GLOSS ANALYSIS OF AGGLOMERATED STONES SUBJECTED TO NATURAL CYCLING

Tânia Cleiciane Barbosa Souza¹ Evanizis Dias Frizzera Castilho² Maria Angélica Kramer Sant’Ana³ Mariane Costalonga de Aguiar⁴ Mônica Castoldi Borlini Gadioli⁵

ABSTRACT

Theoretical reference: Agglomerated stones are defined as composites formed by a mixture of resin, mineral aggregates and additives. Among the desired qualities of a stone is its gloss, which may change over time, exposure to the elements, use, among others. This problem can occur in both ornamental stones and agglomerated stones.

Method/project/approach: 3 types of agglomerated stones measuring 7cm x 7cm were used to carry out the test. First, the samples were cleaned with running water without the use of cleaning products, and with the help of a soft bristle brush, then they were left to drain the excess water. After 10 minutes, they were placed in an oven at 75°C for 2 hours to dry. After drying, the first gloss measurement was carried out. After measuring the initial gloss, the samples were exposed in a natural environment exposed to the elements (wind, heat, sun and rain) for 285 days, and then the final gloss was measured.

Results and conclusion: This work sought to compare the loss of gloss and chromatic observation in agglomerated stones subjected to natural cycling. The importance of the mineralogical composition of the samples can be seen, all of them have a percentage of quartz in their composition greater than 74%. The greatest loss of gloss, color change, occurs in the sample (A3).

Research implications: Compare the loss of gloss between samples of three types of agglomerated stones and compare with the chromatic loss, evaluating these changes when the sample is subjected to weathering over time.

Originality/value: perform gloss analysis on agglomerated stones, after natural cycling simulating weathering.

Keywords: Agglomerated Stones, Gloss Analysis, Natural Cycling, Technological Characterization, Artificial Stone.

ANÁLISE DE BRILHO DE ROCHAS AGLOMERADAS SUBMETIDAS A CICLAGEM NATURAL

RESUMO

Referencial teórico: As rochas aglomeradas são definidas como compósitos formados por uma mistura de resina, agregados minerais e aditivos. Entre as qualidades desejadas de uma rocha está o brilho, que com o passar do tempo.
tempo, exposição às intempéries, com o uso, entre outros, podem sofrer alterações. Esse problema pode ocorrer tanto em rochas ornamentais naturais como em rochas aglomeradas artificiais.

**Método/projeto/abordagem:** Foram utilizados 3 tipos de rochas aglomeradas de tamanhos 7cm x 7cm para a realização do ensaio. Primeiramente, foi realizada a limpeza das amostras com água corrente sem o uso de produtos de limpeza, e com o auxílio de uma escova de cerda macia, em seguida, eram postos para escorrer o excesso de água. Após 10 minutos, foram colocados em estufa a 75°C por 2 horas para secar. Depois da secagem realizou-se a primeira medida de brilho. Após a medição do brilho inicial, as amostras foram expostas em um ambiente natural exposto aos intempéries (vento, calor, sol e chuva), durante 285 dias, e depois medido o brilho final.

**Resultados e conclusão:** Este trabalho buscou comparar a perda de brilho e observação cromática em rochas aglomeradas submetidos à ciclagem natural. Pode-se perceber a importância da composição mineralógica das amostras, todas elas apresentam em sua composição um percentual de quartzo superior a 74%. A maior perda de brilho, alteração de cor, se dá na amostra (A3).

**Implicações da pesquisa:** Comparar a perda de brilho entre as amostras de três tipos de rochas aglomeradas artificiais e comparar com a perda cromática, avaliando essas mudanças quando a amostra é submetida a intempéries ao longo do tempo.

**Originalidade/valor:** realizar a análise de brilho nas rochas aglomeradas artificiais, após ciclagem natural simulando o intemperismo.

**Palavras-chave:** Rochas Aglomeradas, Análise De Brilho, Ciclagem Natural, Caracterização Tecnológica, Rocha Artificial.

RGSA adota a Licença de Atribuição CC BY do Creative Commons (https://creativecommons.org/licenses/by/4.0/).

