The use of calabashes as sound absorption alternative material

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ABSTRACT: This paper aims to give some scientific information on calabashes used as sound absorption alternative material. For two decades the need for concert halls with adequate acoustic quality has been increasing in Brazil. Therefore, modern buildings have been built in our country according to adequate standers. Nevertheless, the cost of the necessary acoustic materials in current use is prohibitive. In order to reduce building budgets, researches have been done by the acoustic lab from UFSM since 1986. The present research aims to find out whether residue material derived from calabash industries in our state can work properly as sound absorbent material at a low cost. The evaluation of the sound absorption coefficient for these materials was obtained using sound measuring equipment employing the frequency range from 100 Hz to 4.000 Hz. In order to get the best performance, the material was installed in at least eleven ways and a math model was used to describe the phenomenon. The obtained results indicated that the researched material behaved as Helmholtz resonator. This research has provided scientific information on how calabash residue cab be used as a sound absorption alternative material.

Keywords *alternative acoustic material, room acoustics, reverberation time.*

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1. INTRODUCTION

The question of the characteristics and functioning of industrialized acoustic materials have been widely discussed by several authors in the specialized bibliography. These authors describe not only the types of acoustic materials commonly used in civil construction, but the potential of sound absorption of these materials for acoustic treatment. However, there is not yet enough information on the acoustic performance of alternative materials at a low cost. The aim of this study was to evaluate the sound absorption potential of the material from the gourds production process in Rio Grande do Sul. The mate, a cultural trait which originated in ancient indigenous who inhabited the region of Paraguay and Rio Grande do Sul during the seventeenth and eighteenth centuries, currently generates a significant portion of GDP gaucho. The enormous popularity of this habit among the gauchos brought a considerable increase in the production of gourds for mate. But the residual material from the production of gourds does not find a favourable economic destination, staying as organic waste in the courtyard of the companies in the sector. Motivated by this context and the need for economically sustainable products, also in the acoustic area, was developed this work.

The Figure 1 bellow shows calabash residues staying as organic waste in the courtyard of the mate companies:

Figure 1: calabash residues staying as organic waste in the courtyard of the mate companies

2. METODOLOGY

Initially it was made a previous classification of gourds to select those that had similarity in size, shape, outer diameter and thickness, in order to compose the sample for the experiments. The experiments were carried out in the standard chamber of the Acoustics Laboratory of Federal University of Santa Maria, according to international norm ISO 354. In the experiments were used the following equipment, as shown in the figure 2 bellow:

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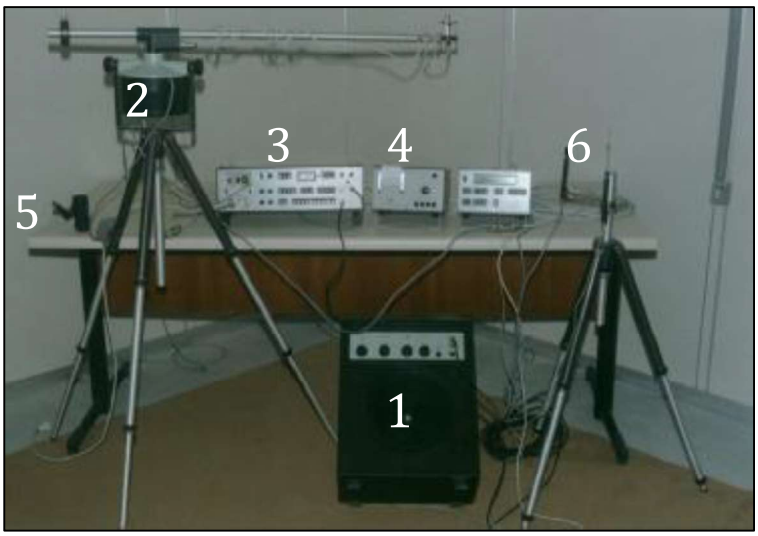

Figure 2: acoustic equipment in the acoustic laboratory of Federal University of Santa Maria

Where 1 = sound source B & K type 4224; 2 = rotating microphone B & K type 3923; 3 = acoustic analyser B & K type 4418; 4 = printer B & K type 2318; 5 = sound calibrator B & K; 6 = climate analyser B & K type 1213.

