

Original scientific paper

Received: 25.08.2019

Accepted: 18.12.2020

UDK: 684.4:712.26

THE QUALITY OF WOODEN MATERIAL IN OUTDOOR FURNITURE

Elena Nikoljski Panevski¹, Ivo Kanevce²

¹ Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia,
Faculty of Design and Technologies of Furniture and Interior-Skopje,
e-mail: nikoljski@fdtme.ukim.edu.mk; elenanikoljski@gmail.com
kanevceivo@gmail.com

ABSTRACT

The aim of this paper is to analyze the quality of wooden material in outdoor furniture. For the purpose of this work, exterior furniture and urban equipment or a garden set, were designed. By analyzing this type of furniture and its needs from anthropometrical point of view, there comes the need for design of several different pieces of furniture, including: chair, armchair, stool, two-person bench, 3-person bench, rectangular table, square table, swing and matching flower pots.

On the other hand, by analyzing outdoor furniture and its needs from material aspect, there are certain reasons for using thermo wood, mainly on account of the positive consequences of its use.

The ultimate goal is to get a quality seating and leaving outdoor in which the human factor is very important. Through better understanding of the parameters of ergonomics, the designer can improve health and safety in furniture. Actually, it is the planner's obligation and task to constantly monitor research in the field of ergonomics so as to implement, maintain and improve the design of furniture.

For that purpose, the anthropometric standards for this type of furniture were observed, as well as the chosen material which meets the requirements of permanent use and desired look.

Key words: ergonomics, anthropometry, human factor, design, construction, material, thermo wood, environment, interaction

1. INTRODUCTION

The following stages of development were applied for designing this set of outdoor furniture:

- research studying the triangle as a geometric shape, its features, meanings and semantics;
- anthropometric and ergonomic data for outdoor furniture;
- the choice of materials and their options, as well as the main features that would make them suitable for this type of furniture;
- design project for each individual piece in this set of furniture;
- constructive elaboration of each piece of furniture cross sections and constructive ties;
- perspective three-dimensional view of the whole set;

'Material' has been a central point of research and practice agendas for decades in product design (Ashby & Johnson, 2009; Manzini, 1986). Most of the seminal works have centralized around how to guide designers in selecting proper materials within the *shape* and *manufacturing process* limitations and/or requirements (Ashby, 1999; Ashby & Cebon, 2007; Mangonon, 1999). More recently, a newly founded research direction that scrutinizes materials' active role in shaping our experiences with products has gained attention among scholars (Ashby & Johnson, 2009; Karana, 2009; Karana, Pedgley, & Rognoli, 2014; Pedgley, 2009; Rognoli & Levi, 2004; van Kesteren, 2008; Zuo, 2010). Many influential studies have been conducted to inform how we sense materials (Fenko, Schifferstein,

& Hekkert, 2010; Howes, Wongsriruksa, Laughlin, Witchel, & Miodownik, 2014; Laughlin, 2010; Rognoli, 2010; Sonneveld, 2007; Westeils, Schifferstein, Wouters, & Heylighen, 2013), how we attribute meanings to materials (Karana, 2009), and how materials elicit emotions (Ludden, Schifferstein, & Hekkert, 2008). Nevertheless, how to design for experiences with and for a particular material at hand remains poorly understood to date, even if that material is wood.

2. RESULTS AND DISCUSSION

Triangle is one of the three basic forms. Each of the basic forms has its own morphological and semantic features. The triangle is the most stable form because of the three points of support. Triangles are the strongest shape. When a force is added to a triangle it is spread evenly through all three sides. Eye movement when observing the triangle is always directed dynamically to one of the bases. Semantically analyzed, the triangle carries a long history of hidden meanings, or more specifically, identifications. From a design point of view, different triangles have clearly defined visual characteristics that cannot be derived from their true shape, but only from the structural skeleton that creates it. The structural skeleton of each triangle derives from its contour. It is the simplest structure to be obtained from a given shape. The placement of the triangle can dramatically change the character of the visual form (Arnheim, R. *Art and visual perception*, 1981). The two pictures (Fig. 1) are triangular, but their shapes differ. Version a' rises from the solid base to the sharp peak, while in version b' the wide and hard top holds the balance of the sharp peak with difficulty and unsteadily. Triangle is a form in which each color has a different value. In fact, each color is accentuated by a certain form, and by another muted. The triangle most accentuates the yellow color (Fig. 2) according to Kandinsky (Kandinsky, W. *for Spiritual in Art*, 1995); when the yellow color is in triangular or another pointed form, it sounds stronger.

The proportions expressed in figures 1: 1.618 represent the golden intersection. One way to achieve this proportion is by drawing a five-pointed star in the right pentagon. In this way we also get the so-called "golden triangle" (Fig. 3). This triangle has two angles of 72 degrees and one angle of 36 degrees. If the base of the triangle is conditionally assumed to be 1 in length, then the inclined sides (proportional to the base side) are 1,618 in length. This proportion represents the so-called "golden number". Simply put, this ratio is approximately 2: 3 and this ratio and proportion have been used in shaping objects, furniture, interiors, and architecture since ancient times, and were considered aesthetically beautiful (Pythagoras, *The Order and the Doctrine of Pythagoras*, 2009).

The fractal structure of the equilateral triangle (Fig. 4) and the fractal of the proportional gradient of the golden triangle are an interesting basis for designing different variations of ornaments in the interiors. Applications of the triangular ornament were a characteristic feature of the interiors in the old eastern civilizations.

If we analyze it in the Christian context in the middle Ages, the triangle is a symbol of the Holy Trinity - the unity of the Christian religion. The equilateral triangle is a symbol of perfection. The triangle as a decorative element is present a lot in the interiors of the old and traditional Macedonian houses, ranging from stool chairs, through the stylized trim/carved decoration, to the triangular patterns of carpets, embroidery on clothes, tablecloths and other decorative items that adorned the houses.

When designing the furniture in this paper, two triangles are taken as the starting point: the equilateral and the triangle derived from the golden triangle (2:3), for the sake of dimensional needs and functionality, it is modified to a triangle with two angles of 80 degrees, and one angle is 20 degrees (Fig. 5, 6).

Consideration of function and ergonomics and utilization of advanced technology are the principle factors in furniture product design.

There is no doubt that ecologically friendly materials and implementation of mass-production will contribute to making sustainable environment; so, in addition to the adaptable function of the product, appropriate manufacture method should be adopted in today's furniture and product design. By means of Autodesk CAD and 3D Max software, the entire components design representation can be easily finished and prepared for Computer Numerical Control Cutting. Before processing the fabrication of this furniture, a small-scale model can be made by laser cutting technology for testing the visual effect and stability.

