MATERIALS CLASSIFICATION IN FURNITURE DESIGN – FOCUS ON SUSTAINABILITY

Paulo Cesar Machado Ferroli
UFSC, Departamento de Expressão Gráfica, pcferroli@gmail.com
Emanuele de Castro Nascimento,
Graduanda de Arquitetura e Urbanismo
UFSC, Departamento de Arquitetura e Urbanismo – emanuele.cn@hotmail.com
Lisiane Ilha Librelotto
UFSC, Departamento de Arquitetura e Urbanismo – lisiane.librelotto@gmail.com
Franchesca Medina
Graduanda Arquitetura e Urbanismo UFSC, Departamento de Arquitetura e Urbanismo – fr.medn@gmail.com
Luana Toralles Carbonari
UFSC, Departamento de Arquitetura e Urbanismo – luanatcarbonari@gmail.com

ABSTRACT

The materials classification increases in complexity as new materials are constantly released on the market. The furniture designer, usually a designer or architect, needs to stay current with the emergence of new wood panels, new composites, new metal alloys, and so on. The choice of materials is a crucial moment in the project, as it marks the transition between the conceptual design for the actual project. The currently available classifications are generalist and, strictly speaking, fit for any product. However, the practice shows a difficulty in selecting the most appropriate materials considering the specific area of each project. The present article initially demonstrates the difficulty of the available tables, shows case studies in furniture projects and finally presents a classification proposal focused on furniture design.

Key Words: Sustainability; Materials; Classification; Design

1. INTRODUCTION

Authors like Callister Junior and Rethwisch (2016) present a detailed and complete overview of materials that are used in almost all engineering courses, design and architecture in the country. For the authors, the traditional classification begins by grouping the materials into three large groups: metals, ceramics and polymers. This initial way is based mainly on the chemical composition and the atomic structure of the base materials. In the part referring to polymers, the authors divide into synthetic and natural, including in this second subgroup those derived from plants or animals such as wood, bamboo, rubber, cotton, leather, silk, wool, natural fibers of ramie, hemp, coconut, etc. .

The new materials arising from contemporary technologies are placed in three separate groups: composites, semiconductors and biomaterials. Of these, the group of composites presents a subdivision with already well-known materials such as the various types of concrete and mixed fibers, such as glass, carbon and kevlar, among others. According to Manzini (1993), the constant emergence of new materials forces a continuous reorganization of their classification. Attempts of classification seek to organize properties, strengths, limitations and use examples, seeking to ease the process of material selection.

The periodic table currently has 118 elements, many known and used for centuries for material obtaining. The difficulty of the material classification can be exemplified with the steel element. Being a binary alloy of Iron and Carbon, itself is divided into several types according to the quantity of iron and carbon, with different characteristics of hardness, mechanical strength, malleability and ductility, among others. By adding other elements to the steel, the alloy steels originate. Among these are stainless steel, quick-machining and deep-drawing. It is estimated that in 2017, more than 300 new types of steel were tested, of which only a small portion is likely to be available for industrial uses.

Ferroli et al. (2017) present a classificatory table of materials (table 1), in order to facilitate the selection process. It serves as the basis for the beginning of the process, whose method is demonstrated in the website: Sustainable Materioteca of UFSC that is in constant adaptation. Establishing a relationship with the systematics used in design projects (pre-conception, design and post-conception), the tables are more suitable for the methodological stages of conception.

[Table 1] Classification of materials based on FEM - Material Choice Tool. Source: Ferroli and others (2017)

Table 1	Natural, processed and coated woods	Table 2	Paper, cardboard and cardboard
Table 3	Ferrous metals (cast iron and steel)	Table 4	Non-ferrous metals (alloys)
Table 5	Sintered materials - Powder metallurgy	Table 6	Polymers - plastics (commodities, engineering, high-performance)
Table 7	Polymers - blends	Table 8	Polymers - adhesives
Table 9	Cement, concrete and aggregates	Table 10	Ceramics (common) and Glass
Table 11	Natural materials (gemstones, stones, leather, wool, and others)	Table 12	Natural fibers (rami, sisal, jute, coconut, etc.) and artificial fibers
Table 13	Rubber and plastic - processing	Table 14	Oils and greases
Table 15	Paints and varnishes	Table 16	Nano technology materials
Table 17	Advanced composites	Table 18	Other materials not included in the previous tables

The tables are complemented by physical samples, which allow the user to a tactile experimentation and data sheets of each material that present a brief introduction of the material, focusing on the Life Cycle Analysis (LCA). They follow basic concepts, properties, characteristics, a brief history of the material and main types, classified according to national and international standards (SAE, ASTM, DIN, NM, ISO, etc.)