1 INTRODUCTION

The consumption of ornamental stones by the civil construction sector is growing and each year Brazil increases its production and exports, being today one of the largest producers and exporters in the world. Although natural stones have a large consumer market, agglomerated stones have become a more frequent option for finishing buildings, and their use has been gradually increasing. Commercially, these stones can be called artificial stones, agglomerated stones, engineered stones, quartz surfaces, and others.

Agglomerated stone is a product resulting from an industrial process that encompasses the combination of aggregates, predominantly quartz with different particle sizes, as well as additives and binding agents, which may consist of resin, hydraulic cement or a hybrid composition between the two, as specified in the standard EN 14618 (SPANISH ASSOCIATION OF NORMALIZATION AND CERTIFICATION, 2011).

To use natural stones and agglomerated stones, it is necessary to carry out technological tests to characterize them and enable specific use, as well as preserve their characteristics (CASTILHO, 2018).

One of the most important aesthetic characteristics of stone is its gloss. Over time, this may change due to the use of chemicals, exposure to bad weather, among others.

Therefore, these materials require care and attention to the technological characteristics and environments in which they will be used. In general, external environments are very aggressive, requiring additional maintenance and costs. Therefore, this work carried out the study of three artificial agglomerated with the purpose of providing guidance on their characteristics and whether there is a possibility of their external use.
2 THEORETICAL REFERENCE

Agglomerated stones are composed of a polymer matrix that integrates stone elements, such as natural quartz and other minerals, generally representing a proportion of 90% to 94% by weight (CARVALHO et al., 2018).

As they have superior properties compared to natural stones, due to their low porosity, low water absorption and high mechanical resistance, they are suitable materials for a variety of applications, including wall coverings, floors and countertops (LEE et al., 2008). The density of agglomerated stones is lower than natural stone materials, leading to a reduction in weight per square meter, thus reducing logistical costs (DE MARTINI et al., 2018).

In the manufacturing process of agglomerated stones, binders are used, generally thermosetting epoxy or polyester resins, and hydraulic cement can also be used, alone or in combination with the resin. The aggregates used have different particle size ranges and the most commonly used include quartz, granite or marble powder (PAZETO and VIDAL, 2020).

Industrial manufacturing takes place through the combination of aggregates, resin, binder and pigments, the latter two being responsible for improving the material's properties. Then, this mixture is introduced into a mold, closed and the vacuum vibro-compression process takes place. (LEE et al., 2008). This process is widely used in the production of agglomerated stones due to its efficiency in producing pieces with superior physical and mechanical properties, meeting different aesthetic standards.

Due to the greater demand for the material in the domestic market for the product, imports of artificial stones in Brazil have been surpassing those of natural stones, according to the Associação Brasileira de Rochas Ornamentais (ABIROCHAS, 2022). As a result, several studies have been carried out with agglomerated stones in order to evaluate their properties (CASTILHO et al., 2023, GADIOLI et al., 2023, AGRIZZI et al., 2022, GOMES et al., 2012).

Due to the high demand for these artificial materials, studies have also been carried out using waste from the production of natural ornamental stones to manufacture these agglomerated stones. This too, as a possibility to contribute to sustainable development in the sector, with several studies in the area (CASTILHO et al., 2023, ALMEIDA et al., 2023, GOMES et al., 2020, BARRETO, et al., 2023).

Assessing the properties of the stone is of fundamental importance to avoid pathologies, which will alter everything from the aesthetic features of the stone to its physical-chemical characteristics. These changes can interfere with aesthetics, durability and especially safety when applied in civil construction (BORBA et al. 2011).

A parameter for evaluating stone alterability can be carried out by evaluating loss of gloss, since the action of weathering on the stone surface can promote variations in surface gloss (CARVALHO, 2010).

There may be a loss of gloss in stone materials and a compromise in the aesthetic aspect of coatings used in civil works. One of the factors that can influence the surface gloss of stones are: the mineralogical composition, size of the crystals, roughness, properties of the stone material such as mineralogy, specific mass and size of the crystals, as well as the direction of the stone's unfolding in relation to the orientation of the crystals (SILVA et al, 2008).