The following material is provided for making this garden furniture: teak wood or maple wood obtained by a thermo wood procedure for seats and legs. The bearing structure and joints are made of cast aluminum with anthracite and silver effect. This is important because it is visible and aesthetically complements the design of the furniture. If this material proves to be economically expensive to carry the bearing structure, machined steel can be selected (Fig.5-13). The final appearance of the garden sets should be silver cast aluminum with teak wood and / or anthracite cast aluminum combined with maple wood. In that way we obtain a contrast (Fig.13).

When designing this set of garden furniture, the idea was to maintain the repetition of the elements due to the following factors:

1. Functionality - The set would be intensively exposed to the sun and rain, so it had to go with a full/empty structure;
2. Production - To simplify the production process;
3. Layout - The aesthetics of full/blank and repetition of the motif add dynamics to the look.

In designing the furniture of this research paper, care was taken to maintain the repetition of the elements for both visual unity and simplification of the production process. The thickness of the boards is 1.5; 2; and 3cm. all lamellae are 2.5 cm wide and 1.5 cm thick, and the legs of all elements are 10 degrees sloping. The drawings in the paper show their detailed elaboration (Fig. 5-13)

Nowadays Computer Numerical Control technology aims at achieving the goal of making sustainable products. Not only for making mock-up models; in furniture industry Computer Numerical Cutting technologies are widely used to save labor and economize the time as well. When fewer people are involved in the production process, then the manufacturer can successfully pay less for employment, and thus reach the goal of reducing the product cost. Advanced technology would also help accelerate fabrication; providing the patterns get created inside Autodesk software, they can be quickly transferred to the cutting path of the machine and become extremely accurate, rather than handcrafting them. Additionally, higher number of components could be made in a short period of time and be ready for the final assembling.

The design of the furniture indicates that most of it is wooden, so we decided we could use Thermo wood as main product material¹. In the process of heat treatment of thermo wood, only steam and material heating at temperatures from 190 to 212 ° are used. Heat inside the thermal modification chamber is slowly raised up to a high temperature. The whole process can last as long as 110 hours. When the process is complete, the moisture percentage of the material is around 4–7%. Lowered equilibrium moisture content remarkably enhances the wood's dimensional stability.

Thermo wood obtained in this way is completely natural and does not have any chemical additives. The technology of processing raw materials Thermo Wood® does not violate the natural characteristics and properties of wood. The patented method is based on a gradual temperature modification of wood when its physical and chemical properties are constantly changing².

Improved natural longevity - Due to the breakdown of sugar particles (hemicelluloses), thermo wood does not contain sufficient nutrient concentrations for mold and fungus (COMO certificate). The resistance of thermo wood is measured with standards (letter “D” stands for “Durability”), belonging to the second class of resistance to rotting (EN 350-2). Timber lumber and products belonging to the first and second class of resistance to rotting can be used outdoors without any additional processing.

Non toxic and chemical-free - Thermo wood is a reliable natural material produced using only natural processing methods: in the production process only heat and steam are used without the use of any chemicals. During the process of modifying the raw material, steam plays the role of a protective gas, which protects the material from splitting and damage.

¹ The study of the properties of thermo wood and the advantages of its use began in the 1930s in the USA and Europe, but at that time the process of production of this material did not reach an industrial scale. Only decades later, the VTT Technical Research Institute of Finland became interested in this idea again. In the result there followed the development of new technology for heat treatment of wood, obtaining a patent and launching the Thermo Wood® brand in the late 1990s in Finland.

²Thermo Wood® is a registered trademark and it can only be used by companies that are members of the International Heat Treatment Association. So, the quality of these products is controlled by an external independent party.

Improved thermal insulation - Tests have shown that as a result of the modification, the thermal conductivity of thermo wood is reduced by 20-25% compared to untreated materials of various coniferous species. So, thermo wood is the most suitable material for windows and exterior doors, cladding of façades, outdoor furniture, exterior and interior decoration of saunas and baths.

Resin free - Due to the high temperature of Thermo wood treatment process, resin is removed from the wood. As a result, using this material we can be sure that even at high temperatures it will not produce resin.

Thermo wood is hypoallergenic and safe - During the production process all harmful organic compounds and unsafe emissions, which deteriorate the air quality and can cause an allergic reaction, are removed from the thermo wood. Studies have shown that in pine thermo-D there are twenty times less emissions and compounds than in untreated pine. Because of all these factors thermo wood is the best raw material, too.

Regarding the metal segments of the furniture, we found that aluminum frames would be better choice for our set of outdoor furniture. Aluminum is the most common type of outdoor furniture frame material. Aluminum is a light-weight and durable metal, perfect for outdoor furniture and it is the least expensive type of furniture frame to make because of the abundance of aluminum, according to the scientists.

There are two main types of aluminum outdoor furniture frames to consider, cast and wrought aluminum. Aluminum provides comparable durability to cast and wrought aluminum, but usually with a more attractive price point (durability 20+ years).

Cast Aluminum (lean al.) - This frame material is heavier and more design-oriented than aluminum. The only difference is that the molten aluminum is poured into a cast mold, allowing for intricate designs and shapes that would otherwise not be possible to make. Standard aluminum outdoor furniture is usually hollow, unlike cast aluminum that is slightly heavier but denser and more durable.

Wrought Aluminum - Wrought Aluminum is bent and manipulated into shape and reinforced over and over. Wrought aluminum offers similar design characteristics as its wrought iron counterpart. This could be an option if outdoor furniture is placed on more temperature changeable places and if we are looking for more iron look.

Choosing the right frame material is the most important thing to consider when designing outdoor furniture. It will determine how durable the furniture can be and how long it will last. Outdoor furniture is an investment for the city, that's why we must choose quality material. The strongest and most reliable frames for outdoor furniture are: aluminum, cast aluminum, wrought aluminum, wood/teak or thermo wood, stainless steel, wicker (woven) and wrought iron.

As a traditional material, wood is naturally beautiful, and gives a comfortable feeling to any outdoor furniture. However, wood requires refinish and maintenance every two years minimum in order to maintain the color and protective finish.

Stainless steel offers a modern style to any outdoor space. Proven as a superior outdoor material, it has found its way into outdoor furniture with amazing results. With its resistance to corrosion and oxidation, it makes an excellent choice (durability 20+ years).

Wrought Iron is one of the most durable and longest lasting types of outdoor furniture available, many times lasting for decades. Truly an investment that keeps on giving, wrought iron furniture is also the heaviest frame (durability 25+ years).