In the area of furniture design, designers such as Philippe Stark, Fernando e Humberto Campana, Enzo Mari, Alvar Aalto, Tom Dixon and others use very different materials in their projects. The simplistic view of the use of traditional materials such as wood for the body of furniture, fabric for the upholstery and metals in hardware, commonly used in the design descriptions of the catalogs, is no longer accepted, a more detailed specification is needed. Especially nowadays, with an increasing alert of the environmental questions, a description of the origin and artificiality of the materials used can be decisive in the purchase process.

Aware of this, current designers are increasingly seeking to use natural materials and with less impact to the environment. The constant releases of materials called alternative materials further increase the field of study. Materials such as bamboo, coconut fiber, sisal, hemp, etc. are increasingly present in the furniture. Most of these materials still lack accurate and reliable information. While research on traditional materials requires state-of-the-art laboratories, the controlled environment and skilled labor, and high investment values, this is not necessarily the case when it comes to alternative materials whose “case studies” are often described on blogs or unspecialized websites.

This paper discusses the problem of the complexity of the general classification tables of materials, discusses their inadequacy for the specific area of furniture, demonstrates some case studies with furniture designs and the choice of materials and finally proposes a specific classification of materials for furniture.

2. MATERIALS IN DESIGN

In the past years has increased the importance of the materials within the design. Only in the last three years have been published by the main Brazilian publishers 23 books whose theme is materials and processes, related to design,

architecture or engineering, in addition to the large number of scientific articles published in annals of events and periodicals.

The group of so-called traditional materials, which independently of authorship usually includes woods, metals, plastics and ceramics continues to have priority, although not as much as in older publications. It should be noted that the priority is more pronounced in books than in articles, considering the focus of each publication and the average time elapsed in the editing of the original manuscripts.

In the section on ferrous metals, Chiaverini (2012) presents in detail the influence of the chemical elements added to the Fe-C base alloy, in addition to thermal and surface treatments. Unlike the first editions, where the focus was steel and cast iron, in the latest versions non-ferrous metals are increasingly present. However, there is still a very great emphasis on mechanical building materials, and designers seeking information on light alloys involving copper, tin and noble metals, for example, is not the source of most appropriate consultation. Barbosa (2014) meets the need in most non-ferrous metals, covering aluminum alloys, copper, nickel, titanium, magnesium, tin, lead, zinc, cobalt, zirconium and niobium.

When the subject is plastic, the works of Eloisa Mano are references used in all the university courses in the country (Mano and Mendes, 1999, 2000, Mano, 1991, among others), besides Albuquerque (2001) and the titles provided by the Advanced Plastic Institute, which offers a vast collection of technical works, addressing plastic commodities, industrial, high performance polymers, additives, blends and polymer composites. Most publications, however, are too focused on chemical engineering, materials or industrial chemistry, and the designer does not find what really interests him for the project.

The wood is also contemplated in many publications, and in design the most used are Pereira (2013), which presents a general overview with technical and aesthetic characteristics of Brazilian trees and SENAI (2014), whose emphasis on furniture design makes it an important query source. There are still authors such as Ashby and Johnson (2014), who in addition to the comprehensive book with all material groups, have developed in partnership with other researchers the Granta Design software, which among other things allows the designer a comparative visual analysis between quantitative and qualitative attributes of different materials (non-ferrous metals, ferrous, polymers, fibers, ceramics, etc.).

Scientific journals and annals of events present the main innovations of the sector, with the constant inclusion of new chemical elements in the search of metallic alloys and polymeric of high durability and resistance, preferably with low cost and weight. Engineers and designers who graduated in the 1990s or less need to be aware of changes in the materials. In the same way, the scientific innovations in the field of plastics are documented in high quantity. Technical publications of industries and universities, such as the monthly plastic magazine Industrial, among others, regularly present novelties of new polymer formulations, blends, composites, co-polymers and additives. Since products made from non-biodegradable polymeric materials are currently undergoing a series of environmental restrictions, biopolymers, biodegradable polymers and "green polymers" have become a booming market. The same goes for advanced ceramics, cermets and composites. Manufactured from oxides, carbides, nitrides, etc., the techniques of powder metallurgy have raised these materials to a level of utilization that have led to a cheaper and consequently increase in the supply of manufactured products.

