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RESEARCH REGARDING ACOUSTICAL PROPERTIES OF RECYCLED COMPOSITES

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Abstract: *The paper presents the variation curves for acoustic properties (sound absorption coefficient, reflexive coefficient and impedance ratio) of new materials made from mixture of wood particles and textile waste with different types of binders. The experimental determinations are based on Kundt's tube method in accordance with ISO 10534 standard. The results show that one of the most important factors in sound insulation of composite materials is the type of binder. The proposed materials are intended to be light structures, recyclable or degradable and with high noise reduction efficiency, being proper in buildings structures, noise barrier structures and automotive components.*
Key words: acoustic, composite, noise control, absorption, Kundt's tube, noise barriers

1. INTRODUCTION

The noise control plays an important role in assuring acoustically pleasant environments [1]. One of the most important factors in noise reduction is represented by the materials used in different structures with soundproofing role. The use of composite materials based on textiles residues and wood chips or flacks for noise reduction have two major advantages, namely low production costs and small specific gravity [2, 3]. Knowing acoustical properties of these porous materials is useful for proper application in products such as sound barriers, walls, road surfaces [4, 5, 6]. In order to protect the environment on one hand by recycling the residues from primary and secondary technological process and on the other hand by attenuate the noise from industry or urban traffic, different systems were developed based on recycling solid waste (sterile municipal waste, wood chips, waste polystyrene, slag or fly ash with polymer matrix) [7]. Literature review relieved numerous studies regarding the sound transmission loss of different types of materials such polyester fibre, glass fibre and urethane foam [9]. Also, the variation of sound absorption coefficient carried out by Kundt's tube was determined for the following materials: porous textile materials, latex plate, rigid plate consisting on textile waste, synthetic leather glued on textile support [8, 9].

In this paper the assessment of the acoustical properties of new composite structures based on wood chips and textile waste bonded together with ecological binders is presented. In a previous work, the density and thermal conductivity coefficient were determined for each structure and compared with the expanded and extruded polystyrene values [10].

2. EXPERIMENTAL SET-UP

2.1 Method and materials

One of the widely used methods to determine the acoustic properties (absorption coefficient, impedance ratio, reflection coefficient) is the international standardized impedance tube method [11, 12]. The principle of this method is based on the measurement of transfer function between two signals of microphones mounted inside the tube. In accordance with measurement chain, a loudspeaker is placed at the end of the tube as can be seen in Fig. 1 [13].

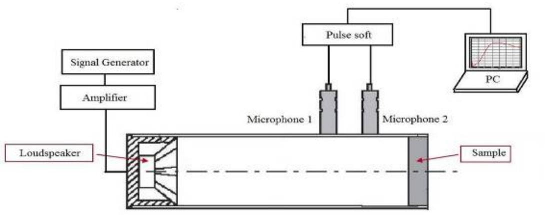

Fig. 1. Schematic view of the experimental set-up

When the tube is fed by 1/3 octave frequency bands, a stationary plane wave is created and pressure measured with microphones can be decomposed into its incident and reflected components. First, the equipment without samples was prepared, in order to configure the microphones and to calibrate them using the calibration function from Pulse soft. [14, 15] This operation is necessary because of phase and amplitude of the two microphones is not perfectly identical. In this sense the frequency response function is measured with the two microphones interchanged position. After calibration, each sample is properly inserted into the tube and the measurements started (Fig. 2).

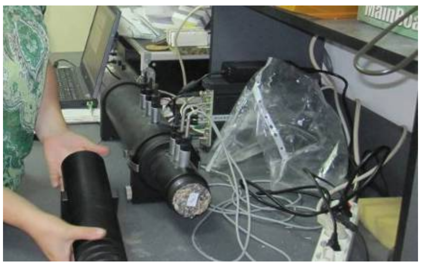

Fig. 2. The experimental set-up

The generated noise is connected to the amplifier and the tube filter emits the set signals. The emitted signal and reflected signal is captured by microphones and transmitted to Pulse hardware and displayed with the Pulse soft. The input data from the project set-up are presented in Table 1 and they are established automatically by soft in the calibration stage.

Table 1. The input data

Tube	**Input**
Type	Medium
Microphone Spacing:	0.0318 m
Distance to Sample from Mic. 2	0.0635 m
Distance to Source from Mic. 1	0.37 m
Diameter:	0.064 m
Lower Frequency Limit:	100 Hz
Centre Frequency (Hz):	1600
Generator	
Waveform:	Random
Signal Level:	1.414 Vrms

Due to the influence of the environment upon the measurements accuracy in situ, the tests were performed in the same environment conditions (atmosphere pressure - 1035.00 *hPa*, temperature - 28.00 *°C*, relative humidity - 46,00%, velocity of sound - 347.89 *m/s*, density of air - 1.195 kg/m^3, characteristic impedance of air: 415.8 *Pa/(m/s)).*

In this study were used green and biodegradable materials, found as inserts of wood (flakes or fibres) and textiles (wool or jute). For the experimental tests, the samples were cut into specimens with a diameter of 63.5 mm and the thickness in the range between 20 – 30 mm) (Fig. 3).