We decided that if the project price becomes too high, we will decide to go with some type of galvanized pure steel like metal galvanized steel³ - which is almost pure steel, slightly alloyed to form a protective patina layer in order to be resistant to all weather conditions. The patina layer initially has a reddish-brown color, becoming darker over time. In industrial or aggressive environment, patina

³ Metal galvanization means full immersing a metal product in molten zinc. Most often the coating thickness of the product is up to 100 microns. This thickness protects the product from possible adverse environmental effects, and does not expose to electrochemical effects. Galvanizing is selected to process metal structures because of its advantages which make this technology much better than the others. If the product is galvanized, it serves much longer than a product that was not protected from corrosion.

layer forms more quickly and the color becomes darker than in cleaner rural areas. However, a protective layer of patina cannot be formed if the surface of the steel is constantly wet or dirty. When used properly, it is expressive, durable and does not require maintenance. Over time corrosion can cause great damage to the metal structure, making it more fragile. It is the galvanizing process that makes the metal product more qualitative. Almost all metal structures can be galvanized. Due to all these advantages, hot-dip galvanizing services are often used in urban construction. Only at first glance galvanizing is a simple procedure. In fact, the technology includes 5 stages; each of them is of great importance and influences the final result⁴. UV resistance shows how well the coating retains its original color and gloss level in accordance with EN10169. The higher the grade, the better the resistance. The corrosion activity categories describe outdoor climatic conditions in accordance with EN12944. The higher the category, the more aggressive the environment is.

3. CONCLUSIONS

Although furniture and products that we use every day are always smaller than buildings and are placed inside or outside the building, furniture/ product design and architecture still have some common characteristics. From functional point of view, both designs aim to create a device that could provide practicability and convenience to humans' daily lives. From design and esthetic aspect, the challenge to maintain the stable structure and function with small material waste exists in both design areas. Thus, furniture and product design can be treated as a type of "mini architecture". As Outdoor furniture or Green Architecture design, furniture and product design can also achieve sustainability with structure innovation, space flexibility and material saving. This paper has been concerned with how to proceed when a certain geometrical form, such as triangle, is a starting point of departure in the design process, and functionality of the product is the expected outcome.

This paper has been concerned with how to proceed when a 'material' is the explicit point of departure in the design process and 'experience' is the expected outcome. Material driven design, which represents our first attempt to facilitate such projects, considering both technical properties of materials and their experiential qualities in relation to how they are received by users. The method suggests that when a material is the point of departure in the design process, the designer takes a journey from material properties and experiential qualities to materials experience vision, from materials experience vision to experiential qualities and to material properties, and finally to products. Activities to support this journey are organized under four main steps as: understanding the material, technical and experiential characterization, creating materials experience vision, manifesting materials experience patterns, designing material/product concepts.

⁴ 1. Degreasing. Metal constructions should be thoroughly cleaned from greasy stains or oils in order to create a reliable protection against corrosion.

2. Etching. At this stage the metal is cleaned of the already accumulated corrosion. It is important for parts that have already been in operation.

3. Washing. Removes various particles left after etching.

4. Drying. Specialists heat the product with the help of special equipment up to 100 degrees. Due to the high temperature, the flux salts are drying.

5. And, finally, the process of galvanizing. As we noted above, the product is completely immersed in molten zinc, due to which it acquires a zinc sheath. It should be noted that all processes occur exclusively in technological conditions, where objects are placed into special tanks.

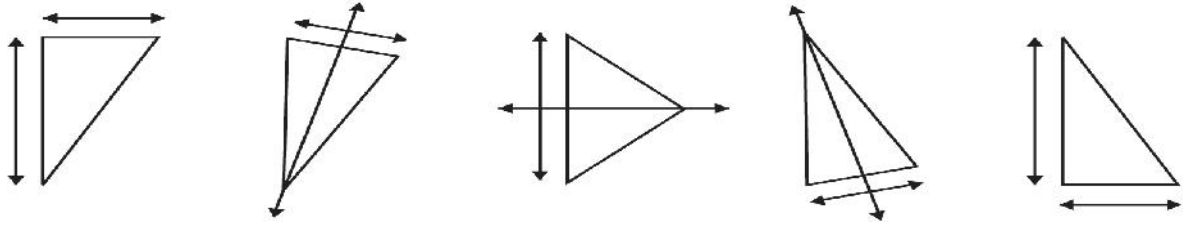


Figure 1

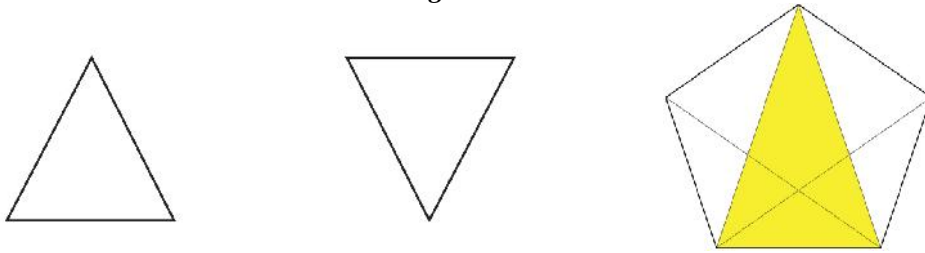


Figure 2.

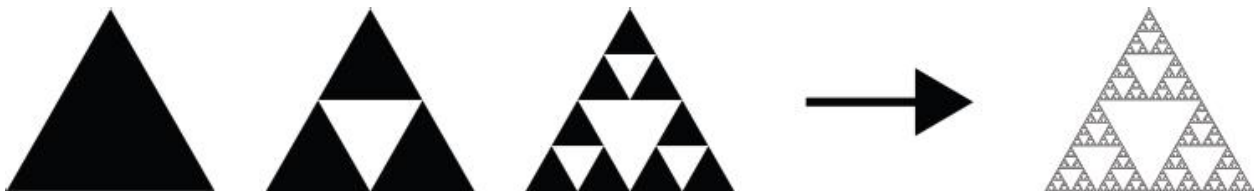


Figure 3.

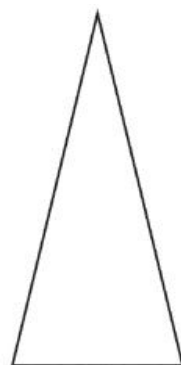
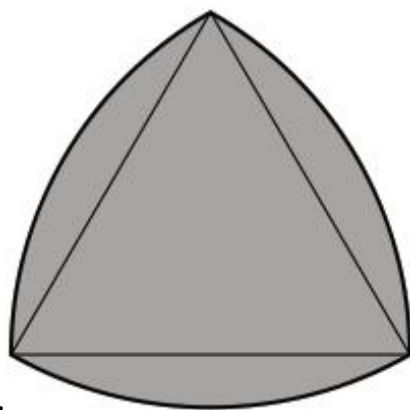


Figure 4.

