Available online at www.sciencedirect.com

ScienceDirect

Ciência & Tecnologia dos Materiais 29 (2017) e270–e274

http://ees.elsevier.com/ctmat

Special Issue "Materiais 2015"

Urbcork – Urban furniture with application of high density cork

Mariana Alves[a, *], Lígia Lopes[a], Jorge Lino Alves[b], Francisco Xavier de Carvalho[a]

[a]*Design Studio – Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal*
[b]*INEGI – Institute of Science and Innovation in Mechanical and Industrial Engineering, Rua Dr. Roberto Frias, 400, 4200-465 Porto, Portugal*

Abstract

Urbcork is an urban furniture line developed at the Faculty of Engineering of the University of Porto (FEUP) for the collection produced by Leets Urban Design. It can be highlighted for its sustainable properties and inclusive design concerns.
Urban furniture is a product to be used by a large number of people in a public space. It has a high level of wear and ageing due to the intensive use, solar exposure and weather conditions.
During the project development there was a conceptual idea about using cork as the main material for the seat and the back. The opportunity of developing a prototype brought the question about how to keep cork properties after a long exposure on exterior.
The main line of investigation was about how to protect cork keeping its natural appearance and extending its properties and conservation over time. Laboratory tests held at CTCOR and FEUP were conducted in order to understand the behaviour of cork on extreme conditions. The results are not yet successful, but with more tests, the product can be well accepted in the international market.

Keywords: Urban furniture; cork composition; sustainability; product design.

1. Introduction

Urbcork is an urban furniture project, developed at the Faculty of Engineering of the University of Porto (FEUP) during the Specialization Course in Design and Product Development. The project started based on the principles of inclusive design, reflecting how do people use and interact with urban furniture. The training, based on a core unifying course, Laboratory Project, was a place of discussion between teachers and students, converging ideas and approaches. The project had the cooperation of a partner company, Norchapa Steel Industries (Fig. 1). During the academic exercise, students visited the company in order to understand the manufacturing processes and installed capacities. The company made the students acquainted with its market and more relevant needs. During the project (held at FEUP), companies' technicians monitored twice the results under development. At the end of each semester, a public presentation of the work was made.
At the end of the workshop, the company selected three projects to be prototyped. Prototypes were developed under the supervision of students and teachers. It was the beginning of a complex process to test the concept, the construction system, the materials and the market position of each line.

Fig. 1. Norchapa facilities.

Corresponding author.
E-mail address: marianacoalves@gmail.com (M. Alves)

http://dx.doi.org/10.1016/j.ctmat.2016.06.005

2. Urbcork - Project

Urbcork is composed by a bench with or without armrests, a bicycle rack together with a bench and a litterbin (Fig. 2). The project was developed considering three main principles: structure, materiality and modular system.
The structure is the common element of the urban furniture line. The seat and the back of the bench are made of high density composition cork. The smooth and warm texture of cork brings comfort to the seats. The benches are suitable for outdoor and indoor urban environments. All the furniture pieces are easily disassembled, allowing flat packaging and local assembly. The modular association of the bench and of the bicycle rack allows different compositions on the urban space.

Fig. 2. Bicycle rack and bench - Urbcork.

The project was developed with inclusive design concerns. The comfort of the seat, the correct arm and back rest, and the movement of standing and seating were important principles during the design process.
During the prototype construction, regular visits to the company allowed to follow the production and to make adjustments (Fig. 3). At the same time, a parallel research was conducted about the cork composition and the coating layer [1].

3. Material selection

The development of the prototype was an important step to test the design, materials and the interaction between the users and the urban furniture. Considering that the project was going to be developed with a metalworking industry, it was a natural decision to use steel for the structure and welding and bending processes. The prototypes were made in iron, coated with primary and painted with an enamel forge finishing. The selection of cork for the seats and the back was related with the good thermal properties, the comfortable touch and the ecological cycle of the material [2].

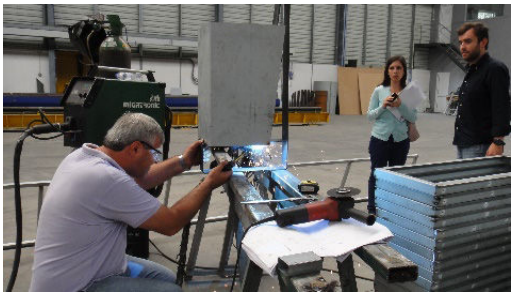

Fig. 3. Norchapa facilities.

