Acoustic properties of broom fibres

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Abstract

Green materials are becoming a valid alternative to traditional synthetic materials for sound absorption. In this paper are reported the measurement of the acoustic properties of the broom plants. The broom plants grow up on hills and mountains. The materials were cut and then were shredded. Test specimens were made of suitable thickness and the acoustic characteristics were measured. The absorption coefficeint of samples of the materials with different thicknesses was measured in the frequency range from 200 Hz to 2000 Hz with a tube of "Kundt"; the flow resistance was also measured.

Introduction

In recent years the attention to the problems of energy saving is increased. In the building sector, the use of insulating fibrous materials represents one of the possible solutions to reach this aim. Actually, even designers experts are showing a growing awareness towards the acoustic quality of indoor spaces. As consequence, in the last decades the sound absorption panels have been used for room acoustic application. These panels are generally composed of porous synthetic materials, resulting from petrochemicals. The growing demand to protect the environment and to use non-polluting materials has given rise to the interest in sustainable materials, that is materials which protects the environment during its entire life (from the moment the raw materials are extracted from the source to the time the final product is disposed of, there must be no permanent damage caused to the environment). Sustainable natural materials can be animal (sheep wool), mineral (natural pumice, expanded clay, cellular glass), vegetable (wood, hemp fibers, jute fibers), furthermore vegetable natural materials store carbon dioxide during their growth. In literature, studies on the acoustic characterization of some sustainable materials can be found. These materials were shredded in order to perform both the normal incidence sound absorption coefficient and the air flow resistance measurements. To improve sound absorption, existing pores in the material must be opened to the outside [1, 2]

The broom shrub

There are different varieties of broom shrub. These shrubs, such as Scotch broom (*Cytisus scoparius*) or Spanish broom (*Spartium junceum L.*), are very common in Mediterranean area and grows both on the hills and on the mountains. In the present study, the variety high from 50 to 200 mm, with fibrous and cylindrical section stem is investigated. In the time, a broad and different use have been made of this shrub: a textile fiber used for the production of ropes as well as fabrics for clothing have been obtained by its stem; in the countryside, it was used to tie twigs; thanks to its root system, in engineering broom is used to consolidate embankments and slopes along the railways and highways. Figure 1 shows the Broom picked up on the hills of Southern Italy, while Figure 2 shows shredded broom.

Figura 1: Broom picked up on the hills of Southern Italy

Figura 2: Shredded broom with an average diameter of 3.0 mm

Acoustic characterization

The measurements of normal incidence sound absorption coefficient were carried out with an impedance tube, in accordance with the procedure described in the ISO 10534-2:1998 [3, 4]. Kundt's tube is 56 cm long and has an internal diameter of 10 cm. Kundt's tube dimensions and the distance between the two ¼" measuring microphones allow for an accurate sound absorption measurement in the frequency range of 200 Hz – 2.000 Hz (Figure 3). The samples were

obtained shredding the branches of broom into pieces on average 150 mm long. In this study, broom branches with an average diameter of 3.0 mm were considered (Figure 2). The loose material was blocked in the tube by an acoustically transparent net with wide links. Broom samples of different thicknesses (60 mm, 80 mm and 120 mm) were tested. For each sample, 4 measurements were carried out. The airflow resistance was measured according to the international standard ISO 9053: 1991 (Figure 4) [5]. Figure 5 shows the particular of the loose broom in the Kundt's tube. The value of the resistivity is R_1 = 550 Rayl/m. Furthermore the porosity Y is defined as the ratio between the volume occupied by the air (Va) and the one occupied by all the material (Vm). The porosity is determined knowing the density of the material prior to the shredding and the density of the granular material; ρ_m (kg/m^3) is the apparent density of the material, ρ_{solid} (kg/m^3) is the density of the material which the skeleton is made of:

$$Y = \frac{Va}{Vm} = 1 - \frac{\rho_m}{\rho_{solid}}$$

The apparent density (ρ_m) was evaluated by weighing different volumes of material into a graduated glass tube, while the density of the solid (ρ_{solid}) was evaluated by weighing the uncrushed material, the volume of the material was determined by reading the water height increment when plunged into the water contained in a graduated glass tube, the porosity is Y=0.67.

