SELECTION OF MATERIALS TO CREATE A MATERIAL LIBRARY IN CARUARU-PE/BRAZIL: CASE STUDY OF ORNAMENTAL STONES

SELEÇÃO DE MATERIAIS PARA CRIAÇÃO DE UMA BIBLIOTECA DE MATERIAIS EM CARUARU-PE/BRASIL: ESTUDO DE CASO DE PEDRAS ORNAMENTAIS

SELECCIÓN DE MATERIALES PARA CREAR UNA BIBLIOTECA DE MATERIALES EN CARUARU-PE/BRASIL: ESTUDIO DE CASO DE PIEDRAS ORNAMENTALES

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ABSTRACT
This study presents the first actions and steps towards creating a Material Library, which is related to the collection of ornamental, natural and synthetic stones. The work method was designed in three stages: 1. Analysis of communication problems perceived between the design and architecture areas in an ornamental stone transformation industry in the city of Caruaru - PE/Brazil; 2. Mapping of raw materials used by the company; 3. Systematization of data based on the mechanical properties and surface treatment of ornamental stones. As a result, a collection of more than 50 samples was catalogued, which will be used for the knowledge and daily use of the general population, for the learning of students, professionals and suppliers involved in the subject of material selection.

KEYWORDS
Environmental impacts; public policy; Generation profile; Cariri.

RESUMO
Este estudo apresenta as primeiras ações e etapas para a criação de uma Biblioteca de Materiais, relacionada à coleção de pedras ornamentais, naturais e sintéticas. O método de trabalho foi desenvolvido em três etapas: 1. Análise dos problemas de comunicação percebidos entre as áreas de design e arquitetura em uma indústria de transformação de pedras ornamentais na cidade de Caruaru - PE/Brasil; 2. Mapeamento das matérias-primas utilizadas pela empresa; 3. Sistematização dos dados com base nas propriedades mecânicas e no tratamento de superfície das pedras ornamentais. Como resultado, foi catalogada uma coleção de mais de 50 amostras, que serão utilizadas para o conhecimento e uso diário da população em geral, para o aprendizado de estudantes, profissionais e fornecedores envolvidos na seleção de materiais.

PALAVRAS-CHAVE
Design de Produto, Pedras Ornamentais, Seleção de Materiais, Biblioteca de Materiais

RESUMEN
Este estudio presenta las primeras acciones y pasos hacia la creación de una Biblioteca de Materiales, relacionada con la colección de piedras ornamentales, naturales y sintéticas. El método de trabajo fue diseñado en tres etapas: 1. Análisis de los problemas de comunicación percibidos entre las áreas de diseño y arquitectura en una industria de transformación de piedras ornamentales en la ciudad de Caruaru - PE/Brasil; 2. Mapeo de las materias primas utilizadas por la empresa; 3. Sistematización

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de datos basada en las propiedades mecánicas y el tratamiento superficial de las piedras ornamentales. Como resultado, se catalogó una colección de más de 50 muestras, que se utilizarán para el conocimiento y uso diario de la población en general, para el aprendizaje de estudiantes, profesionales y proveedores involucrados en la selección de materiales.

PALABRAS CLAVE

Diseño de Producto, Piedras Ornamentales, Selección de Materiales, Biblioteca de Materiales.

1. INTRODUCTION

Knowledge of the materials available on the market and their respective manufacturing processes is essential information for the development of any idea and use of any product. According to Karana (2009), it is the designer's role to select the most suitable materials for a project, from the range of options available today.

However, given the large amount of materials available for selection when using projects, this stage becomes challenging for the project's success. Currently, there are more than 160,000 materials available for design projects, and this demands a continuous research exercise from designers (XAVIER and SILVA, 2021).

At the same time that the lack of information on technical and sensory aspects delays the progress of the process, it also requires extra effort from professionals, who find themselves faced with a huge amount of available materials, and not always with the agility required to obtain information suitable for your project (DANTAS, 2016).

In rural region of Pernambuco there are a large number of micro and small companies that lack technological, administrative, marketing and design resources, among many others, which impact their competitive capacity in the local and national market.

Understanding the local reality, from a design point of view, in agreement with Baxter (2000), means recognizing that, most of the time, companies are unaware of the benefits of design actions and their impact on the development of competitive products, at best. production management and communication between the company and the consumer market.

This context, which could initially be seen as a problem, should be seen as an excellent opportunity for teachers and students from all over Brazil and, especially students of the Design Course at the Centro Acadêmico do Agreste/UFPE, to be able to share the knowledge generated and acquired in academia with society in general and, in particular, with the productive sector in the Agreste region of the state of Pernambuco.