A wide range of cork materials is nowadays available on the market, varying mainly the cork composition and additives to produce composite cork [3]. Density is an important specification of cork composition [4]. Low density (0.30 g/cm^3) and high density (0.58 g/cm^3) composition cork boards were selected for laboratory tests.
The use of cork on outside environment is still an experimental field. There are some temporary constructions and products that have been built, but not many successful examples of cork exposure during long periods of time are published.
The atmospheric agents (sun, rain, wind) and the biological ones (bugs, fungus) are responsible for the accelerated degradation of materials. The sun, under the action of the ultraviolet rays, modifies the surface protection of materials through chemical changes. The rain accelerates the appearance of fissures or cracks and the progressive degradation of materials causing the change of colour and the increase of the surface absorption [5]. With these concerns, a research started about the behaviour of cork during long periods of sun exposure. The main goals were to guarantee the protection of the superficial layer and the integrity of the material.

4. Results and Discussion

4.1. First test

On the first test it was used a low density cork composition with 0.30 g/cm^3 and a colourless protection produced by Subtiltextura and Diera was applied on the surface. After some days of exposure to

rain some changes on the surface were visible. The protection was not totally accurate and the medium particle size allowed the water absorption.

4.2. Laboratory tests at CTCOR

The next step was to make a more precise test to understand the behaviour of the material in extreme conditions. On this test, besides low density composition, high density cork – 0.58g/cm^3, was also used. Laboratory tests were conducted at CTCOR (Cork Technological Centre). Accelerated ageing test and anti-fungal evaluation were made on the three boards of cork: high density reference sample, high density coated sample and low density coated sample.
A specimen taken from the laminate under test was exposed to UV-light and humidity. The test procedure simulates the degradation of the polymer matrix on the sheet surface by exposure to high levels of UV radiation.
The specimens were cycled through periods of exposure to UV radiation followed by periods of no radiation, during which temperature changes occur. The cycle consists of 4 h of dry UV exposure at a black-standard temperature of 60 ± 3°C, followed by 4 h of condensation exposure, without radiation, at a black-standard temperature of 50 ± 3°C.
The product used to coat the samples was CORKGARD WB MURB – LF (colourless), an experimental product developed by Subtiltextura and Diera. It is an aqueous dispersion based in a fluorochemical polymer SCOTCHGARD^{TM}, produced by 3M, combined with polyurethane and acrylic polymers with UV absorbers and a fungicidal agent.
This product was developed to promote water and oil repellence and a high level of resistance to abrasion, UV and ageing.
It is applied by spraying with a compressed air gun or with a roller. The application should be consistent in order to ensure a suitable coating of the surface.
On the high density reference sample (without any coating) it was verified an incidence of slight/moderate blistering of the granule, a significant discolouration and absence of significant bending and/or deflection (Figs. 4 a) and 4 d)). There was a reasonable resistance to the action of UV radiation.
On the high density sample coated with CORKGARD WB MURB – LF (colourless) there was a slight blistering of the granule, a slight discolouration and absence of significant bending and/or deflection (Figs.s 4 b) and 4 e)). On the low density sample coated with CORKGARD WB MURB – LF (colourless) there was a moderate blistering of the granule, a slight/moderate discolouration and absence of significant bending and/or deflection (Figs. 4 c) and 4 f)).

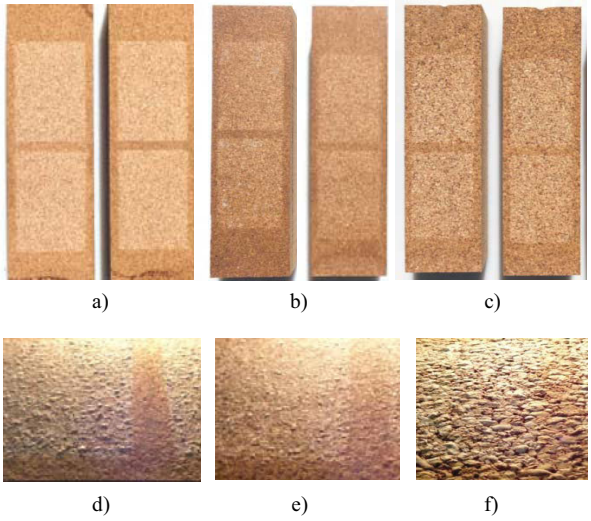

Fig. 4. Cork samples: a) High density reference uncoated, b) High density coated, c) Low density coated, d) High density reference uncoated, e) High density coated and f) Low density coated.

In general the results were satisfactory. The coated high density composition cork had the best performance.
After the laboratory tests at CTCOR, the high density composition cork board was exposed on exterior with the same coating tested on laboratory. In spite of keeping its physical and mechanical properties, after the first month of exposure, there was a significant loss of the natural colour. The applied coating was not totally efficient.

4.3. Determination of the quantity of water absorbed

The tests concerning the determination of water absorption were made at FEUP. High (sample A) and low (sample B) density composition cork samples were prepared for the test. A coated and an uncoated sample were produced for each density cork. They were placed on a vacuum oven during 24 h and weighted (m_1). Both samples were then submerged in a container with distilled water during 24 h and weighted (m_2). There was a second submersion in distilled water during 24 h to weight again the samples (m_3). The last procedure was air drying them during 120 h (m_4).
The results (Table 1) obtained show different samples behaviour. The best results were achieved with the high density composition cork coated sample (sample A coated). The following graphic (Fig. 5) illustrates that the coating applied on sample A had a critical

role in the mass variation. The high density coated sample had a lower increase of mass during the test. On sample B the coating was not significant, concerning the mass variation.

