Application of castor oil polyurethane resin in the dimension stone block infusion reinforcement process

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Synopsis
The resin infusion of dimension stone block is a step in the process of stone processing that aims to provide increased physical-mechanical resistance to the block, thus ensuring that the process occurs safely and without damaging the geometry of the slabs obtained. Therefore, in order to increase the eco-efficiency of this sector, the search for an alternative to the use of epoxy resin, whose compounds are not in accordance with the sustainability precepts, by an ecological non-toxic castor oil-based resin may provide a global market variance of Brazilian materials. For this, the tensile strength of the resins in carbonaceous and silica materials was measured, observing their respective behaviors. The results obtained were satisfactory, showing that the castor oil resin presented good behavior in relation to the tensile strength in the stone block resin infusion process. These results allow one to infer that the use of castor oil resin to replace the epoxy resin currently used will lead to an environmental gain to this stage of dimension stone processing.

Keywords:
Resin, infusion, polyurethane, castor oil.

Introduction
Natural and covering stones correspond to lithologic types extracted from blocks or tiles that can be sawed in different forms and benefited by squaring, polishing and gloss. The quality control in all the stages that the natural stones are submitted, along with their intrinsic characteristics are important factors for the production of high quality slabs. Due to this, fragile or low-cohesive stones, such as some quartzites and pegmatites usually, for example, require differential treatment prior to sawing the blocks, a procedure known as resin infusion. This process has been done to increase physical-mechanical strength of the block in order to ensure that the sawing process of the block occurs safely. However, there is still no literature that shows the minimum values that the resin/stone interface must have in terms of tensile strength/adhesiveness so that the sawing process of a resin infused block occurs within minimum safety parameters. The resin infusion process is carried out from the application of an epoxy resin.

Mineral fillers and fiberglass mesh are also used which form a combined structure that surrounds the entire block. It is worth mentioning that the epoxy resin is composed of mineral and non-renewable raw material, besides having in its composition Bisphenol A and Epichlorohydrin, compounds that are not in accordance with the precepts of sustainability currently fundamental to the success of any industrial sector. In view of this scenario, some studies related to the use of ecological resins, optimization of the stages of natural stones processing and aspects of sustainability in the mineral sector have already been conducted, being able to be listed below the most important ones used in this research: Silveira (2008), Peiter (2013), among others.
Objective

To analyze the performance between surfaces of natural stone resin with epoxy and castor oil-based polyurethane in relation to tensile strength. In order to define possible substitution of the resin currently used by another one derived from non-toxic vegetable matter.

Methodology

Materials

In order to perform this research, two types of stones, one of carbonate composition and another of silica, were selected. Aiming to know the behavior of the resins in these two large groups of natural stones. A quartzite, with a commercial name White Macaúbas and a marble, known as White Shadow, were chosen mainly because they are often resin infused in the beneficiation industry (Figure 1).

The resins used were castor oil polyurethane synthesized from ricinoleic acid and an epoxy composition commonly used for this purpose. To drill holes in the stones, a bench drill rig owned by Federal Institute of Espírito Santo (IFES) was used and the tensile strength test was carried out with the aid of a pulling device with a digital pressure gauge.

Methods

For the preparation of the resins the technical recommendations of the manufacturers were followed, as follows: for the polyurethane resin of castor bean the proportions of polylol and pre-polymer 1: 1.2 and of the epoxy resin and enduring of 1: 0.3. Subsequently, the resins were applied to the rock samples (Figure 2A). To perform the assay the resin samples remain for 48 hours for the curing process to take place completely. The standard adopted was ABNT NBR 13528:2010 - "Revestimento de paredes de argamassas inorgânicas - Determinação da resistência de aderência à tração" (Adapted).The stone samples were then submitted to the execution of the holes to delimit the distribution of the test samples, with a circular section 50 mm in diameter, spaced approximately 60 mm apart and with a depth of approximately 5 mm. The surfaces of the samples were again cleaned for carrying out the gluing of the tablets (Figure 2B). After this step, the tensile strength test was performed with the support of the pull-out apparatus, whose rupture load was supplied through the digital pressure gauge coupled to the equipment (Figures 2C).
Results and Discussions

The pull-out tests performed provided positive results related both to the use of the vegetable resin applied to the carbonate and silica materials and to the use of the conventional epoxy resin in the same materials. The compositional characteristics of the stone greatly influence the adhesive properties of the stone/resin system. The results of the tests performed in White Shadow marble with the castor oil resin presented 49% higher values than those with epoxy resin. In the case of the White Macaúbas quartzite, the values for the epoxy samples were 77% higher than those obtained for with castor oil polyurethane (Figure 3). The mineralogical composition of the rock is the most important factor for the results for the tensile strength, although in both cases all the samples presented considerable results of tensile strength, being observed in some cases the rupture of most of the samples (Figure 4).
Conclusion

The use of products of vegetable origin in the industrial processing of ornamental rocks, in detriment to resins derived from petroleum, as the epoxy resins, contributes to a greater ecoefficiency of this productive chain allowing a differential of the Brazilian products in the international market. The polyurethane castor oil resin showed good behavior in relation to the tensile strength in the stone block resin infusion process, especially in the marble sample, although for the quartzite the results of tensile strength in the epoxy resin samples were higher. As there is no specification in the literature concerning minimum acceptable adhesion values for industrial resin infusion step, this paper aims to collaborate to increase the technical knowledge about this process. For future researches, it is suggested the performance of pull-out tests in different rock materials with addition of mesh and mineral fillers, to analyze the shear aspect of the kinematic mechanism that occurs in sawing of blocks of natural stone, as well as to better understand the variables that influence the adhesion process.

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References


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