

SHORT NOTE**VIRGIN CORK, A POSSIBLE ENVIRONMENTALLY FRIENDLY BY-PRODUCT OF THE CORK WITH ACOUSTIC PROPERTIES FOR ITS USE INSIDE DWELLINGS?**

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ABSTRACT

This paper is a first study to evaluate the acoustical performance of virgin cork environmentally friendly by-product of the cork that can be used inside dwellings. To obtain the acoustical performance of the virgin cork, previously, it was properly treated and flattened into slabs, and later compared to commercial rock wool. The results obtained showed that this material, specially treated and added in some building system, could show good acoustic properties with a certain broadband absorption spectrum.

KEYWORDS: Cork, reverberation room, sound absorption, building.

INTRODUCTION

Cork is a natural and sustainable raw material that has been used in many applications since ancient times. It is obtained from the cork oak tree (*Quercus suber* L.), growing extensively in countries within a Mediterranean climate, that facilitates its growth. The cork industry sector is mainly divided in five subsectors; (a) Auxiliary cork industries where the main activity is to

transform the raw cork slabs from the forest that have not been previously treated into prepared cork slabs that later are transformed into end products; (b) Natural cork producers that generate products directly from the prepared cork slabs, without previously preparation of the cork; (c) Granulate cork producers transforming the forestry cork by-products and wastes from the natural cork industry into small particles of cork between 0.25 mm to 8 mm, an intermediate product that with adhesives and binders, form agglomerated products; (d) Technical stopper producers that use white cork granulate and natural cork discs to generate cork stoppers and (e) Speciality cork producers for different agglomerated products and uses (Pereira 2007).

In this latter case, most of the uses of cork are associated with material researches in different applications being the most numerous a great number of composite materials for building applications (Maderuelo-Sanz et al. 2014). Some of these applications, mainly due to that cork shows, among others, good mechanical, acoustic and thermal properties, are related to building elements, made of cork granulates mixed with different types of binders (epoxy, polypropylene, polyethylene, polyurethane, polyfurfuryl alcohol, etc.) and their use as core material for sandwich components of lightweight structures, medium and high density fibreboard, acoustical underlays, core elements in noise barriers, etc. However, the assessment of the environmental impact, as construction materials of some cork-composites, show high values of CO₂ balance (Yilmaz et al. 2019) due to the presence of the binders, while virgin cork shows more advantageous environmental performance than those (Rives et al. 2012). So the advantage of replacing composite materials that use fossil fuels in their composition or are hardly recyclable, with virgin cork, could be an environmentally friendly way of reducing the carbon footprint of products by fixing and reducing CO₂.

One of the by-product of the cork with less treatment after its obtaining is the virgin cork, named "bornizo" in Spain. This is the first cork obtained from the tree that presents deep fractures and a deformed structure, being a cork resource having low economic value (Knapic et al. 2016). This work is a first study to evaluate the acoustical properties of virgin cork as new possible element inside dwellings, comparing these results with those obtained with materials commonly used. Other properties to be studied in futures researches, that will be compared with those of materials commonly used, will be bending strength, impact resistance, hardness, dimensional stability and thermal properties.

MATERIALS AND METHODS

The material used in this work was virgin cork provided by IPROCOR-CICYTEX. The Virgin cork slabs, once extracted from the cork oak tree, were cooked in water vapour for one hour at 105°C. The slabs were then dried and subjected to a period of 4 weeks resting in a temperature and humidity controlled warehouses. Finally, the slabs were flattened with a press and cut with the appropriate dimensions 0.3 x 0.2 m (width x length). The samples were constructed by combining 170 pieces of virgin cork panels with each panel having a surface area of 0.06 m², resulting in a total sample area of 10.2 m². The averaged thickness of the sample, due to its irregularity surface, was 6 cm (Fig. 1). In this work, five samples were tested and the averaged and the standard deviation of the sound absorption coefficient at random incidence were obtained. In order to compare with some commercial sound absorbers actually used in building, rock wool with a thickness of 5 cm was tested and compared. The samples were situated directly on the reverberation room floor and edged by a wooden frame to minimize the edge effect caused by the exposed boundaries of the test sample.



Fig. 1: Image of one of the pieces of the virgin cork with dimensions 0.3 x 0.2 m and where it is possible to observe its heterogeneity.