Table 1. Determination of the quantity of water absorbed as a function of cork composition

	Sample A coated	Sample A uncoated	Sample B coated	Sample B uncoated
m_1 (g)	102.7277	109.0393	57.0605	56.6999
m_2 (g)	109.3042 (6.40%)	118.1699 (8.37%)	64.4155 (12.89%)	64.7204 (14.15%)
m_3 (g)	112.4227 (9.44%)	122.1604 (12.03%)	69.5378 (21.87%)	69.7569 (23.03%)
m_4 (g)	107.5675 (4.71%)	112.1276 (2.83%)	65.8323 (15.37%)	63.5380 (12.06%)

m_1: mass after samples drying in vacuum furnace
m_2: mass after samples immersion in distilled water during 24 h
m_3: mass after samples second immersion during 24 h
m_4: mass after air drying during 120 h

Sample A: high density composition cork (0.58 g/cm^3)
Sample B: low density composition cork (0.30 g/cm^3)

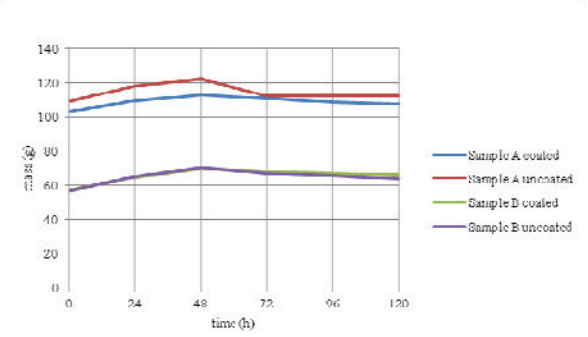

Fig. 5. Determination of the quantity of water absorbed as a function of cork composition.

4.4. Work in progress

The main challenge for the next steps is to develop an efficient protection that can extend as much as possible the cork natural colour and keep the main properties of the material. At the moment there is a work in progress with Subtitextura and Diera companies concerning the adjustment of the coating layer. Several samples have been kept on the exterior during long periods of time to evaluate the UV action through the surface of the cork boards (Fig. 6).

5. Public Presentation of Urbcork

The prototypes developed in this work have been shown in several trade fairs. Leets Urban Design is the brand responsible for the marketing and trading of the products.

a) b)

Fig. 6. a) High density composition cork sample after 3 months of exposure, b) High density composition cork sample after 9 months of exposure.

In July of 2014 at FEUP and in the scope of the conference and exhibition *"Inclusive design and urban intervention",* Urbcork prototypes were exhibited to the public (Figs. 7 and 8). The exhibition and presentation of the prototypes allowed an overview of the design, usability and materials. Urbcork caught the attention of some specialists for the innovative use of cork.

Fig. 7. Exhibition at Faculty of Engineering of the University of Porto (FEUP).

Fig. 8. Exhibition at Faculty of Engineering of the University of Porto (FEUP).

"Cork has a remarkable combination of mechanical, chemical and morphological characteristics. This natural organic material continues to be widely used. It has evolved from simple, direct usage of the raw material, through products involving some industrial

transformation to the point where it now represents a potential source material for high technology industries (...)" [5].

6. Conclusions

Although a satisfactory result was not yet achieved in terms of extending the durability of the high density composition cork boards, when exposed to the exterior environment, Urbcork has already potentialities in the urban furniture market, mainly to covered outdoor spaces or controlled public spaces.
The first tests and the first prototype were not completely successful raising concerns relative to long term exposure to the natural environment. At this moment is still impossible to guarantee the validation of the product; however, with more tests and with more efficient surface barriers, we believe that this product could be accepted in the international market.

Acknowledgements

The author wish to acknowledge DesignStudioFEUP, Norchapa Steel Industries, Diera, Sedacor and Corkart.

References

[1] B. Soares, L. Reis, L. Sousa, Proceedings of ICM11 - 11th International Conference on the Mechanical Behavior of Materials, Como, Italy, June 5-9, 2011.
[2] A.C. Pereira, H. Brezet, H. Pereira, J. Vogtlander, Journal of Shanghai Jiaotong University (Science) 17(3) (2012) 360.
[3] A. Mestre, J. Vogtlander, J. Cleaner Prod. 57 (2013) 101.
[4] A. Mestre, L. Gil, Cienc. Tecnol. Mater. 23(3-4) (2011) 52.
[5] S.P. Silva, M.A. Sabino, E.M. Fernandes, V.M. Correlo, L.F. Boesel, R.L. Reis, Int. Mater. Ver. 50(6) (2005) 345.