Use of Wastes from Ornamental Stones Processing in Landscaping Blocks

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Abstract. The State of Espírito Santo (Southern Region of Brazil) produces about 80\% of Brazilian exports of natural Stones, which are mainly directed to European countries and the USA. The city of Cachoeiro de Itapemirim and the surroundings account for about 90\% of the State’s production. The mineral sector is the main economic activity in the area and responsible for the generation of thousands of direct and indirect jobs. Before the finished products reach the market, blocks, extracted from the quarries, go through several processes as splitting, cutting and polishing. Each one of those stages generates a substantial quantity of wastes in the form of mud. Estimation for Cachoeiro de Itapemirim is around 60,000 tons/month of that kind of wastes. The main objective of this work was the construction of low cost landscaping blocks, using residues of marbles and granites processing, from companies located in Cachoeiro de Itapemirim. It also aims their use in degraded areas, with a high degree of slope that are resulting from erosion and human activity, thus stabilizing the slope and minimizing future landslides. Wastes were used in the form of mud, with fine particle size, mixed with cement and sand, and varying proportions to make landscaping blocks. Physical indexes, visual inspection, dimensional verification, compression strength, flexural strength, and mineralogical and chemical analyses were tested for the blocks. The results are positive regarding mechanical resistance.

Introduction

Dimension and ornamental stones industry in the State of Espírito Santo accounts for more than half of Brazilian total production and about 80\% of Brazilian Exports. Altough spread on the whole State, the main pole is the Cachoeiro de Itapemirim Productive Cluster – APL (from Portuguese Arranjo Produtivo Local), Southern of the State, centered on that city and embracing other 14 surrounding counties. Cachoeiro de Itapemirim, with a geographical area of 877 sq. km and a population estimated at 201,259 inhabitants [1], is polarizing the development of this whole southern region due to the production of ornamental which accounts for 70\% of local GDP.

That APL has about 1,800 companies of the productive chain of ornamental stones, mainly micro and small enterprises, which account for about 16,500 direct jobs and 80,000 indirect jobs [2]. Table 1 shows an overview of the stones industry in Brazil and in the State of Espírito Santo.
### Table 1. Brazilian Stones Industry Overview - [3, 4]

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
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<tbody>
<tr>
<td>Estimated ROM (2010)</td>
<td>8.9 Million tons 50% from Espírito Santo (ES)</td>
</tr>
<tr>
<td>Brazilian GDP share (2010)</td>
<td>0.18%</td>
</tr>
<tr>
<td>Espírito Santo GDP share (2010)</td>
<td>8%</td>
</tr>
<tr>
<td>TotalExports (2010)</td>
<td>≈2.2 Million tons 70% by ES</td>
</tr>
<tr>
<td>ProcessedExports (2010)</td>
<td>761,053 tons 92% by ES</td>
</tr>
<tr>
<td>Share of Brazilian Foreign Trade Surplus (2011)</td>
<td>3.13%</td>
</tr>
<tr>
<td>Total companies (2008)</td>
<td>12,000 (2,000 on ES)</td>
</tr>
<tr>
<td>Direct Jobs (2008)</td>
<td>110,000 (25,000 on ES)</td>
</tr>
<tr>
<td>Indirect Jobs (2008)</td>
<td>400,000 (105,000 on ES)</td>
</tr>
</tbody>
</table>

The production of ornamental stones involves two main steps: the extraction (extraction in quarries) and processing (preparation of final products in sawmills and finishing units). The latter is divided into: split (slabs making) and finishing (polishing, cut into smaller pieces and / or other finishes). During each of these steps are produced large quantities of waste. These wastes can be classified into two types [5]: Gross wastes are generated in the quarries, at the time of obtaining the blocks, or pieces resulting from the slabs, tiles and other products’ cutting. The other type consists of fine residues, of material removed during the cutting and polishing processes, composed mainly of stone powder, but also with some steel residues (from gang saws blades, steel shot and cutting disks), lime (from the blocks’ sawing) and other chemicals (from polishing and finishing). The main source of fines waste is the step of sawing the block into slabs, where about 30% of the block is transformed into rock powder. Figure 1 shows the various stages of slabs production and an estimation of main quantities of wastes generated in each of them in the Brazil.
Figure 1 – Main stone’s wastes generated on the production of ornamental stones

Considering the large amount of fine waste that is generated in the region of Cachoeiro de Itapemirim, several uses for these wastes are being studied in Regional Unit of CETEM. Among the various applications of waste in the construction industry, it was considered interesting for this work, the production of landscaping blocks with structural function, for containment of slopes due to repeated landslides observed in the rainy season.

Constant episodes of flooding occur in rainy season in all municipalities around Cachoeiro de Itapemirim. In one these episodes more than 10,000 people were affected, and as morphology of this region is mountainous and covered with soils degraded by intensive agricultural exploitation since its occupation, destabilization of slopes frequently happens causing many accidents and serious disorders.

