Characterization of Stone Slurry Waste for Reutilization Purposes as Building Construction Material

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Abstract: Brazil is the 4th biggest dimension stone producer and the 7th greatest exporter. Due to its large stone production, Brazil faces a challenge, which is to find appropriate destination to the huge volume of generated waste throughout the process, mostly slurry from sawing process. Predominantly, Brazilian production comes from the state of Espirito Santo. In this region, frequently the slurry waste generated is stocked in industries own area or even dumped on unauthorized open sites. Researchers search for applications to the slurry stone waste as an industrial raw material. However, a gap persists between the results already achieved and a methodology to rational and economical affordable application. This paper aims to analyze physical, chemical and mineralogical the powder wastes produced by conventional metallic blades loom (DSPW-CL) and diamond wire loom (DSPW-DL) during stone processing to promote its valorization as a building construction material. This could mitigate dimension stone industry impact and improve life quality around the areas of production.

Key words: Waste management, conventional metallic blades loom, diamond wire loom, environment impact.

1. Introduction

Dimension stones industry adds significantly to Brazil’s gross domestic product. Many rock outcrops and the huge processing fields grant the autonomy throughout the whole industrial stone process. It makes Brazil the 4th largest dimension stone producer and the 7th greatest exporter. The state of Espirito Santo, in Brazil, produces 60% of national dimension stone, among granite, marble and other natural stone materials [1]. Due to the large stone production, Brazil faces a challenge, which is to find appropriate destination to the huge volume of generated waste throughout the process.

Ornamental stone processing process is composed by different stages. It begins with the sawing of the rock in loom machines. There are two main types of loom, the conventional metallic blades loom one or the diamond wire one. The mud originated varies according to the peculiarities of sawmills, but it is mainly composed by water, stone powder, steel grit and lime. The first type saws the stone blocks into plates by friction them against the metallic blades as abrasive fluid runs through the sheets. This abrasive mud intends to keep the blades cool and lubricated. It also aids to clean the channels between the plates and avoid blades corrosion. In the adamantine thread loom only water is used as lubricating and cooling fluid. As there is no addition of other components, the residue is composed strictly by stone powder and water. Unlike the conventional one, the waste from adamantine thread loom is not reused for cutting process, being directly discarded. A major advantage of this loom is that its residue does not have steel (grit) so it can be used as ceramic materials, without the risk of oxidation. In the end of the process, the mud produced is sent to ponds or sedimentation tanks. Press filters are employed to reduce the moisture content. The water withdrawn returns to the sawing process.

During the entire processing from 20% to 35% of the original input is turned into waste, mostly powder [2]. In Espirito Santo state, the whole amount of waste is about 60,000 tones monthly [3]. All this waste requires proper disposal otherwise it could lead to a number of
environmental risks. Sanitary landfills are the correct disposal. However, because the control is poor and the transportation costs are high, industries frequently stock this slurry in their own area or even dump them on unauthorized open sites. When disposal inappropriately, this waste inflicts many environmental problems such as contamination of water resources, silting of streams and rivers, soil clogging, soil and air pollution in general. Therefore, researches have been carried out to find applications to the slurry stone waste as an industrial raw material. This could mitigate its environmental, social and economical impact. Once civil construction industry demands a huge and diverse number of materials, several researches try to incorporate this waste in mortar mixtures [4], concrete [5], asphaltic concrete [6], ceramics [7] among others construction material. In spite of the number of studies, a gap persists between the results already achieved and a methodology to rational and economical affordable application. This paper aims to analyze physical, chemical and mineralogical slurry stone wastes originated from conventional and adamantine loom during stone processing to promote its valorization as a building construction material.

2. Materials and Methods

Ornamental stone processing companies located in the state of Espirito Santo provided the conventional loom powder waste (DSPW-CL) and the diamond wire loom powder waste (DSPW-DL). The samples were quartered, dried in a drying oven for 24 hours at 100 ± 5 °C, dislodged and passed in the sieve number 10 (opening 2.00 mm).

The samples were submitted to characterization test following the Brazilian Standard specifications: (1) a grain size distribution analysis [8, 9], (2) compaction [8, 10], (3) Determination of the specific gravity of soil [11], (4) LL (liquid limit) [12], (5) PL (plastic limit) [13] and (6) SL (shrinkage limit) [14]. Mineralogical analysis was performed by XRD (X-ray diffraction) with D8-Discoverey equipment from Bruker AXS.