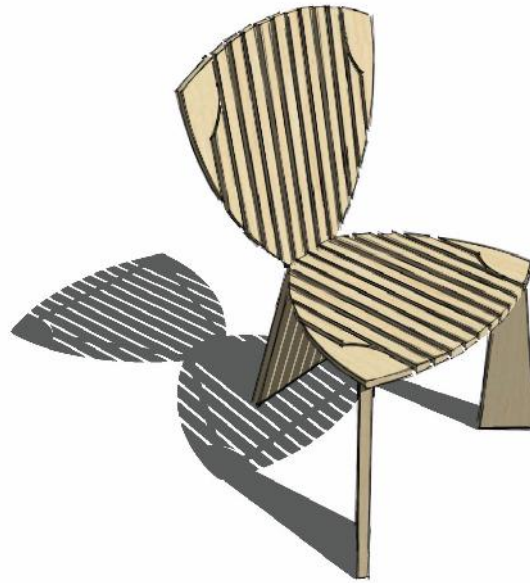


Figure 5.

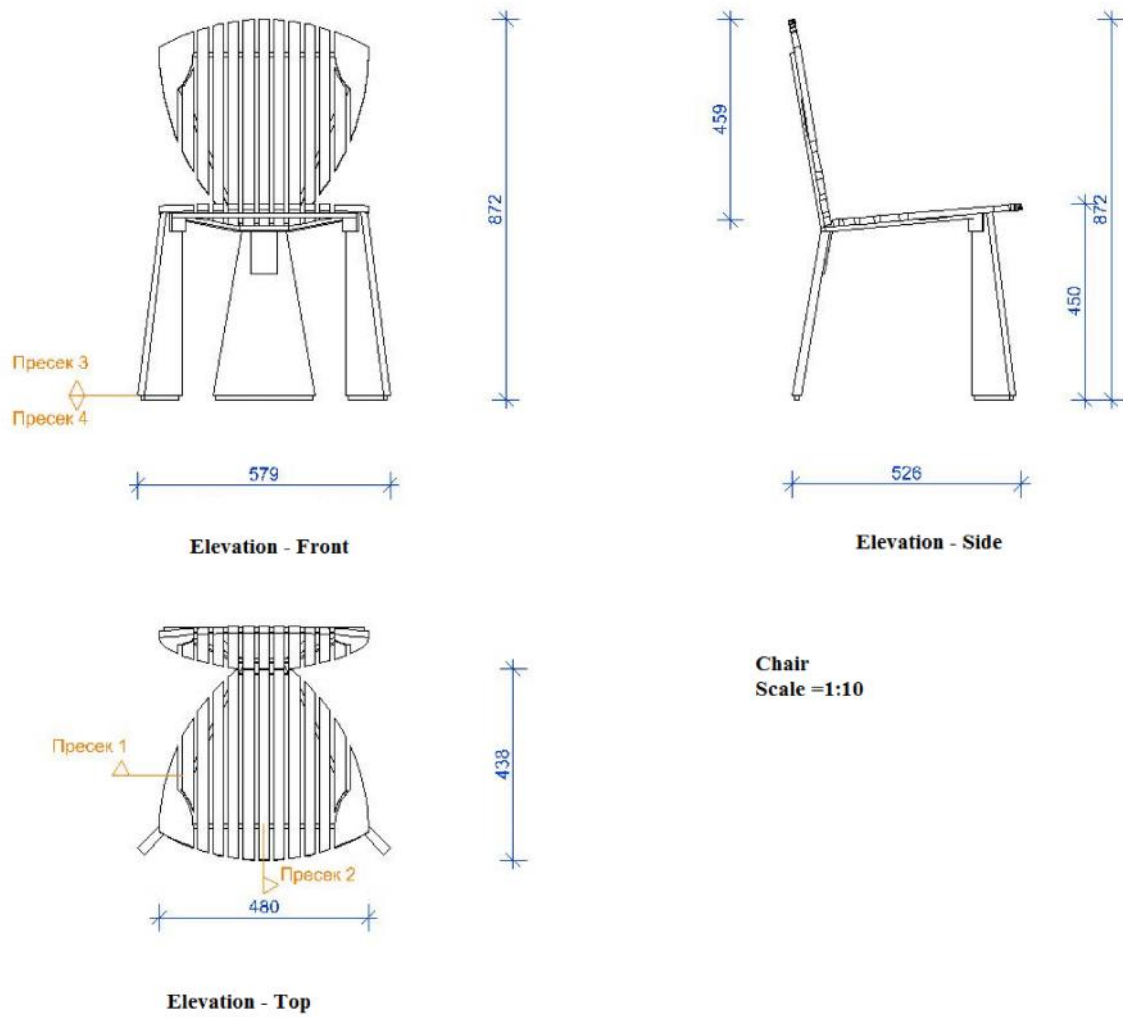




Figure 5a.

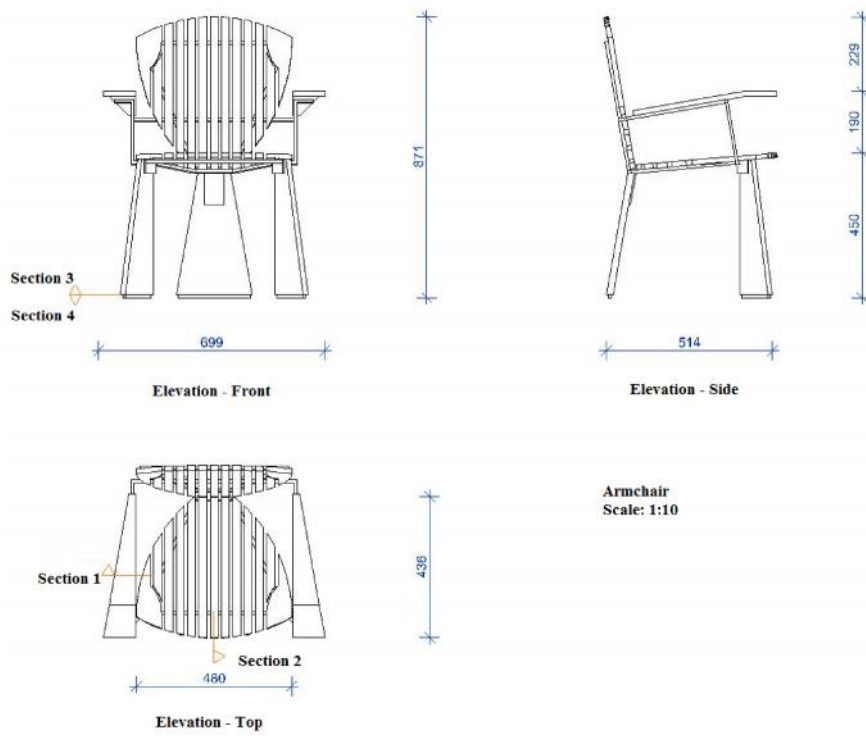




Figure 6.

