to impermeabilization of the structure.

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