Objective

The objective of this study is to evaluate the technical feasibility of using fine residue (mud) from sawmills in the production of landscaping blocks to contain slopes. It is intended to reduce the environmental impact caused by incorrect disposal of this waste and minimize the visual and structural impacts caused by landslides. That low-cost Landscaping blocks produced, shall have both structural and aesthetic functions.

Materials and Methods

Materials

- Fine wastes from stones cutting, provided by MARCEL - Mármore Comércio e Exportação company and Monte Libano Environmental Association (AAMOL). Material sampling followed the standard ABNT NBR 10007 [6].
- Portland Cement CP II – E – 32 RS
- Natural Sand

Wastes characterization

- Grain shapes and surface texture was characterized by Scanning Electron Microscopy (SEM) with micro-analisisys by dispersive energy (EDS) in a FEI Quanta 400, in CETEM.
- Granulometric distribution of both waste and sand was analyzed with a Ro-Tap equipment, with screens of 16, 20, 30, 40, 50 and 100 mesh (Tyler). Screening time was of 30 minutes for each 1,000 g of each type of sample. After the screening, each fraction was weighted and classified. Granulometric distribution is important to the void index of the final product and therefore to the compacity of the mortar.

Specimens making

Eighteen cylindrical specimens of 15 cm x 30 cm, as required in Brazilian Standard ABNT NBR 5738 [7] were molded; nine of them with the addition of 10% of wastes (cement, sand and waste ratio 3:6:1) and another nine specimens with the addition of 25% of wastes (ratio 1:2:1). The assays below were made on these specimens:
- Absorption of water by immersion: this test shows the absorption capacity of a given body and its voids index, through the relationship between the dry and saturated sample. Tests were made in three samples with 10% of waste and three with 25% of waste, following the Brazilian Standard NBR 12118 [8].

- Uniaxial compressive strength: compressive strength resistance of the specimens was measured accordingly to the Brazilian Standard ABNT NBR 5739 [9], in a CONTENCO HD 200T testing machine. This standard settles the requirements for molding. Twelve specimens, 28 days of setting time, were tested (6 with 10% of wastes and 6 with 25% of wastes). Complementary it was also measured the velocity of propagation of ultrasonic waves that indirectly assess about the alteration and cohesion degree of the samples to be tested. A PUNDIT (Portable Digital Indicator Ultrasonic Non Destrutive Tester) with a 200 kHz transmitter was used on the specimens.

**Results and discussion**

**Aggregates characterization (SEM):** Analysis of scanning electron microscopy showed that waste’s grains are angular, rather heterogeneous, and in various sizes, with predominance of the smaller ones (Fig. 2). This characteristic can affect compaction of the mortar once the angular shape grains can difficult the filling of voids. The chemical analysis by EDS of this material showed some percentage of iron on the fine stones’ wastes, probably coming from steel grit and blades of the gang-saws.

![SEM Image of wastes from the stones’ cutting](image)

Figura 2. SEM Image of wastes from the stones’ cutting - CETEM/MCTI.
**Granulometric distribution:** The next figure (Fig. 3) shows the granulometric distribution of both sand and wastes.

![Granulometric Distribution](image)

Figure 3 – Granulometric distribution of sand and wastes - CETEM/MCTI.

The graphic above shows the granulometric distribution of the natural sand and stones’ wastes. The characteristic dimension of the sand is 0.150 mm and that of the wastes is <0.150 mm.

**Uniaxial compressive strength:** According to the Brazilian Standard ABNT NBR 6136 [10], light-weight blocks belong to the AE Class, that means blocks for general uses, as external walls above or under the ground that can be exposed to humidity or weathering without cement mortar lining. AE Class Blocks must have a minimum compressive strength between 6 and 16 Mpa, depending on the specific use they'll have. For landscaping blocks, the minimum required strength is 6 MPa.

All the results of compressive strength on the specimens tested were superior to 10 MPa (Fig 4). Most of the specimens made with 10% of wastes had better results than the ones made with 25% of wastes. Either way, all the results were satisfactory.
Figure 4 – Uniaxial Compressive strength - CETEM/MCTI.

The medium values for the velocity of ultra-sonic waves were 3,200 for the 10% residues specimens and 3,300 for the 25% of wastes, normal values for that kind of material, verifying integrit of the specimens.

**Water absorption by immersion:** According to the Standard, water absorption must be less than 10% in order keep the structural integrity. All the samples tested met that requirement, being the obtained indexes: 3.5% for the samples with 10% of residues and 6.1% for the samples with 25%.

**Conclusions**

Among the various ways of reducing the environmental impacts caused by the ornamental stone sector, the use of their waste in the construction industry becomes a viable practice.

Good results were obtained by building landscaping blocks with some stones’ processing wastes in their composition. Both mortars used, prepared with 10% and 25% of fine waste from the processing units, showed good characteristics for the production of building blocks. The addition of 10% the residue provided less water absorption and porosity and higher compressive strength, but the results obtained with 25% of residue were also satisfactory.

**Acknowledgments**

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**References**

[1] Information on: http://www.ibge.gov.br