The need of Laboratory or factory manipulation of chemical elements added in steel, aluminum alloys, polymeric or ceramic alloys inhibits amateur attempts. This does not occur in the manipulation of materials such as tree bark, knuckle, coconut fiber, sugar cane, horsehair and even bamboo. The ease of processing and obtaining the material, possibility of using common workshop machinery, lack of ABNT standardization processes and access to the material in nature facilitate free trial. Another aspect to be observed concerns the time of research and development to which the material is submitted. While traditional materials have a history of more than 200 years of research, many of the alternative materials surveys count for a few years, at most a few decades.

2. 1 Furniture Design - Designers, Projects and Materials

Traditionally furniture refers to woods. This popular view is directly related to the historical use of wood in furniture. From the earliest records of the history of furniture, with few exceptions, furniture from ancient Egypt, Roman Empire, Renaissance, European classics (France, England and Portugal among others) going through the twentieth century movements (Arts and Crafts, Art Nouveau, Bauhaus, etc.) has the wood as its main material It is also influenced by the fact that only the furniture in the residential furniture group is considered as mobile. Only later came the inclusion of other types of furniture, especially the urban. Firstly it is necessary to separate the groups of furniture that will be considered here. These groups were defined mainly considering the aspects of use of the furniture:

1). Residential furniture: designed for indoor use, with few users (usually family nucleus and guests), with a non-aggressive environment and little exposure to inclement weather.
2). Internal condominium furniture: designed for indoors, but with many users (inns, schools, restaurants, etc.). The environment is not so aggressive, not subject to weather, but the material is more subject to wear by shared and more intense use.
3). External condominium furniture: outdoor use, with many users, controlled public environment (balconies, decks, etc.). With aggressive environment, subject to weather, wear by shared and intense use.

4). Street furniture: designed for outdoor use, with many users, in open-access public spaces (squares, walkways, bridges, parking lots, etc.). Aggressive environment, subject to inclement weather and possibility of vandalism, with heavy use.

The study of furniture through projects of recognized designers can demonstrate the evolution and use of certain materials according to the time in which they were designed. Enzo Mari designed in 1971 a series of furniture such as the Day Night sofa bed and Sof Sof armchair, both with metallic structure (medium carbon steel). This trend remained unchanged throughout the 1970s, when the designer basically used metals and wood. In 1980, the Zanotta project was produced with PA (Polyamide - nylon) seat. Enzo Mari did not venture into the universe of alternative materials, as illustrated by his famous series of Bamboo Vessels, launched in 1969, which were actually made of Vinyl Polyvinyl chloride. (Giorgi, 2012).

Philippe Starck belongs to the group of contemporary designers that usually uses modern materials. Examples of this are the chair Louis Ghost, 1999, Mr. Impossibile chair, 2007 and chair Mi Ming, 2008. All in transparent or pigmented polycarbonate (PC) with variations in PETG. The designer used alternative materials, especially in the Lou Read chair, 2011, whose resin structure is covered by rawhide and mainly in the 2011 Zartan chair, all built with bamboo and covered with linen and hemp. (Morozzi, 2012).

In Brazil, Perrone (2012) presents the main works of Fernando and Humberto Campana. The designers began their work in the furniture sector around 1988 with the "positive and negative" chairs, both cast iron, which gave rise to the so-called "uncomfortable" series, all made of the same material, without concern for the finish. In 1991, they released the chair Favela, made with pieces of pine. The Campana brothers are examples of designers who use abundant alternative materials, as can be seen in the projects Red Chair (1993), Armchair Plastic Bubble (1995), Table Tatto (1999), whose lid is constructed with PVC drain covers, Poltrona Jacaré (2002), Célia Chair (2004) made of OSB and the Wicker Bank, 2008.

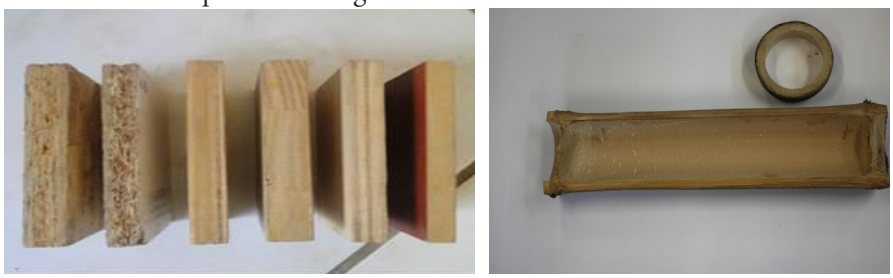
Designers born in the 1950s and 1960s had a beginning of sustainable education. As Ramalho and Santos (2015) explain, at the time of World War I (1914-1918) the first political actions of protection to the environment arose. In 1948 was founded the first world organization of protection to the nature, IUCN (International Union for Conservation of Nature). But it was only in 1972 that UNCHE took place in Stockholm, the first world environmental conference, where the United Nations Environment Program (UNEP) was established. The concepts and discussions of this conference led in 1984 to the spread of the concept of "ecologically sustainable development" at the time these designers were graduating. In 1992, RIO-92 was held in Rio de Janeiro, which established clear guidelines and goals for sustainable development, with concrete objectives, limits and deadlines for actions in all spheres of society. Agenda 21 was written during the Conference. However, the analysis of designers' designs born between 1950 and 1960 shows that the environmental issue had little impact on material choices. This reality is a bit different in designers born in the 1970s onwards.