The ornamental stone industries work on the frontier of the following areas: architecture, civil engineering and interior design. Marble and granite stores receive a large demand for orders from a wide range of professionals to meet the most varied and different audiences and desires. The pieces range from basic civil construction elements such as: door sills, kitchen sinks and bathroom washbasins; to furniture and decoration elements with high added value.

Ornamental stones, both natural and synthetic, are raw materials with unique characteristics, which require attention from extraction in the deposits to the final processing with the transformation of the blades into design objects.

The experience of one of the authors of this investigation, as an interior design analyst and responsible for communication between designers external to the company and the production line of the marble factory Atual Granitos Indústria e Comércio de Pedras LTDA - ME in the city of Caruaru - PE , brought to light the need to systematize knowledge, both commercially and academically, about the technical limitations of natural and synthetic ornamental stones, as well as their manufacturing processes.

The company's design sector believes that one of the main causes for rejecting budgets, based on original projects from designers outside the company, is related to the lack of information about the material selection area. The projects that come to the company, most of the time, do not take into account the technical limitations of the materials, and when executed without considering the specific limitations of each type of stone, they can generate rework and/or losses in the manufacturing process, increasing the costs of the final product.

Material selection is a complex step in the design process, since, in addition to the volume of existing materials, each design decision demands a series of objective and subjective variables. Objective variables involve knowledge about the physical and mechanical properties of materials, as well as their manufacturing processes. While subjective ones depend on the association of the material with a certain culture and territory.

One possible tool, among many others, that can be applied to facilitate communication between professionals involved in projects is the Material Library. Which is made up of a collection of samples, images, technical data and important information about materials and technologies related to the materials used to produce a specific artifact within the most diverse production scales.

This article presents the results of the classification and cataloging process of ornamental raw materials, both natural and synthetic, from the collection of the Atual Granitos Indústria e Comércio de Pedras LTDA –ME factory, leader in ornamental stone products in the rural region of Pernambuco. Which donated all the physical samples that make up, today, the first collection of the Material Library of the Design Course at CAA/UFPE.

This study is also part of the final work of the Design Course, linked to the Design Course of the Centro Acadêmico do Agreste (CAA), of the Federal University of Pernambuco (UFPE).

As an academic collection, this research seeks to provide technical and sensorial information on ornamental stones, both natural and synthetic, to provide students with easier and more direct access to data and material samples to support project teaching.

In this sense, the study is of great importance and its implementation is justified by the enormous possibility of guiding the specification of diverse and different materials to students. At the same time, it is justified by facilitating the understanding of its physical and sensorial aspects aimed at the ornamental stone market while seeking autonomy and security when choosing the material.

The Importance of Material Libraries for Commercial and Academic Spaces

Ashby and Johnson (2010) state that materials are the raw material of design, which dictate the opportunities and limits of design. Therefore, it is important that the designer exercises knowledge about the available materials, seeking a better allocation of these in a specific or everyday project.

Users' sensations and perceptions of materials are usually the direct result of the designer's planning. Therefore, the designer is responsible for different ergonomic factors, among many others, regarding the selection of materials. What makes Material Libraries relevant structures, where professionals from various areas can locate materials and manufacturing technologies to apply in their projects (PAGNAN, 2018; MENDONÇA et al., 2023).

In the educational field, Material Libraries contribute to professional training and practice, allowing students and young professionals to have access to information to expand their repertoire and knowledge (XAVIER and SILVA, 2021).

In this sense, for design students, access to the material with its specifications helps beyond the creative process; knowing the material in the aspects relevant to the project avoids errors and delays, since the selection of the appropriate material can be carried out in combination with the technology available in the local industry and the designer's demand.

Material libraries also benefit areas involving design practice, such as architecture, urban planning and engineering. This happens because they are resources that promote proficiency in the use of materials, deepening knowledge of new materials, new resources, technological development and the use of these materials.

Material libraries are also understood as a relevant space for different spaces, such as: academia, commerce and industry. In the absence of these spaces, display cases fulfill a similar role, that is, the satisfaction of knowing the material that is being acquired, or the material chosen for the project. However, the samples are not catalogued.

The systematization of technical characteristics is necessary to avoid inducing the choice for a commercial offer.

Research actions on the theme of material selection, in the Brazilian scenario of undergraduate Design, are on the agenda and were discussed during the 1st National Material Library Forum, held in the city of Florianópolis/SC during the 11th Project Sustainability Meeting - ENSUS, in 2023.

This event brought together several Brazilian researchers who work on this topic, with the aim of strengthening the area of materials selection in Design courses in the country. The large number of national initiatives clearly demonstrated the validity of this approach, which provides professionals in the field, sectors and social and economic segments linked to manufacturing and manufacturing, easy and quick access to essential and facilitating information for the development of new projects, products and services.