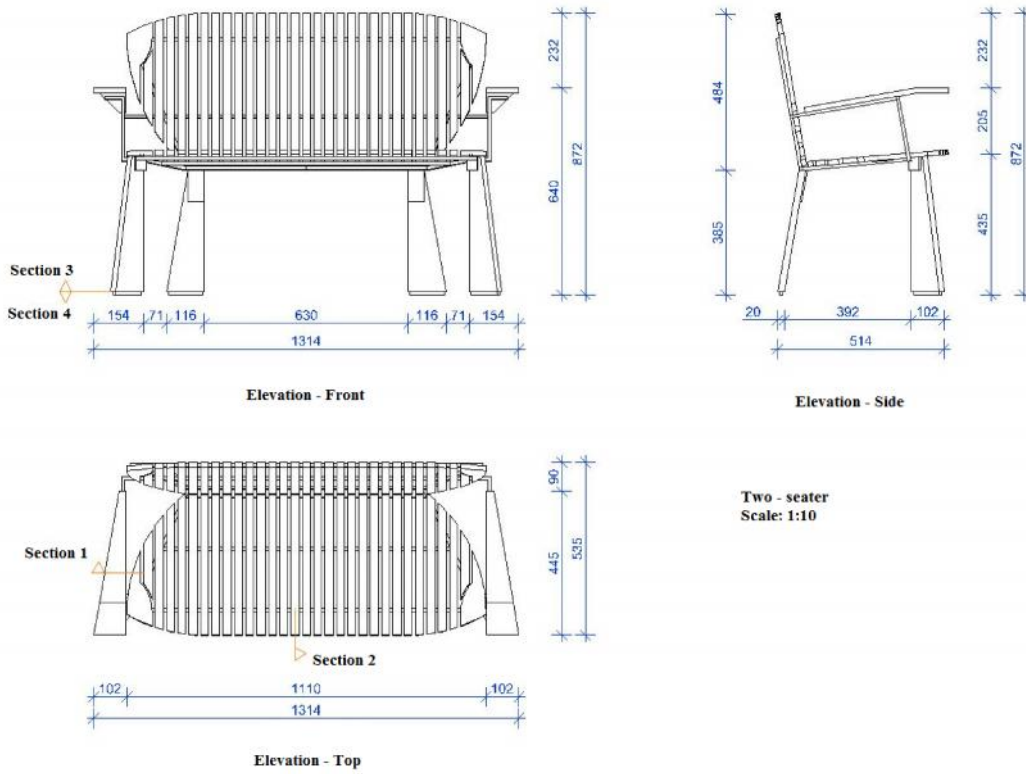




Figure 7.

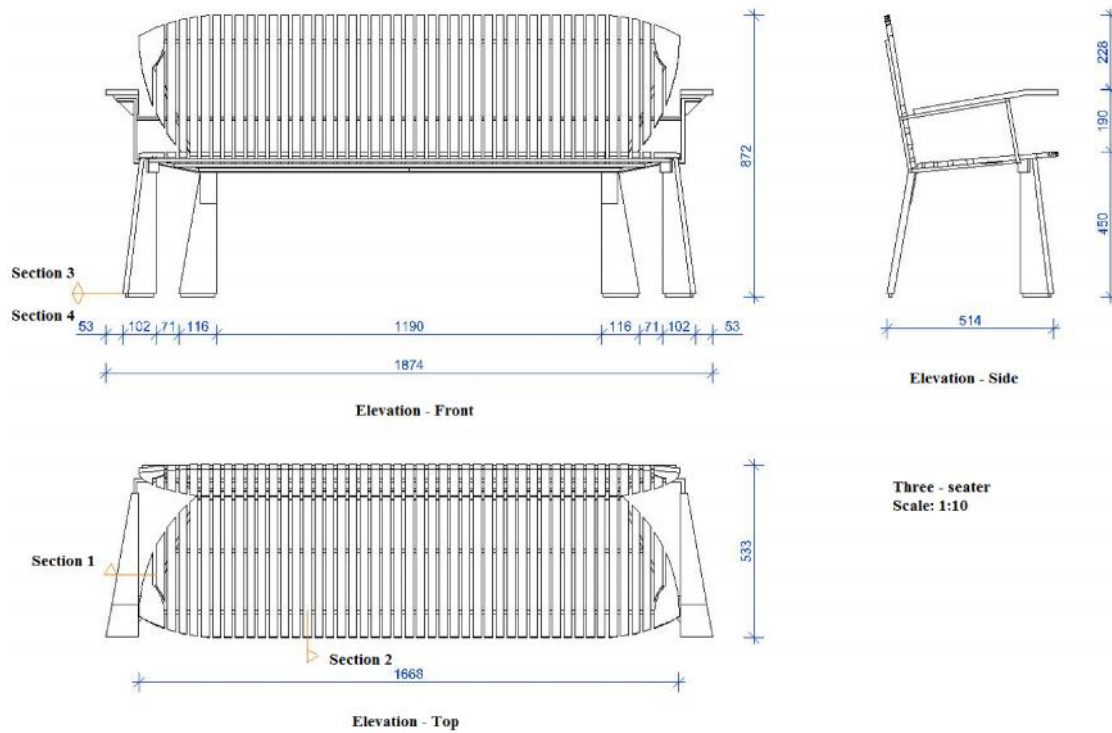
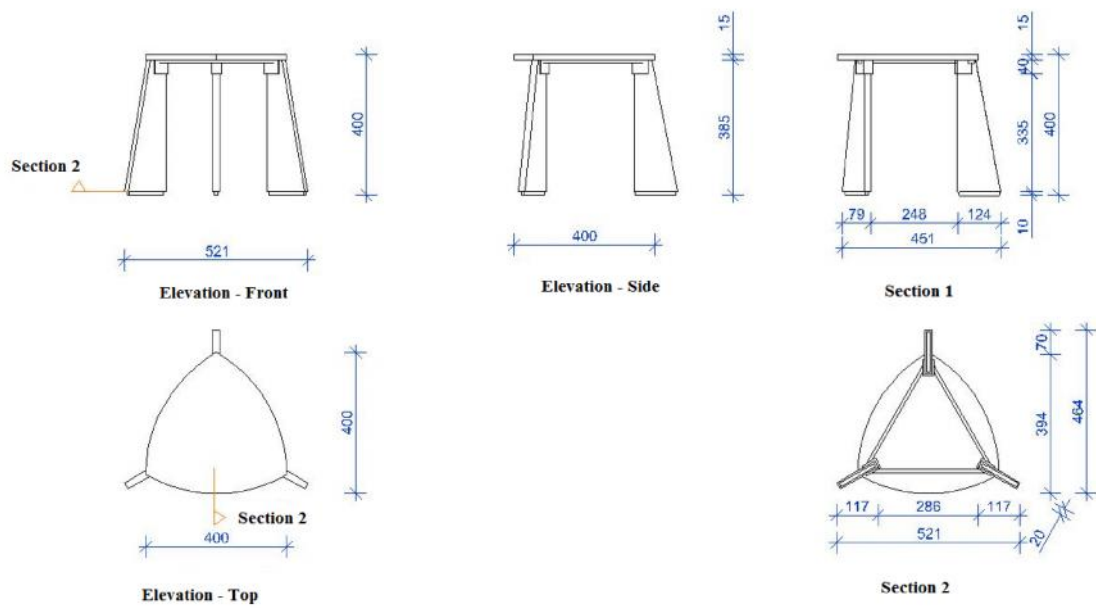