After several projects using different materials, Michele De Lucchi (Biamonti and Corradi, 2012) launched in 2005 the collection The Design of Madeira. According to the designer, the goal would be to salvage the wood as the classic material for furnishing, by valuing it. After years of being replaced by metal alloys, composites and fibers, or even being covered by plastic films, the wood returns, according to De Lucchi, to its original place as the main material of the furniture industry.

3. PROPOSAL FOR CLASSIFICATION OF MATERIALS FOR FURNITURE

Considering the above, it is verified that the way the materials are classified does not meet the expectations and needs of the furniture designers. The classification tables are, in general, very complex and approach materials that are not used for the specific purpose studied here. The first moment for the proposal of the classification was the division between the furniture categories previously described: residential, condominial internal, condominial external and urban. Some subcategories found in the bibliography, such as the so-called nomadic furniture (Souza, 2016), are included in one of these groups.

For the classification of materials were studied properties, general characteristics, strengths, limitations and everyday examples of use of each material. As far as possible, physical samples of the materials were analysed whenever possible to verify subjective characteristics such as tactile issues (softness, roughness, thermal sensation on the touch), beauty, smell, etc. Figure 1 shows a set of top view samples for visual comparison. This type of analysis allows, for example, the need for subsequent finishing.



[Figure 1] Samples for analysis of subjective questions. Source: prepared by the authors.

For the final composition of the tables, after the initial separation into groups of furniture, the next step was a survey of the materials supply market, considering factors such as ease of manufacturing, the degree of specialization of labour, machinery, direct acquisition costs and transport, indirect costs, quantity of suppliers, supply, demand, environmental legislation, recycling factor, life cycle analysis, aesthetic issues (texture, gloss, etc.), and comfort and safety in use (ergonomic aspects). The tables shown in table 1 of this article were used as a starting point for the preparation of the proposal. The primary analysis reduced from 18 to 7 tables. After this first step, the materials were classified according to the suggested group and subjective criteria were adopted to determine the factors. The factors originated from the FEM tool: Auxiliary Tool for Material Selection, by Ferroli and Librelotto (2012), which are: manufacturing and productive; marketing and social services; economic and financial, aesthetic and product presentation, ergonomic and safety and ecological (environmental). Table 2 shows the results of the applied research in group 1 - natural and processed woods for residential furniture. Due to space constraints, this article will present only that group. The other tables are available in the Sustainable Materioteca site of UFSC.

[Table 2] Classification of materials for furniture - natural and processed woods - part 1 - residential furniture. Source: prepared by the authors.

Natural and transformed wood							
Residential furniture							
Determinant factors			Marketing	Economic	Aesthetics	Ergonomic and safety	
Natural Conífera	Pinus	******	*****	******	**	***	***
	Cipreste	****	****	****	***	***	***
	Cedrinho	****	****	****	***	***	***
	Zimbro	**	**	**	****	**	**
Natural frondosas	Pau-marfim	******	****	***	***	***	***
	Peroba-rosa	****	***	***	****	****	**
	Canela	***	***	****	***	***	***
	Amendoim	***	***	***	***	***	***
	Cedro	**	***	***	****	****	***
	Cerejeira	*****	*	*	*****	****	*
	Uva do Japão	*****	***	***	****	***	****
Transformada Compensada	Compensado laminado	****	****	****	***	***	***
	Compensado sarrafiado	******	****	****	**	***	***
	MDP	**	*****	*****	****	***	***
Reconstituída inflada	Sofboard núcleo de PU	***	**	****	***	****	**
	Sofboard de EPE	***	**	***	***	***	***
Madeira aglomerada	Aglomerado BP	***	****	*****	**	**	**
	Aglomerado especial	***	****	****	***	***	**
Aglomerado de media densidade	MDF ST	*****	*****	****	****	***	***
	MDF MR (umidade)	*****	****	***	****	****	***
	MDF FR (contra chama)	*****	****	***	****	***	***
	MDF HD (resistência)	*****	****	****	****	****	***
OSB	OSB3	***	***	****	**	***	***

FINAL CONSIDERATIONS

The purpose of this article was to show the development of tables to choose materials with a focus on furniture design, considering four types: residential, condominial internal, condominial external and urban. It initially demonstrated a history of the use of traditional materials in furniture design, gradually being replaced or supplemented by alternative materials. This created a problem for material selection because of the difference in relevant and reliable informational data between the various material groups.