The Model and Prototype Laboratory Material Library - FabLab, at the University of Vale do Rio dos Sinos/RS, goes beyond a collection for consultation. It offers a learning environment that integrates materiality and processuality, allowing students to develop skills in product design, materials and prototyping techniques, explains Marques (2023).

At the Federal University of Santa Catarina (UFSC), the Material Library linked to the Virtuhab Research Group of the Architecture and Urban Planning department is divided into a physical Material Library (collection of physical samples itself), composed of diverse samples, end virtual Material Library (where traditional analyzes and links with sustainable issues can be found). And also, the Construteca (composed of models and prototypes demonstrating materials and related manufacturing techniques), which also includes the rapid prototyping process (FERROLI, 2023).

The Material Library of the Federal Institute of Santa Catarina (IFSC), Jaraguá do Sul Campus, aims to identify the possibilities of presenting materials that meet the demands of fashion and clothing designers, as users of virtual Material Libraries.

There is also Materialize, which is characterized as a material library network project that provides information from physical samples and in a virtual environment. Today, it operates and involves the University of São Paulo (USP), the Federal University of Rio Grande do Norte (UFRN) and the Federal University of Espírito Santo (UFES).

Dantas (2023) states that Materialize aims to develop projects and actions to build the digital physical collection. And, in particular, the sharing of information, cataloging of regional materials, and new materials resulting from academic research developed at the universities that are part of the network.

Materials are organized into groups, subgroups and types. All based on their properties and presented in an organized manner in several aspects: dimensions, weight, mechanical and wear resistance, ease of manufacturing, durability, material availability, cost, recycling feasibility, and degree of standardization.

All this so that the designer can refine the choice of material effectively and satisfactorily in the specific context of use. Considering, in addition to the material, project limiting factors such as: budgetary and technological restrictions, and labor availability in the region.

In addition to the technical variables related to the material, the aesthetic attributes, such as color and texture, are subjective variables associated with a certain culture and territory. For example, in the Agreste region of Pernambuco, Crema Marfil Marble is associated with "church marble". Pinta Verde Marble is called "cemetery tombstone marble". At the same time, Ultracompact Calacata is currently the stone that is "in fashion".

These ideals are influenced by social, economic and cultural factors. Therefore, materials require constant analysis, as the dynamics of these factors transform people's relationship with materials over time.

According to Mol (2023) there are different operational profiles for Material Libraries, such as: commercial, private or academic. The collection of the Ornamental Stones Material Library, of the Design Course of the Centro Acadêmico do Agreste (CAA) da Universidade Federal de Pernambuco (UFPE, will be of a commercial and academic nature. The commercial aspect will assist design, architecture and engineering professionals in deciding which material to use in the project. The academic aspect will provide students with practical contact with the materials and their most relevant characteristics for future projects. Initially, it will be presented and will operate with a physical collection. However, there is a strong intention that it will soon operate with a virtual collection, with curation and organization of collections.

2. METHODOLOGICAL PROCEDURES

The method proposed for this study was designed based on three phases. Phase 1. Analysis of communication problems between design and architecture during the execution of a real project. Phase 2. Mapping of the raw materials used by the company. Phase 3. Systematization of data and organization of the collection based on the mechanical and sensory properties of natural and synthetic ornamental stones.

In Phase 1, the lead time of a company service for manufacturing stone elements was monitored and recorded.

Lead time is a concept that emerged from the Toyota Production System and refers to a method for carrying out agile management and providing greater continuity to deliveries on production lines (SHINGO, 1981). This method is applicable to the supply chain as it measures the waiting time between ordering and delivery to the consumer. In this study, the project selected for this exercise was a residential kitchen.

A One of the authors of this research followed the aforementioned project from the moment the order was registered through the following stages: analysis of the original project; approval of the budget by the client; manufacturing of the stone elements; delivery and installation of the pieces according to the approved project.

The authors of this research believe that the design solutions that reach the company are carried out with little technical knowledge about the physical and sensory characteristics of the materials.

By observing the process flow, it was possible to perceive weak points in communication between the company's design sector and external architecture professionals.

In Phase 2, the catalogs of raw material suppliers were analyzed and interviews were carried out with the respective commercial representatives. Aiming to understand how the commercial sector presents its products to customers in retail.

A methodological step, which supported the mapping of the samples, was the participation of one of the authors in the Ultracompact Blades Workshop, in March 2024, with Ezequiel Netto, CEO of The Rock Brazil. This event expanded the repertoire of technical information related to suitable equipment for manufacturing structural elements with such materials. At this event, abrasive materials that can be used for finishing and others that can, on the other hand, damage the material during use were also presented.