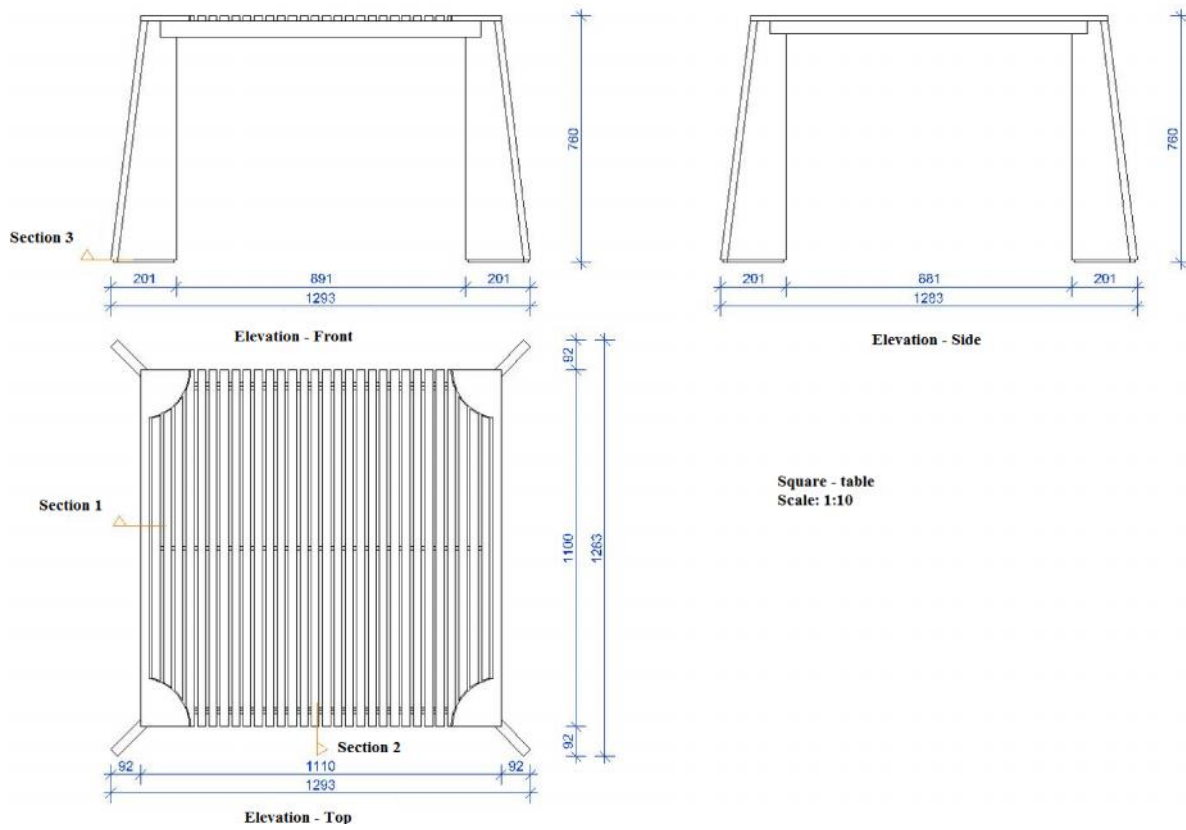
Figure 8.



Chair
Scale: 1:10



Figure 9.



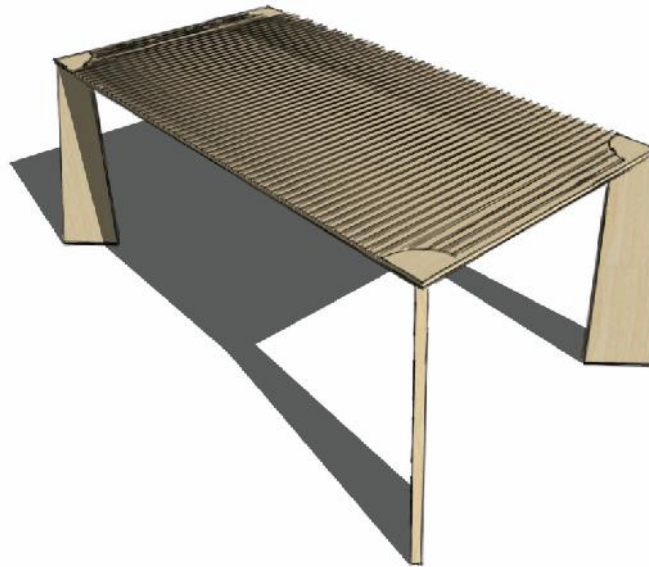


Figure 10.