Gloss analysis due to exposure to various products or environmental conditions is essential before selecting the coating material, as the resulting changes may be irreversible.
3 METHODOLOGY

To carry out this comparative study of gloss analysis due to natural cycling, three agglomerated stones were selected, measuring 7cm x 7cm. In Figure 1 are samples (A1), (A2), (A3) of agglomerated stones.

![Sample of agglomerated stones.](source)

The next step was the petrographic characterization of the samples that are described in Table 1.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Agglomerated stone A1: (A) Macroscopic appearance: white color, equigranular, with fine grain (&lt; 1 mm), phaneritic texture and structure with around 30% of grains in relation to the matrix, mineralologically composed of quartz (99%) and muscovite (1%), is in the process of being altered or has already been altered to clay minerals. (B) Photomicrograph showing quartz grains with irregular, subrounded to angular contacts, and microcracks filled with secondary minerals. Crossed polarizers and 2.5x magnification objective lens. Legend: Qz= Quartz, Arg= Clay minerals and MAT= Matrix.</td>
</tr>
<tr>
<td>A2</td>
<td></td>
</tr>
</tbody>
</table>
Agglomerated stone A2: (A) Macroscopic appearance: white color, inequigranular, with grain size varying from fine (< 1mm) to medium (1 to 5 mm) and structure with around 30% of grains incorporated into the aphanitic matrix (70%). (B) Photomicrograph showing the grains that make up the material, which are quartz (25%), glass (5%) and clay minerals (1%), and an inequigranular texture with crossed polarizers and a 2.5x magnification objective lens. Legend: Qz= Quartz, Vd= Glass, Arg= Clay minerals and MAT= Matrix.

Agglomerated stone A3: (A) Macroscopic appearance: inequigranular dark gray color, composed of 75% very fine quartz matrix and 25% grains (quartz and glass) incorporated into it, the grain varying from fine (< 1mm) to medium (1 to 5 mm). (B) Photomicrograph showing rounded quartz crystals (26%) and glasses (4%) with angular grains with crossed polarizers and a 2.5x magnification objective lens. Legend: Qz= Quartz, Vd= Glass and MAT= Matrix.

Source: PAZETO et al., 2020.

The stones used are known as quartz surfaces, often used in surface coating applications such as kitchen countertops, flooring and wall coverings. Samples A1, A2 and A3 come from different suppliers of quartz surface materials, referred to in this work as agglomerated stones. These materials are manufactured using the vacuum vibrocompression method and have quartz in their basic composition, polyester resin as a binder and pigments (PAZETO et al. 2020).

Before the natural cycling of the stones, they went through a cleaning process with running water and brushed with a soft bristle brush. They were then dried in an oven (Figure 2) at 75°C for 2 hours.

Figure 2. Drying of samples in an oven. Source: Prepared by the authors (2022).

Gloss was then measured using the Gloss Meter device (Figure 3), capable of measuring the gloss of flat surfaces, which, through the incidence of a known quantity of light, quantifies the reflectance in GU measurement units.
According to the device manufacturer, the reference angle was chosen using a geometry test (Table 2) to indicate which light angle would be used. These measurements were carried out on the three agglomerated stones. The measurements were carried out using the angle of incidence of light at 20º, 60º and 85º. The angle of 20 is used for high gloss surfaces, 60º for medium gloss surfaces and 85º for low gloss surfaces. The reference angle obtained by the geometry test adopted during the gloss unit measurements was set at 60º for all agglomerated stones.

<table>
<thead>
<tr>
<th>Average value for the 60º angle</th>
<th>Reference angle to be used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between 10 and 70 gloss units</td>
<td>60º</td>
</tr>
<tr>
<td>Above 70 gloss units</td>
<td>20º</td>
</tr>
<tr>
<td>Below 10 gloss units</td>
<td>85º</td>
</tr>
</tbody>
</table>


For better precision of the values, 5 brightness measurements were taken on each test specimen and the average between these values was taken to obtain a more representative result of the brightness of each material.