In Phase 3, based on the data collected, a cross-referencing matrix was created to systematize the data and a collection was organized based on the mechanical and sensory properties of natural and synthetic ornamental stones.

3. RESULTS

3.1 Phase 1. Analysis of communication problems between design and architecture during real project execution.

The company Atual Granitos Indústria de Pedras e Comércio LTDA - ME focuses its operations on the area of cutting, finishing and assembling ornamental stones at the service of customers and commercial collaborators.

The company has a showcase collection with more than 180 different material samples. The company's design department is responsible for answering customers' questions about the materials (Figure 1).

Figure 1: Service area and display at the Atual Granitos Indústria e Comércio de Pedras LTDA - ME store.

Source: Authors.

In order to optimize the manufacturing process, the company provides guidance services to external designers and end customers during the execution of orders.

There are two possibilities for order entries into the company: those originating from an architecture office and those developed by the company's own design department.

In this company, the design department is responsible for several stages of the process, from receiving the project to the moment of on-site assembly. The (Figure 2) shows the stages of the production flow under the responsibility of the company's design department.

Based on the observation of the service flow, the process begins with the reception of the architectural project or the preparation of a proposal for the client.

The design sector is responsible for receiving and/or preparing projects and carrying out an initial analysis on the feasibility of the proposal.

At this stage, it is verified whether the characteristics of the materials selected in the original project are compatible with the company's technological restrictions, regarding cuts, assemblies, finishes, and details on accessories such as: sinks, wet gutter, socket tower, dispenser and tap.

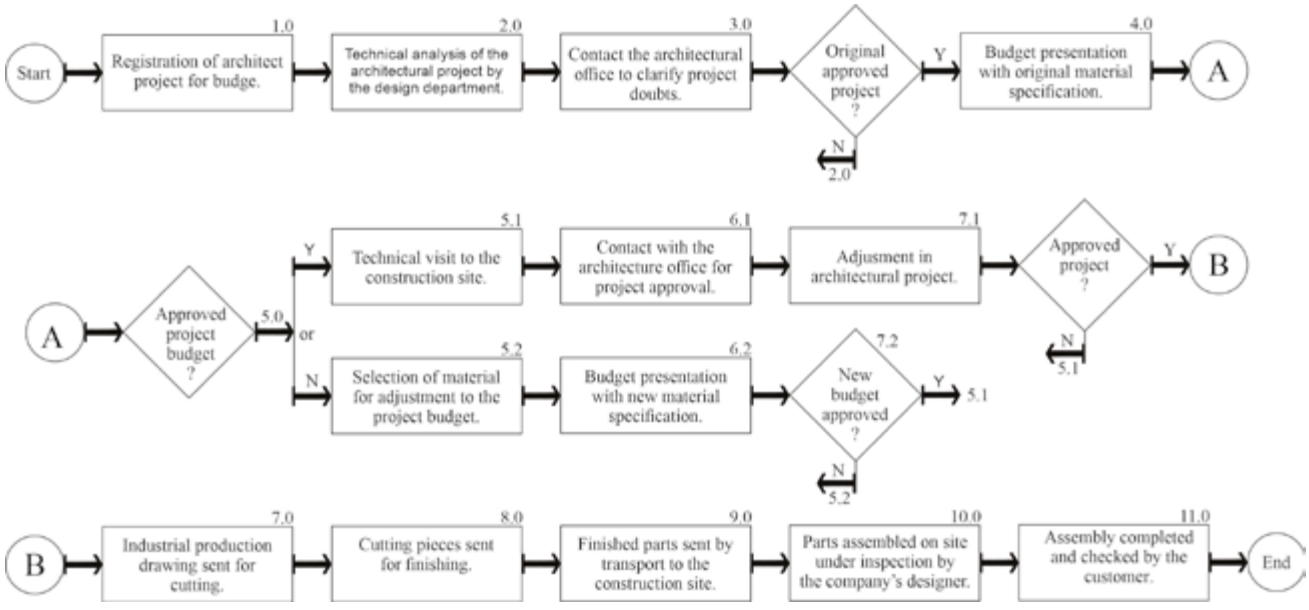

Figure 2: Flow of production steps at Atual Granitos Indústria e Comércio de Pedras LTDA – ME.

Source: Authors.

Another activity in the sector is to establish contact with the architect responsible for the project to clarify the proposed solutions. Technical adjustments are usually proposed with regard to materials and structural systems. Communication with the end customer takes place to approve the service budget.