Figures 3-8 below refer to the acoustic experiments:

Figure 3: some of the raised pieces with opening down

Figure 4: raised pieces with opening down put together in the reverberation chamber

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Figure 5: some of the joined pieces

Figure 6: joined pieces put together in the reverberation chamber

Figure 7: gourd bottoms glued on sheets of plywood

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Figure 8: natural calabashes in the reverberation chamber

The raised pieces with opening down behave as Helmholtz resonators, whose mathematical modelling is described in the Figures 9-10 below:

$$f = \frac{c}{2\pi} \cdot \sqrt{\frac{S}{[\,1{,}6\,.\,(Ri + L)\,]\;.\;Vi}} \qquad (9)$$

where f = internal resonance frequency of gourd in Hertz; c = speed of sound in air; S = area where air passes; Ri = gourd's inner radius; L = gourd's thickness; Vi = gourd's internal volume.

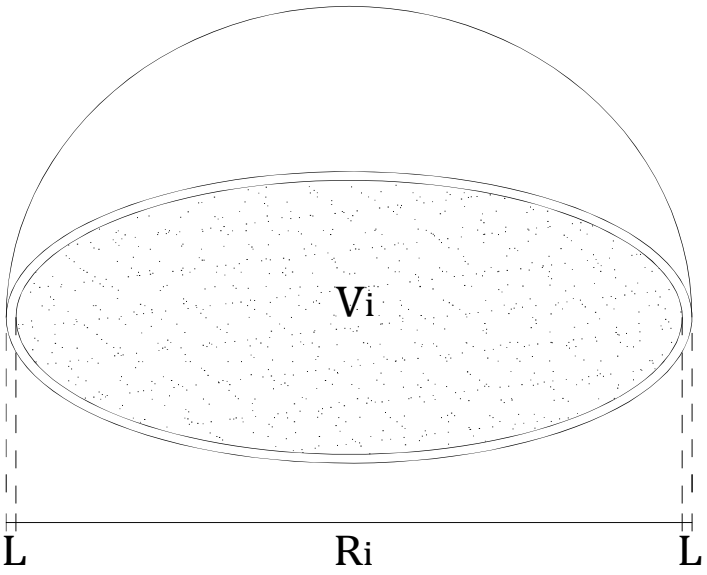

Figure 10: schematic drawing of a gourd

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3. RESULTS

Figures 11-14 below summarize the acoustic results:

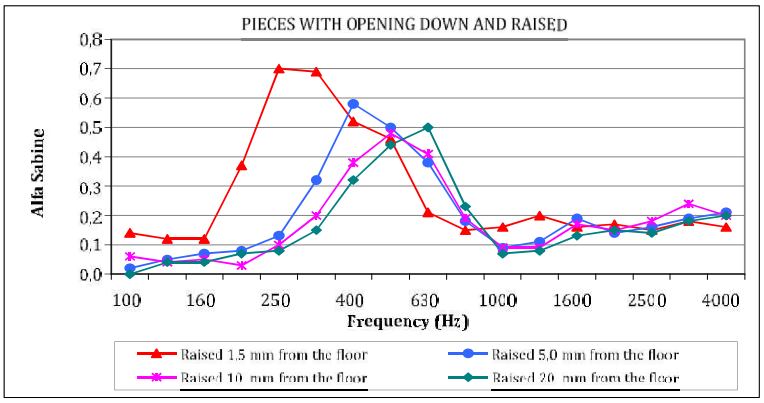

Figure 11: raised pieces with opening down

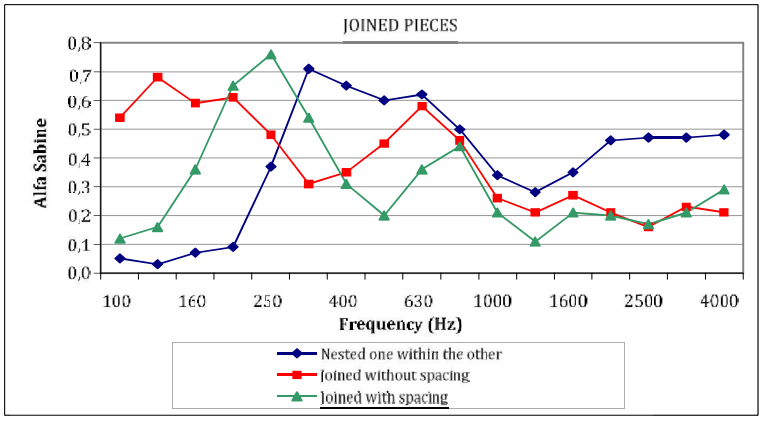

Figure 12: joined pieces

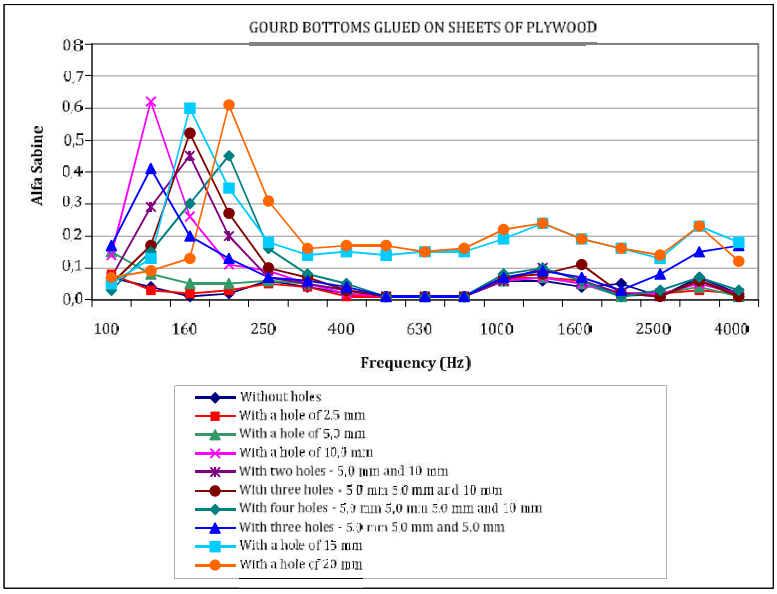

Figure 13: gourd bottoms glued on sheets of plywood

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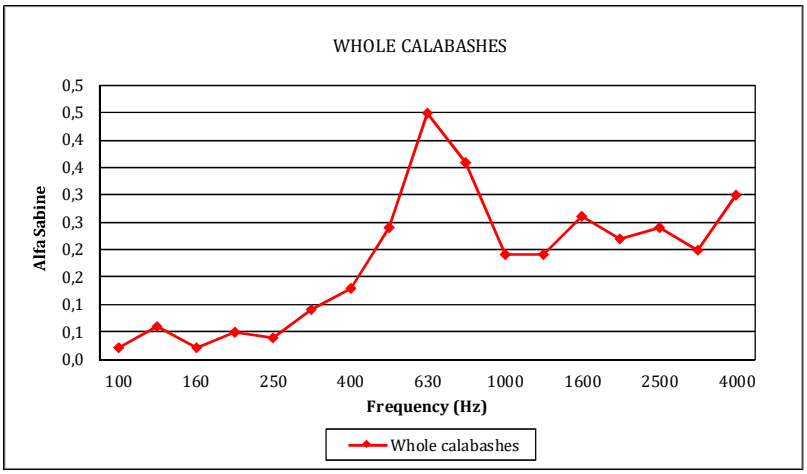

Figure 14: whole calabashes

4. CONCLUSIONS

The research findings were the following:

- The evaluated material, being an abundant waste in the south of the country, characterizes itself as an alternative acoustic material at a low cost and sustainable;
- The calabash residues behave as Helmholtz resonators whose resonant frequency will depend on the chosen assembly. In addition to the sound absorption property, the peculiarly rounded geometric shape gives the gourds the ability to be an efficient sound diffuser;
- The material studied, being a natural product and because of the woody constitution, requires specific treatment for insect attack protection, as well as fire and decomposition;
- Concerning raised gourds with opening down, whose absorption varies depending on how much they are distant from the floor, it can be concluded that it is possible to adjust its height depending on the frequency to be corrected;
- The joined pieces have one of the highest absorption coefficients and amplitude at low frequencies, but this is the arrangement more difficult to implement;
- The gourd bottoms glued on sheets of plywood behave as the classic Helmholtz resonator, whose frequency and magnitude of Alpha Sabine varies depending on the gauge and number of holes;
- The mechanism of sound absorption due to the internal volume of the calabash residues serves as reference for the study of other similar alternative materials, such as coconut shell, disposable containers, and remains of processed products.

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