Figure 4 shows the directions where brightness measurements were taken on the sample.
After measuring the initial gloss, the samples were exposed in a natural environment exposed to the elements (wind, heat, sun and rain), for 285 days on a support approximately 60 cm from the ground (Figure 5).

![Figure 5. Samples exposed to the elements. Source: Prepared by the authors (2022).](image)

After the entire period of exposure of the samples to the elements, the specimens were washed, dried in an oven and the final gloss of each material was measured.

4 RESULTS AND DISCUSSION

The results of the average gloss analysis can be observed in Figure 6, showing the initial and final measurements of the samples in Gloss Units (GU). It is noticeable that the initial gloss measurements of the samples were similar, maintaining a certain homogeneity of gloss among the artificial materials. However, when observing the final measurements, it is evident that sample A3 deviated from the others.

In natural stones, differences in gloss alterations when exposed to weathering are attributed to factors such as varying degrees of mineral alteration, mineral diaphaneity, among others.
To provide a clearer visualization, the gloss reduction percentages for each sample were obtained, as shown in Table 3, highlighting that the highest percentage loss occurred in stone A3.

**Table 3. Gloss Reduction of Agglomerated Stones after Natural Weathering**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Average Gloss Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.78</td>
</tr>
<tr>
<td>2</td>
<td>13.80</td>
</tr>
<tr>
<td>3</td>
<td>47.30</td>
</tr>
</tbody>
</table>

**Source:** Prepared by the authors (2023).

Furthermore, stone A3 exhibited the most significant chromatic alteration (Table 4), while samples A1 and A2, which were aesthetically similar, experienced a lower loss of gloss by the end of the cycle. The change in light reflection measured by the device may also be related to the surface color change of the stone. This is because the color and grain structure of the samples are among the factors that contribute most to the gloss change (BENAVENTE et al., 2003).
Table 4. Photos of the materials before and after weathering.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
</tr>
<tr>
<td>A2</td>
<td><img src="image3" alt="Image" /></td>
<td><img src="image4" alt="Image" /></td>
</tr>
<tr>
<td>A3</td>
<td><img src="image5" alt="Image" /></td>
<td><img src="image6" alt="Image" /></td>
</tr>
</tbody>
</table>

Source: Prepared by the authors (2023).

It can be observed that the agglomerated stones with lighter shades (A1 and A2) did not show a significant color change, and the gloss loss was lower than the dark-colored stone.

The greatest loss of gloss and chromatic modification occurred in the dark-colored sample (A3), and may also be related to the lower quartz content in relation to the samples (A1 and A2), as well as the removal of the black pigment used in the manufacture of this type of material.

5 CONCLUSIONS

This study aimed to assess the loss of gloss and chromatic alteration of agglomerated stones exposed to natural weathering. It can be observed that these materials underwent chromatic modification and a decrease in gloss after exposure to the natural environment subjected to weathering for a period of 285 days. However, the dark gray-colored stone (A3) experienced the most significant chromatic and gloss changes. About that, the white samples
(A1 and A2) maintained their color, with no considerable chromatic alterations, only changes in gloss.

The results of this study indicate that the agglomerated stones studied, in general, are susceptible to chromatic modification and loss of gloss when exposed to external conditions, making them recommended for indoor applications. It is suggested that specifiers of these materials complement this study with other technological characterization tests for a correct and secure choice regarding the application of these materials as coatings in construction.

ACKNOWLEDGMENT

The authors are grateful to the Fundação de Amparo à Pesquisa e Inovação do Espírito Santo (FAPES) process no. 2022-3RGD8.

REFERENCES


GOMES, VINICIUS RODRIGUES; BABISK, MICHELLE PEREIRA; VIEIRA, CARLOS MAURÍCIO FONTES; SAMPAIO, JURACI APARECIDO ; VIDAL, FRANCISCO WILSON HOLLANDA ; GADIOLI, MONICA CASTOLDI BORLINI . Ornamental stone wastes as an alternate raw material for soda-lime glass manufacturing. MATERIALS LETTERS, v. 269, p. 127579, 2020.