After the client has approved the budget, technical visits are carried out to the assembly site to check for possible problems in the work that could make it difficult to install the parts. The purpose of the visits is to check the measurements to ensure the exact calculation of the quantity of stones.

The manufacturing drawings for stone elements must be reviewed twice to avoid wasting material. During manufacturing, the parts are separated by cutting plane in order to optimize the use of raw material sheets to reduce waste and material waste (Figures 3 and 4).

Figure 3 and 4: Production line and stock of ornamental stone sheets at Atual Granitos Indústria e Comércio de Pedras LTDA – ME.
Source: Authors.

In the finishing stage, the proposed joints, edge refinement, polishing and cutting adjustments are carried out. At this stage, the first quality control takes place by checking the project, with the aim of certifying the finishes and the agreement between the stones.

After the assembly and finishing tests, the second quality control deals with checking the final product to be sent to stock and, subsequently, logistics to the on-site assembly location. The parts must be organized in the transport vehicle for delivery in such a way that the parts remain anchored, without rocking, as they are made of fragile ceramic material.

During the assembly of the part on site, it is necessary to have a design professional from the company present at the construction site to monitor the assembly step by step. The project is only considered delivered when the client approves the installation.

In the case of the U-shaped kitchen, the object of study of this investigation, the original architectural project presented feasibility problems regarding the surface of the material and/or the dimensions of the industrial raw material, which burdened the first budget for the service (Figure 5). The budget was presented but was not approved, which required new technical adjustments.

The original architectural project had proposed Super Nano synthetic stone, a white material commercially recommended for environments with a high incidence of grease. However, there were problems in the dimensional specification of the industrial raw material, that is, the proposed dimensions were incompatible with the manufacturing process.

Figure 5: Original U-shaped kitchen design.
Source: Architectural project provided by the architect and client.

After technical guidance from the company's design department and the customer's haptic contact with the material samples, new solutions were perceived as possible for cost reduction, including replacing the material with another with lower added value.

The approved decision was to replace the Super Nano with the Black São Marcos Granite stone, a natural material, in black, semi-gloss, with a brushed finish and low cost (Figure 06).

Any change in material generates the need to change the structural technical specifications in the architectural project (Figure 07). And all this time invested increases the execution time of the order.

After the budget was approved, the next step was to measure the measurements on site, comparing the measurements suggested by the project with the reality of the physical space. Often, the mapping of stone installation problems is not noticed by the space designer.

In the case of the U-shaped kitchen, some of the problems noticed were: discrepancies in the type of covering applied to the wall and the height of the electrical boxes. In addition to adjustments to the architectural project that were suggested to avoid demolishing what had already been executed by the builder.

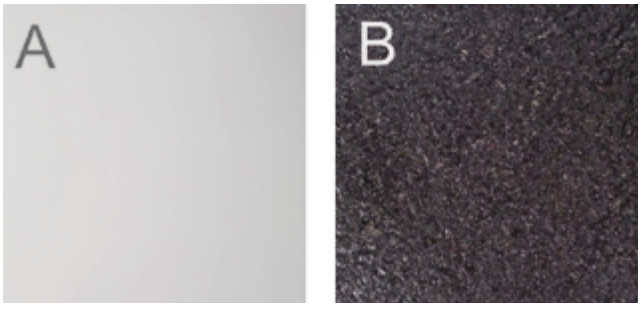

Figure 6: Differences between the material suggested by the architect (A) and the material selected for the project (B).
Source: Authors.

It is important to highlight that in a product design with ornamental stones, the detailing of the finishing in the cutting of the ornamental stone sheets and the type of cutting finish of the basins and accessories are fundamental criteria in the manufacturing process. Therefore, it is necessary to take into account the following aspects:

- Add 20mm to the length of the wet areas (where the sink and tap are installed) to embed in the wall, gluing with mortar to prevent future leaks.
- Add 40mm to the width of the side where the wet area meets the dry area (counter area) to increase the contact area of the stones.
- Add 2mm to the height of the side uprights, anticipating possible floor differences that help with water falling from the floor.
- The countertop level alignment is done by the upper section and the floor level adjustment is done by cutting the stone, adjusting according to the floor.

Figure 7: Modified U-shaped kitchen design.
Source: Authors.

Finally, in the case of the U kitchen, the lead time increased by 250% of the regular time, since the deadline to carry out a project developed internally is 60 days. It was noted that the time taken to complete the services was hampered by the lack of knowledge about the aesthetic and technical aspects and by changes in the specifications of the industrial raw material. matéria prima industrial. This problem created a chain reaction with delays in the execution of other professional services and a negative experience for the customer.