Based on previous applications, the authors developed seven practical tables that seek to guide the designer in the choice of materials, establishing correlations with factors of fabrication, productivity, aesthetics, market, society, environment, ergonomics, safety and costs. Preliminary application studies conducted to date indicate the need to test the tables in the four furniture groups in at least three to five different project design situations. These tests have already been started with the application of university product design classes.

BIBLIOGRAPHY

1. Acosta, C., & Carbonari, G. (2017). *Laje mista de bambu-concreto leve: estudo teórico e experimental*. MIX Sustentável, 3(2), 48. doi: 10.29183/2447-3073.mix2017.v3.n2.48-56
2. Albuquerque, J. A. (2001). *Planeta plástico: Tudo o que você precisa saber sobre plásticos*. Porto Alegre: Sagra Luzzatto.
3. Barbosa, C. (2014). *Metais não Ferrosos e suas Ligas - Microestrutura, Propriedades e Aplicações.* Rio de Janeiro: e-papers.
4. Callister, W. D. (2013). *Ciência e engenharia de materiais: uma introdução*. Rio de Janeiro: LTC.

5. Carbonari, G., Silva Junior, N., Pedrosa, N., Abe, C., Scholtz, M., Acosta, C., & Carbonari, L. (2017). *Bambu - o aço vegetal.* MIX Sustentável, 3(1), 17. doi: 10.29183/2447-3073.mix2017.v3.n1.17-25
6. Chiaverini, V. (2008). *Aços e Ferros Fundidos.* Sao Paulo: ABM.
7. Ferroli, P., Librelotto, L., Vidigal, M., & Setter, D. (2017). *Sistema de leitura integrada amostras – site para classificação de materiais numa materioteca interdisciplinar*. In V ENSUS - Encontro de Sustentabilidade. (pp. 318-327). Florianópolis.
8. Giorgi, M. (2012). *Enro Mari. Coleção Folha grandes designers.* São Paulo Folha da Manhã.
9. Greay, T. (2011). *Os elementos: uma exploração visual dos* átomos *conhecidos no universo*. São Paulo: Blucher.
10. Lefteri, C. (2017). *Materiais em Design – 112 materiais para design de produtos.* São Paulo: Blucher.
11. Mano, E. (1991). *Polímeros como materiais de engenharia*. São Paulo: Blücher.
12. Mano, E., & Mendes, L. (1999). *Introdução a polimeros.* São Paulo: Blucher.
13. Mano, E., & Mendes, L. (2000). *Identificação de plásticos, borrachas e fibras.* São Paulo: Blucher.
14. Material Science | *AZO Material.* (2019). Retrieved from https://www.azom.com/.
15. Materioteca Sustentável. (2019). Retrieved from http://materioteca.paginas.ufsc.br/.
16. Manzini, E. (1993). *A matéria da invenção.* Lisboa: Centro Português de Design.
17. Morozzi, C. (2012). *Philippe Starck. Coleção Folha grandes designers* São Paulo: Folha da Manhã.
18. Neri, G. (2012). *Jasper Morrison. Coleção Folha grandes designers* São Paulo: Folha da Manhã.
19. Pereira, A. F. (2013). *Madeiras Brasileiras – guia de combinação e substituição*. Blucher: São Paulo.
20. Perrone, C. E. L. (2012). *Fernando e Humberto Campana. Coleção Folha grandes designers.* São Paulo: Folha da Manhã.
21. Plástico Industrial | Aranda Editora. (2019). Retrieved from http://www.arandanet.com.br/revista/pi
22. Sánchez Quintero, C., & Da Cunha Silveira, W. (2016). . D*esenvolvimento de uma ligação estrutural para construção com bambu Gradua*. MIX Sustentável, 2(1), 98. doi: 10.29183/2447-3073.mix2016.v2.n1.98-106
23. Senai-SP. (201SP. (2014). *Madeira – matéria-prima para o design.* SENAI – São Paulo.
24. Souza, C. E. (2016). *Móveis nômades, é possível?* In Habitus Brasil: (http://www.habitusbrasil.com).