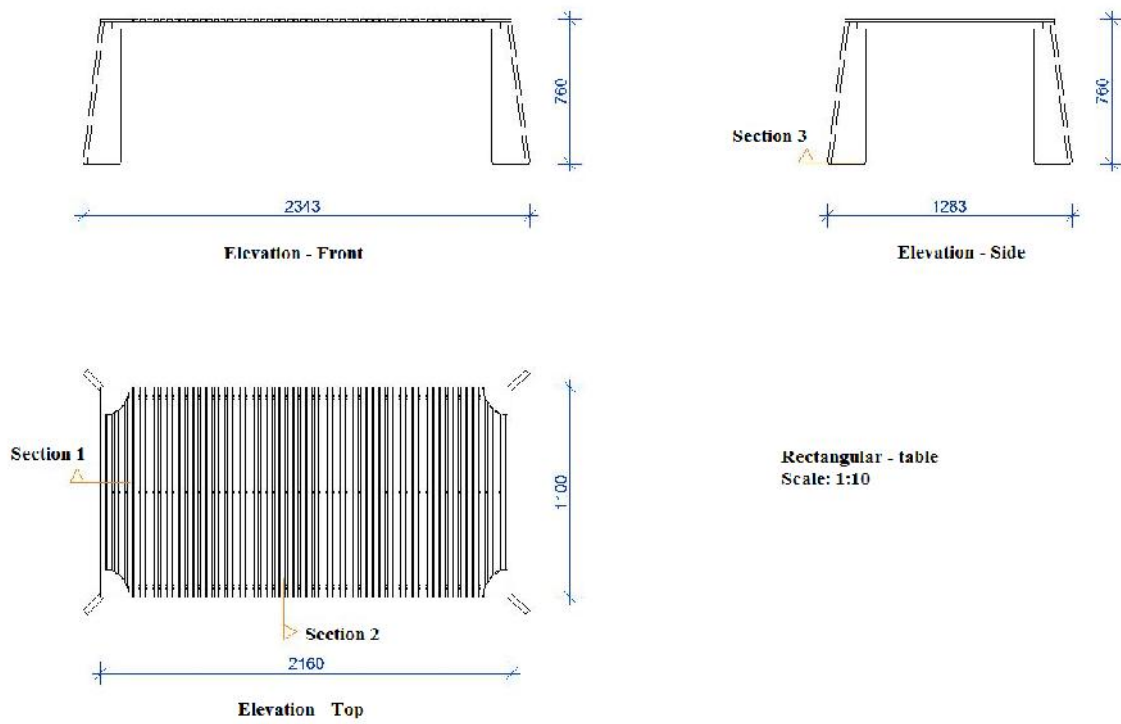
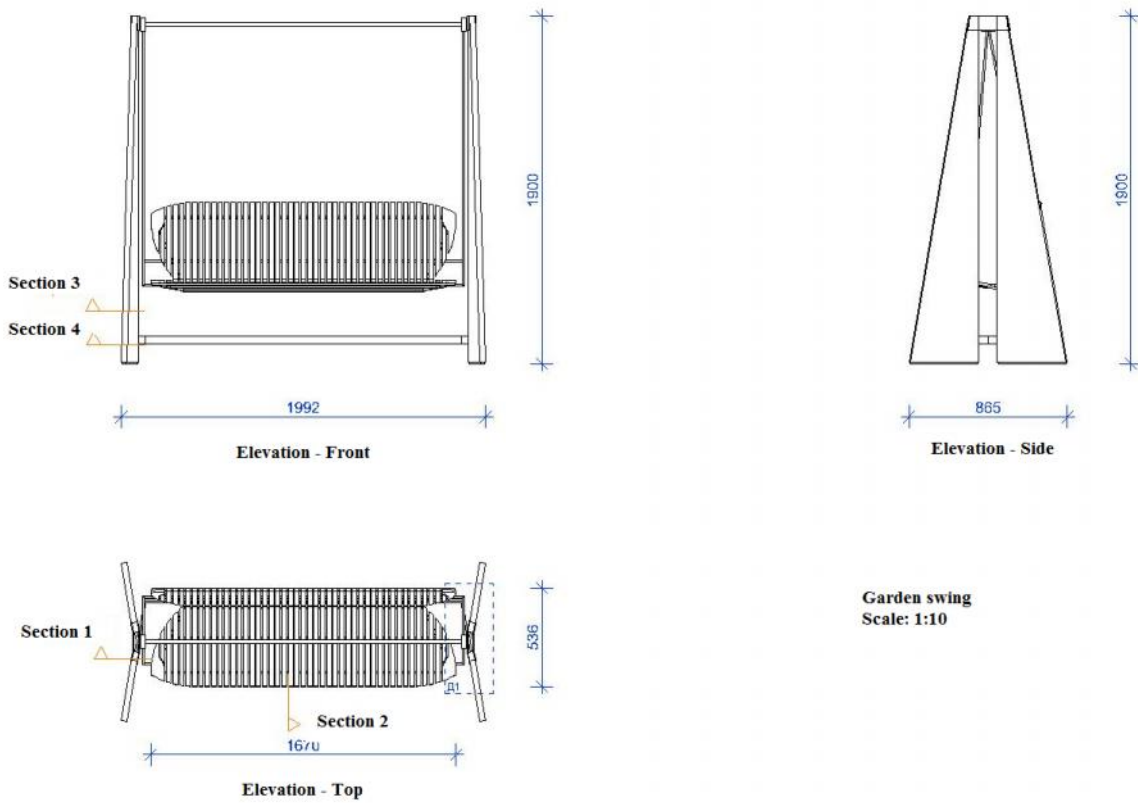




Figure 11.



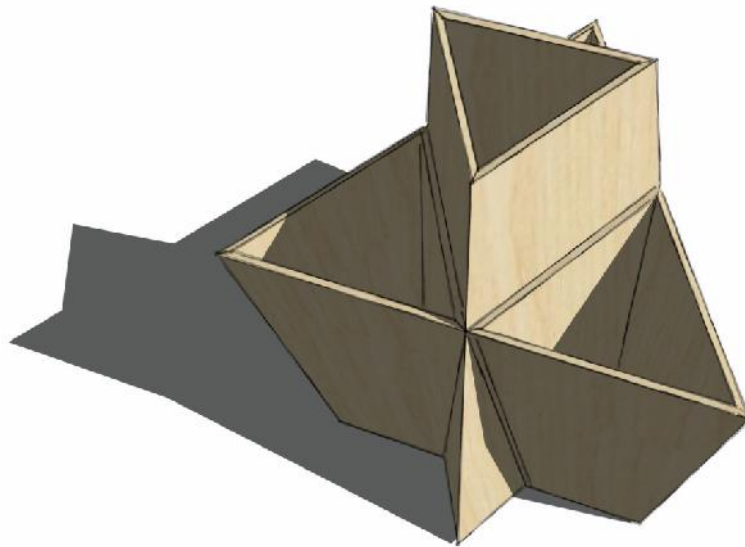


Figure 12.