Usually, the standard method to evaluate the sound absorption properties of a sound absorber, in laboratory, is based on the international standard ISO 10534-2 (1998) that uses an impedance tube. With this method it is possible to obtain fast measurements using small samples (29 mm and 100 mm in diameter), however, when the sample is not homogeneous, like happen with virgin cork (Fig. 1), the values of the sound absorption coefficient show uncertainties due to the constitution and pore structure of the samples, that may vary considerably from different regions of a large sample. Therefore, in this work, the method to evaluate the acoustical performance of large samples was based on the international standard ISO 354 (2003). With this method it is possible to obtain the random incidence absorption coefficient, through the measurement of the reverberation time in the reverberation room, with and without the test samples. The room used, according to the international standard ISO 354, is located at the Politechnical School of Cáceres, Spain. It is an oblique-angled room with pairs of nonparallel walls. The geometrical data of the room are: volume 201.81 m³; floor area 42.96 m²; ceiling 43.06 m²; total surface area 206.69 m². The instrumentation used for measurements, all based on products by Brüel & Kjær (B&K), were a sound level meter type 2260 with a microphone type 4189, an OmniPower Sound Source Type 4292-L and a power amplifier type 2734. Firstly, the equivalent sound absorption area was calculated through reverberation time periods and Sabine's equation and later the absorption coefficient. Reverberation times were obtained, with controlled temperature and humidity, in the frequency range from 100 Hz to 5000 Hz, in bands of thirds of octaves, using the Interrupted noise method. According to ISO 354 standard, for each sample, the number of decay curves was 12 and the reverberation time was evaluated within a decay range of -5 dB to -25 dB. During the measurements, ambient air temperature (15.4°C - 17.2°C) and relative humidity (53% - 59%) were monitored and recorded, in real time, in order to calculate propagation sound speed and air absorption.

RESULTS AND DISCUSSION

Fig. 2 shows the averaged sound absorption coefficient, at random incidence, of the virgin cork and rock wool samples tested in this work. The sound absorption coefficient spectra of rock wool is typical of fibrous absorbers; it increases quickly until the maximum at 800 Hz ($\alpha = 0.72$), after which it decreases slightly until 2000 Hz ($\alpha = 0.54$), and then increases again slightly to reach 0.69 at 5000 Hz. However, for virgin cork the absorption coefficient spectra is almost constant between 100 Hz and 325 Hz (0.10), increasing quickly until 800 Hz ($\alpha = 0.60$) and becoming almost constant between 800 and 5000 Hz (0.65), with a slightly peak at 2000 Hz ($\alpha = 0.68$). In the case of virgin cork, for similar thickness than rock wool, the values of the random sound absorption coefficient are obtained at medium to higher frequencies, above

1000 Hz, being this value higher than for the rock wool, while for low frequencies, the sample of rock wool shows higher values than virgin cork. If we compare the frequency range for each porous material, achieved at sound absorption value of 0.60, virgin cork sample shows a sound absorption bandwidth of 4200 Hz, while in rock wool sample this frequency range is around 4700 Hz, being the value of the maximum sound absorption coefficient higher in rock wool sample than virgin cork sample. In both types of samples, it can be seen that the value of the sound absorption coefficient decreases to lower frequencies.

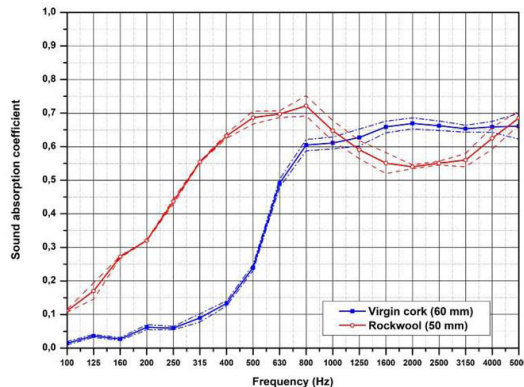


Fig. 2: Absorption coefficient spectrum at random incidence, averaged values with standard deviation. Comparison between rock wool and virgin cork.

This different acoustical performance, between the virgin cork and the rock wool, is mainly due to the physical properties of the rock wool; the lower density of the rock wool ($120 \text{ kg}\cdot\text{m}^{-3}$ in the rock wool versus $175 \text{ kg}\cdot\text{m}^{-3}$ in the virgin cork), its high connected porosity (> 90% in the rock wool versus 60% in the virgin cork) and the lost of energy, due to the viscous and thermal effects that happen inside the porous material, where the sound energy is attenuated, via friction with the pore walls, and converted into heat. This latter is the most significant effect in the low frequency range and in it, physical properties like flow resistivity (higher in the rock wool), tortuosity and, to a greater extent, viscous and thermal characteristic lengths (Maderuelo-Sanz et al. 2016).

CONCLUSIONS

This work shows a first investigation of the acoustical performance of virgin cork. Virgin cork is a natural and sustainable raw material of great ecological value that needs minimum treatments which make it very interesting from a building and sustainability perspective due to its low emissions and the great potential for fixing and capturing CO_2 . The results obtained show that the values of the random sound absorption coefficient obtained in the mid and high frequency bands, are slightly higher than those obtained for commercial rock wool, used nowadays in building. However, this does not happen in the case of low frequencies, where the acoustical performance of rock wool is significantly better. Therefore, initially it seems so interesting to introduce this type of natural material in some building solutions that show good acoustic properties. However, in order to make it possible to use it in buildings, it is also necessary to determine other types of properties in future works such as fire resistance, warping, dimensional stability or thermal and mechanical properties.

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