Morphological analysis was performed by SEM (scanning electron microscopy) on the Zeiss EVO 10 equipment and by reflection optical microscopy on the Nikon ECLIPSE MA200 equipment. The chemical compounds were detected by EDX (Energy dispersive x-ray spectrometry) analysis using the Oxford X-Max equipment.

3. Results and Discussion

Specific gravity results show that DSPW-CL grains size is bigger than DSPW-DL. This fact is explained by the low reuse ratio of the procedure. Steel grit particles in the DSPW-CL were little affected by abrasion during the sawing process. It was not possible to determinate liquid and plastic limits to the samples analyzed thus the materials are non-plastic. The gap between DSPW-CL and DSPW-DL degree of shrinkage results is justified by steel grit in DSPW-CL. It reduces the material contraction potential. Table 1 sums up all physical characterization results.

According to the grain size analysis (Fig. 1) more than 80% of the samples particles have dimensions below 75 μm (fine particles such as silt and clay). Hence, the wastes are classified as powders [15]. A difference of 12% in the sand size particles content on the samples as well as DSPW-CL curve variability is justified by the steel grit presence.

The XRD patterns results in Fig. 2 show the major minerals detected of samples analyzed.

Mineralogical analysis found igneous rock minerals such as quartz, mica, and feldspar on the samples.

| Table 1 Physical characterization parameters of DSPW-CL DSPW-DL samples. |
|---------------------------------|-----------------|-----------------|
| Parameter                       | DSPW-CL         | DSPW-DL         |
| Moisture content                | 1.01%           | 0.95%           |
| Specific gravity                | 2.84            | 2.56            |
| Liquid limit                    | -               | -               |
| Plastic limit                   | -               | -               |
| Shrinkage limit                 | 29.73%          | 29.98%          |
| Plasticity index                | Non plastic     | Non Plastic     |
| Degree of shrinkage             | 17.86           | 13.75           |


Quartz was the major mineral in both waste samples. DSPW-CL presented the following minerals: andesine, anorthite, and labradorite (plagioclase group mineral); muscovite (also known as white mica); zeolite and quartz (silicate group mineral). DSPW-DL presented the following minerals: anorthite and microcline (feldspar potassium group); muscovite, and quartz. Well-defined peaks from DRX suggest the chemical stability of the crystalline composes.

In order to determine the chemical elements on the samples, EDX analysis was applied to multiple areas. Fig. 3 shows SEM micrographs of DSPW-CL and DSPW-DL samples in 2,000 times magnified images. Fig. 4 presents the material morphological pattern obtained by reflection optical microscopy analysis.

The EDX results indicate silicon oxides, aluminum oxides and potassium oxides as the main compounds of both wastes (see Table 2). It suggests that these wastes may be originated from silicate rocks materials, as expected. Steel oxide and calcium oxide in DSPW-CL are a result of steel grit (used as an abrasive material) and lime addition (used to grease the loom).

The SEM micrographs (Fig. 3) indicate the grain shaped morphology, result of the stone slicing process. The grain size varies from 5 nm to 35 nm. The reflection optical micrograph reflection was based on the rupture and cleavage. It has detected the presence of some cleavage behavior minerals, such as muscovite, also confirmed by DRX results. Minerals with two
natural cleavage planes were found, all of them classified as feldspar mineral. Quartz the main mineral detected by DRX has no natural cleavage plane and consequently it presents a conchoidal fracture breakage surface. All these properties confirm the crystalline materials presence.

Approximately 70% of the sample is composed by $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$. Such fact, combined with the low $\text{SO}_3$ content and the superior to 20% amount of particle smaller than 45 $\mu$m may indicate some pozzolanic activity in the material [6].

4. Conclusion

Based on the data presented in this paper, it can be concluded that:

- Both wastes analyzed are silicic-aluminum material composed mainly by crystals and thus chemical stable.
- DSPW-CL has a high-level content of iron oxide and calcium oxide due to the incorporation of grit and slaked lime throughout the stone processing.
- Most of the particles size is equivalent to silt and clay. This fact indicates the potential of these materials
to be employed as filler in the construction industry.

- Some discontinuities were verified DSPW-CL size grain distribution as a result of the grit added.
- Low compressibility resistance was verified in both materials.
- The morphological analysis showed irregular form particles produced by the sawing process.
- The data shown in this paper suggest that DSPW-CT may possibly present some pozzolanic activity. Pozzolanic potential should be verified by Ref. [16] experiments in future works.
- DSPW could be an option of income to the construction industry to produce many materials. DSPW valorization can promote a more sustainable and economical destination contributing not only to mitigate dimension stone industry impact but also to improve life quality around the areas of production.

References