3.2 Phase 2. Mapping of the raw materials used by the company.

Raw Material

The company uses two types of industrial raw materials for architectural finishing: natural rocks and ornamental stones. Natural stones are classified as ornamental rocks, while artificial stones, composed basically of quartz, are produced in the form of sheets and classified as ornamental stones (ALENCAR, 2013).

ABNT standard 15.012:2003 (2013), apud Alencar, defines ornamental rock as natural rock material, subjected to different degrees or types of processing, used to perform an aesthetic function. These rocks are extracted from nature in deposits in the form of blocks. They are then sent to the processing industry, where they undergo the first process to transform sheets with the appropriate polishing for commercialization.

Marble and granite are noble materials used as ornamental rocks, due to their aesthetic effect, durability, mechanical resistance and flexibility in the design and dimensions of the piece. This nomenclature, from a geological point of view, generalizes its properties, but does not encompass aesthetic variations. Quartzites are not popular, but they are well accepted in the market. These ornamental rocks can be used on wet area countertops, floors, internal and external walls, as ornaments in buildings, as coverings for concrete stairs, etc. However, the physical characteristics of each rock determine the technical quality of the piece for the intended service (CRESPO, 1996).

Synthetic stones, also known as artificial agglomerated rocks, are industrial solutions for taking advantage of the high volume of solid waste generated by the extraction and primary or secondary processing of natural ornamental stones. Under express demand

from the consumer market, stones are better managed in production (AZEVEDO, 2006).

Resistance to rupture is one of the most important properties to be considered when selecting this material (ALENCAR, 2013). Each rock has a composition with a predominance of one or more minerals and, therefore, a reference on the Mohs Scale, created in 1812 by the German mineralogist Friedrich Mohs.

This scale classifies minerals according to their hardness, that is, their resistance to scratching (1 - 10). Talc (1) is the softest, and diamond (10) is the hardest of the natural minerals (Figure 8).

Talco	Gipsita	Calcita	Fluorita	Apatita	Feldspato	Quartzo	Topázio	Coríndor	Diamante
1	2	3	4	5	6	7	8	9	10

Figure 8: Mohs hardness scale.
Source: adapted from Alencar (2013).

Natural Stones

Marbles

The term marble is used commercially to designate all carbonate rocks capable of being polished and shined. These are rocks with low hardness (3 to 4 on the Mohs scale), porous and have a great variety of colors and textures. Figure 9). Exposing this material to grease and pigments can stain it. The use of abrasive substances such as bleach and aluminum degreaser can degrade the material, leaving it opaque. This material is recommended as a cladding for facades and pool edges, as it is lightweight and does not retain heat.

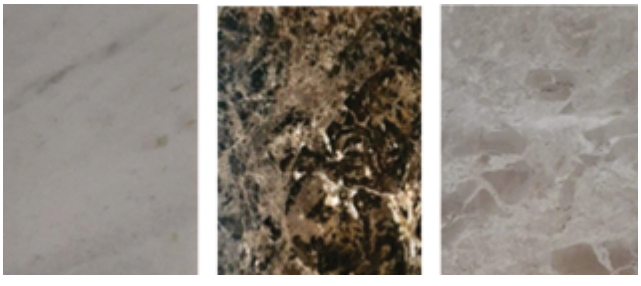

Figure 9: Samples of the diversity of colors and textures of Marbles.
Source: Authors.

Granites

Granites correspond to a broad group of silicate rocks, whose most common mineralogical association presents a composition of quartz, feldspars and micas. They are hard rocks (6 to 7 on the Mohs scale), resistant to rupture and have various colors and textures, although they are still susceptible to stains (Figure 10). The use of abrasives is not recommended, as they damage the surface. Light-colored granites are recommended for bathroom sinks, window and door frames, sills, copings, among other architectural finishes. Dark granites are recommended, in addition to those mentioned above, for kitchen countertops, as neutral soap and alcohol can be used to clean the stone.

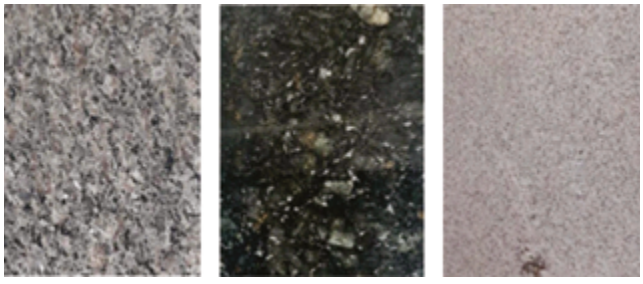

Figure 10: Samples of the diversity of colors and textures of Granites.
Source: Authors.