Figure 3: Tube of Kundt, for the absorption coefficient measurements

Figure 4: System for the measurement of the resistivity R_1, with the method of the alternate air flow

Figure 5: Loose broom in the Kundt's tube

Discussion

Figures 6, 7 and 8 show the mean values of the normal incidence sound absorption coefficient measured for each broom sample. The results of the absorption coefficient measurements performed on samples 6 cm, 8 cm and 12 cm thick show not sufficient values at frequencies lower than 800 Hz, while an appreciable increase is shown at frequencies above 800 Hz. These results are comparable to sound absorption values of other loose granular materials [7, 8]. For the sample 12 cm thick, the sound absorption coefficient values are acceptable at low frequencies, while an increase occur for frequencies above 1.400 Hz.

Conclusions

This paper presents an example of "green" materials application in building acoustics. In particular, broom samples with different thicknesses, has been tested. Broom is a vegetable natural fiber, widespread plant in the hilly area, cheap and completely recyclable and compostable. The measurements made with the impedance tube indicate good values of the absorption coefficient for the different thicknesses of the considered material. These results are comparable to the sound absorption coefficient of commercial porous materials with a rigid structure. The results of the measurements confirm the possibility of using the broom fiber in order to obtain sound absorption units in a cheap and effective way.

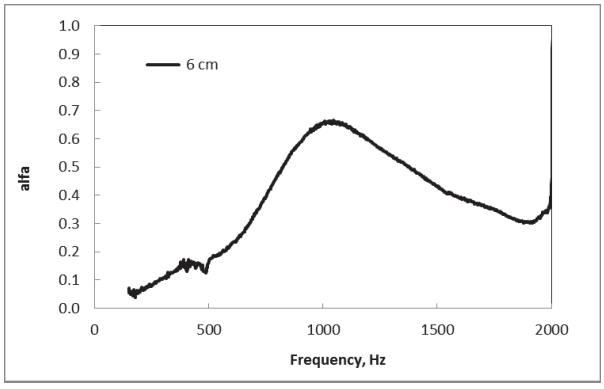

Figure 6: Results of the average value of the absorption coefficient measurements performed on samples 6 cm, thick

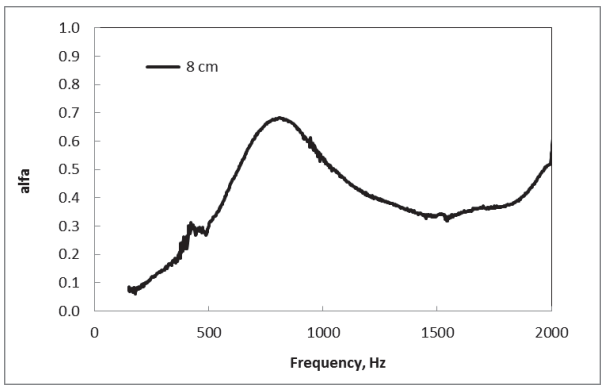

Figure 7: Results of the average value of the absorption coefficient measurements performed on samples 8 cm, thick

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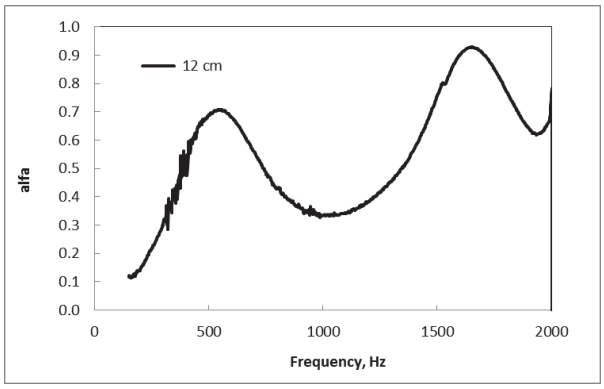

Figure 8: Results of the average value of the absorption coefficient measurements performed on samples 12 cm, thick

Acknowledgments

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