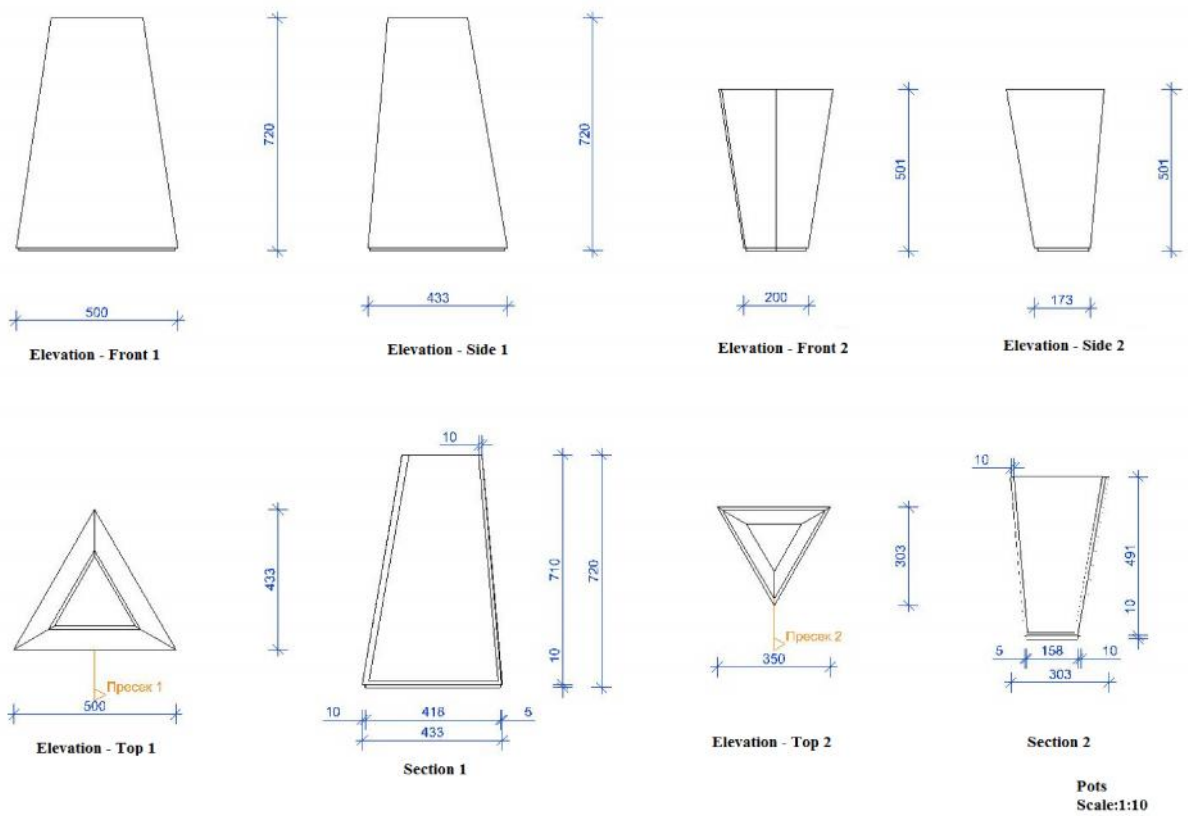




Figure 13.

REFERENCES

- [1] Ashby, M., & Cebon, D. (2007). *Teaching engineering materials: The CES EduPack*. Retrieved June 1, 2015, from http://web.mit.edu/course/3/3.225/refs/Teaching_Engineering_Materials.pdf
- [2] Ashby, M., & Johnson, K. (2009). *Materials and design. The art and science of material selection in product design* (2nd ed.). Oxford, UK: Butterworth-Heinemann Elsevier.
- [3] Dupont. (2007). *Corian®: 40 years – 40 designers*. Retrieved June 24, 2015.
- [4] Karana, E., (2009). *Meanings of materials* (Doctoral dissertation). Delft University of Technology, Delft, the Netherlands.
- [5] Karana, E., Hekkert, P., & Kandachar, P. (2008). Materials experience: Descriptive categories in material appraisals. In *Proceedings of the Conference on Tools and Methods in Competitive Engineering* (pp. 399-412). Delft, the Netherlands: Delft University of Technology.

- [6] Laughlin, Z. (2010). *Beyond the swatch: How can the science of materials be represented by the materials themselves in a materials library?* (Doctoral Dissertation). King's College London, University of London, London, UK.
- [7] Lindberg, S., Hartzén, A. S., Wodke, T., & Lindström, M. (2013). *Hierarchic design and material identity*. Retrieved June 1, 2015.
- [8] Lindström, M., Gamstedt, K., Barthold, F., Varna, J., & Wickholm, K. (2008). *Hierarchical design as a tool in development of wood-based composite applications*. Retrieved June 24, 2015.
- [9] Löwgren, J., & Stolterman, E. (2004). *Thoughtful interaction design: A design perspective on information technology*. Cambridge, MA: MIT Press.
- [10] Ludden, G. D. S., Schifferstein, H. N. J., & Hekkert, P. (2008) Surprise as a design strategy. *Design Issues*, 24(2), 28-38.
- [11] Manzini, E. (1986). *The material of invention*. Milan, Italy: Arcadia Edizioni.
- [12] Manzini, E. (1989). *Artefatti. Verso una nuova ecologia dell'ambiente artificiale* [Artifacts. Towards a new ecology of the artificial environment]. Milan, Italy: Domus Academy.
- [13] Nikoljski, P.E. 2011: "*Integralnost kaj nedvizniot i dvizniot mebel vo makedonskata kukja od XIX vek i moznosti za kontinuitet*", UKIM - Skopje, Faculty of Forestry, Doctoral Dissertation.
- [14] Nikoljski, P.E. 2014: Semantics and significance of decoration on Macedonian traditional movable furniture from 19th century, *Wood, design and technology*, Scientific, professional and Informational Journal of Wood Science, Design and Tehnology, Vol. 3, No.1, Skopje, 2014.
- [15] Nikoljski, P.E. 2016: Semantic of symbolic decoration on Macedonian traditional movable furniture from 19th century, *Drvna Industrija*, Vol. 67 (2): 187-192.
- [16] Rognoli, V. (2010). A broad survey on expressive-sensorial characterization of materials for design education. *METU Journal of The Faculty of Architecture*, 27(2), 287-300.
- [17] Rognoli, V., & Karana, E., (2014). Towards a new materials aesthetic based on imperfection and graceful ageing. In E. Karana, O. Pedgley, & V. Rognoli (Eds.), *Materials experience: Fundamentals of materials and design* (pp. 145-154). Oxford, UK: Butterworth-Heinemann.
- [18] Rognoli, V., & Levi, M. (2004). How, what and where is it possible to learn design materials? In *Proceedings of the 7th International Conference on Engineering and Product Design Education* (pp. 647-654). Bristol, UK: The Design Society.
- [19] Rognoli, V., Salvia, G., & Levi, M. (2011). The aesthetic of interaction with materials for design: The bioplastics' identity. In *Proceeding of the Conference on Designing Pleasurable Products and Interfaces* (No. 33). New York, NY: ACM.