Quartzites

Quartzite is a metamorphic rock composed of more than 75% quartz and other elements such as muscovite, biotite, sericite, tourmaline and dumortierite. This configuration provides greater hardness (7 on the Mohs scale) and, consequently, a high extraction and processing cost when compared to marble and granite (BRANCO, 2022). The material's surface has colors and textures that attract consumers with unique architectural designs (Figure 11).

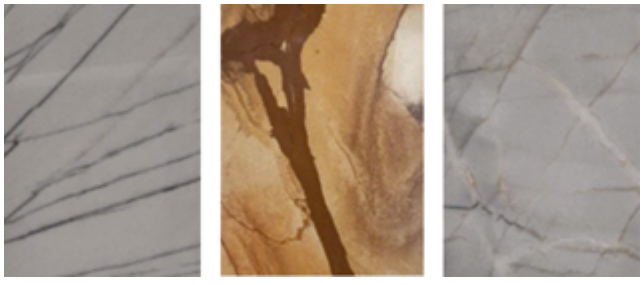

Figure 11: Samples of the diversity of colors and textures of Quartzites.
Source: Authors.

In its composition, quartz is recrystallized, which makes the rock more resistant to stains caused by grease or pigment. They are suitable for the same locations and applications as granite, and abrasive products do not damage the rock.

Synthetic Stones

Super Nano

This material has quartz, feldspar and silica in its composition. It is melted at 1600°C and reduced to nanoparticles. When cooled, a solid, homogeneous material is obtained and is extremely resistant to rupture (6 on the Mohs scale).

Figure 12: Super Nano.
Source: Authors.

The aesthetic characteristics of this material: brightness, white color and smooth texture, make it the most popular among architects and end consumers (Figure 12).

As it is easy to clean, Super Nano is associated with a hygienic material, and as it has great resistance to thermal expansion it can be applied internally and externally; however, it has a high manufacturing cost. It is manufactured in two dimensions: 1.60 x 2.80m and 1.60 x 3.00m, both with 18mm thickness and its hardness is 6 on the Mohs scale.

Quartz surface (Silestone)

Silestone is a material composed of 94% quartz and 6% resin and pigments. These components are pressed in 15 thousand tons, forming a blade with very varied colors and high performance. It has high resistance to stains, acids and high resistance to impact and scratching (7 on the Mohs scale) (Figure 13).

However, due to the resin, contact with heated products, utensils and objects is not recommended, as they can cause permanent damage. Exposure to direct and indirect sunlight (UV rays) is also not recommended, as it affects the color tone. They are manufactured in dimensions 3.06 x 1.44m and 3.25 x 1.59m, with thicknesses of 12mm, 20mm and 30mm and their hardness is 7 on the Mohs scale.

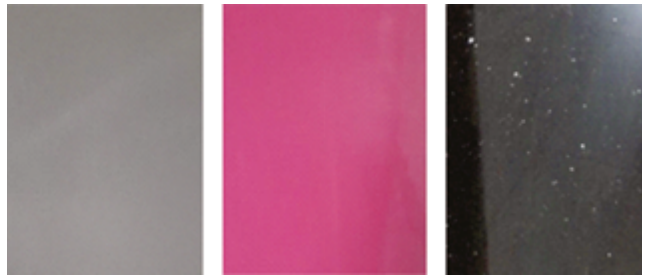

Figure 13: Samples of the diversity of colors and textures of Quartz Surfaces (Silestone).
Source: Authors.

Ultracompact

This material is composed of porcelain, glass and quartz particles, among other minerals. It is pressed at 25 thousand tons and then synthesized at 1800°C. It has high hardness (7 to 10 on the Mohs scale) and low thermal expansion. It is recommended for kitchens, floors or facades exposed to the elements (Figure 14). The manufacturing cost is high and can be found in sizes of 0.71 x 0.71m or 3.20 x 1.44m. It can also have a thickness of 8, 12, 20 or 30mm or even 2.60 x 1.00m with a thickness of 4mm.

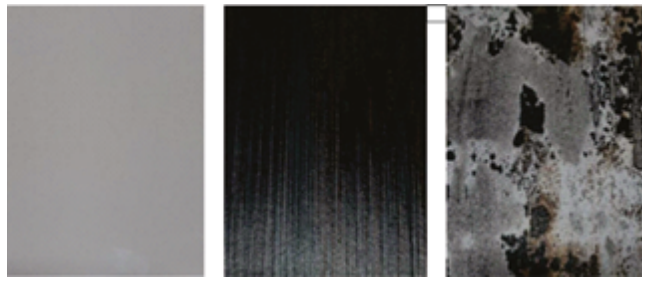

Figure 14: Samples of the diversity of colors and textures of the Ultracompacts.
Source: Authors.

3.3 Phase 3. Systematization of data and organization of the collection based on the mechanical and sensory properties of natural and synthetic ornamental stones.

In view of the data collected in Phase 2, a process of systematizing the information was proposed, based on the mechanical and aesthetic properties, as well as the costs of the ornamental stones available at the company (Table 01).

The origin of the stone is a recurring question among clients and designers and tends to add value to the project. The mineralogical composition and the mechanical property of hardness serve to specify the viable locations for the use of each material.

The dimensions of the industrial raw material are relevant to avoid amendments that are not well accepted by clients and architects.

The surface finish is the finish originating from the rock processing industries. These finishes add value and

modernity to the material, as they follow fashion trends.

Industrial finishing is carried out in the stone slab processing industry. The material cost ratio is directly proportional to the characteristics of both finishes. The selection of materials must consider both the aesthetic aspects and the production cost of the raw material.

Ornamental stones	Natural Marble	Synthetic Ultracompact
Origin	Brazil Italy	Spain
Predominant composition	Calcite Dolomite	Porcelain Class Quartz
Hardness scale (Mohs)	3 to 4	7 to 10
Dimensions	Variable	0.71 x 0.71 3.20 x 1.44 All by 8/12/20 or 30mm thick 2.60 x 1.00 with 4mm thick
Surface finish	Crude Polished Levigated Brushed Flamed	Polished Suede Volcano
Industrial finish	Simple/Rounded Half-rounded Beveled Half-rounded with freze Recess	Simple Beveled
Average cost (m^2)	R$ 470,00 to R$ 1.950,00	R$ 2.250,00 to R$ 9.300,00
Image		

Table 1: Cataloging model of samples from the company Atual Granitos. .
Source: Authors.

A physical collection with more than 50 samples of ornamental stones was proposed to serve as an orientation guide for students, designers and suppliers involved in the subject of material selection.

4. DISCUSSIONS

The opportunity to systematize the experience and publish its results will ensure developments in the classroom and in other environments that deal with local development policies. This academic experience highlights the importance of the University - Company relationship in the training of students in general, but especially for product design students.

By experiencing the reality of the local production park, students are encouraged to relate theory and design practice, understand how they should position themselves to act professionally, and put into practice the articulation between the areas of Design, Production, Communication and Market. The University-Company relationship, so necessary in this current context, depends greatly on the efforts of professors and students to raise awareness among all businesspeople about sharing this knowledge.

Monitoring the creation and realization of a kitchen project, a product requested and carried out by Atual Granitos Indústria e Comércio de Pedras LTDA - ME, made it possible to relate the main communication difficulties between the architectural project and the manufacturing restrictions of ornamental stones.

The lack of knowledge about technical limitations, raw material costs and the interpretation of architectural design in the cutting, finishing and assembly sectors of the marble factory were some of the main problems listed.

As indirect results of the study, after systematizing the data and organizing the collection of natural and synthetic stones based on their mechanical and sensory properties, there was a change in the store layout that had a positive impact on the time and quality of customer service.

At the same time, it is extremely important that the approach to the industrial environment raises the Design student's perspective, both regarding communication problems that may occur during the chain of events for the production of an artifact, and for their professional growth. To achieve this objective, it was necessary to become familiar with the raw materials, manufacturing processes and the consumer market, in addition to an in-depth understanding of the legislation in force for the sectors studied.

5. FINAL CONSIDERATIONS

The entire process of classifying and cataloging the company's ornamental stone collection met the two

motivations cited by Dantas (2016), that is, bringing students, designers and suppliers closer to the commercial and academic areas.

The commercial motivation focuses on the partnership between the companies that manufacture the materials and the designers, becoming a showcase for new materials and innovative processes.

Based on this study, the store layout was restructured by classifying the stones (natural and synthetic) and by the hardness scale of the collection. Another very positive change is that the flow of people and materials was optimized, which generated feelings of trust and security in customers when hiring the service.

There were also changes in the entrepreneur's acceptance of a calendar of events within the store. As a result, lectures on the selection of materials are currently being held.

Academic motivation, which promotes easy access for students to information and material samples to support project teaching, was met by the decision to donate samples from the collection to the Design Course at the Centro Acadêmico do Agreste - UFPE, accompanied by the installation of exhibition equipment.

This pedagogical articulation must be encouraged to allow both students and teachers to recognize the reality of companies and, from there, be able to contribute and seek innovative and sustainable solutions.

The next stage of the research will be the development of a virtual Material Library, making remote access possible for users in search of information on the aesthetic, technological and use aspects of ornamental stones.

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