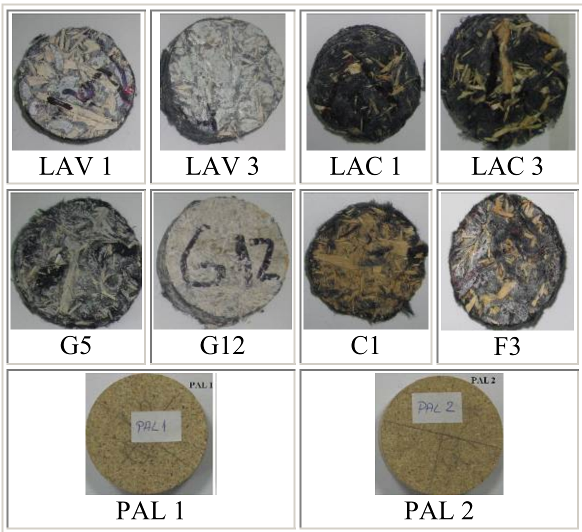

Fig. 3 The composite samples studied with impedance tube

The differences between samples consist on the quantities of raw materials or the type of binders, which conduct more or less to the compaction of the particles. The characteristics of composite materials are presented in Table 2.

Table 2. Characteristics of agglomerated structures

Code/ Weight m [g]	Content and amount	Density, ρ [g/cm^3]
	White Acrylic Copolymer (WAC)	
LAV 1 20,958	Wood flakes 150 g, Wool 150 g 40% WAC, 60% water	0,197
LAV 3 20,327	Wood flakes 150 g, Wool 150 g 50% WAC, 50% water	0,244
	Ecologic Acrylic Copolymer (EAC)	
LAC 1 13,866	Wood flakes 150 g, Wool 150 g 400ml EAC	0,157
LAC 313,958	Wood flakes 150 g, Wool 150 g 500ml EAC	0,193
	Gyps solved in Water (GSW)	
G5 32,174	Wood flakes 150 g, Wool 150 g 600 g Gyps solved in water	0,415
G12 47,322	Wood flakes 100 g, Wool 100 g, Wood fibers 100 g 1000 g Gyps solved in 900 ml water	0,656
	Clay solved in Water (CSW)	
C1 55,216	Wood flakes 150 g, Wool 150 g 800 g CSW in 500 ml water	0,626
	Flour Solved Water (FSW)	
F3 22,854	Wood flakes 150 g, Wool 150 g 500 g FSW in 1000 ml water	0,130
	Particle board (PAL)	
PAL 1 34,023	Wood chips Particleboard - commercial) Formaldehyde	0,700
PAL 2 37,63	Wood chips Particleboard - commercial) Formaldehyde	0,720

The binder and the amount of binder in the composition are different noted as: White Acrylic Copolymer (WAC), Ecologic Acrylic Copolymer (EAC), Gyps solved in Water (GSW), Clay solved in Water (CSW) Flour Solved Water (FSW), Particle board (PAL). All samples were obtained in the same laboratory conditions, including the pressure parameter.

2.2. Results and discussion

The sound absorption coefficient indicates what amount of sound is absorbed in the actual material and depends of the frequency type. In Fig. 4 the variation of sound absorption coefficient against the frequency is presented, for different materials.

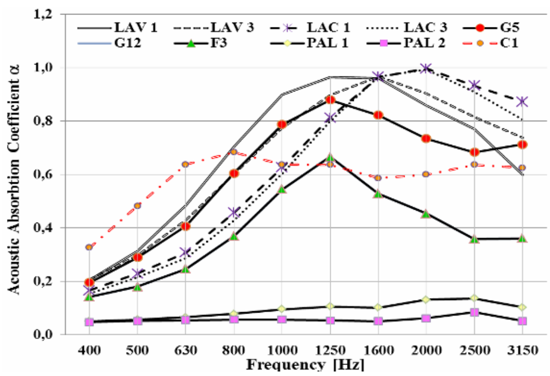

Fig. 4. The effect of type of binders on sound absorption coefficient

It can be noticed that the composition of tested materials have influence on the sound absorption.

According to the absorption classes described in the international standard ISO 11654 (Tabel 3) the samples can be grouped in following cathegories[14]:

- The samples LAV1, LAV2, LAC1, LAC3 and G5 are described by high absorption of sound for the frequency range between 1000 – 3200 Hz – class A
- The samples C1, G12 and F3 present a medium value of the absorption coefficient, arround 0,7 being part of class C. An interesting behaviour is recorded by sample which

contains clay solved in water, namely the constant capacity of materials to absorb a relative wide range of frequency (650 – 3000 Hz).

- The lowest absorption was recorded by samples PAL 1 and PAL 2, for all frequencies, being in E or below class.

Table 3. Absorption Classes[9]

Absorption coefficient α	Sound Absorption Class
1,00 – 0,90	A
0,85 - 0,80	B
0,75 – 0,60	C
0,55 – 0,30	D
0,25 – 0,15	E
0,10 – 0,00	Not classified

Figure 5 shows the variation of sound absorption coefficients against the density of the tested materials. First, the maximum values of absorption coefficients were selected from previous charts and then were compared to the variation of density. So, the increasing of the value of the density of materials leads to the decreasing of the absorption coeficient.

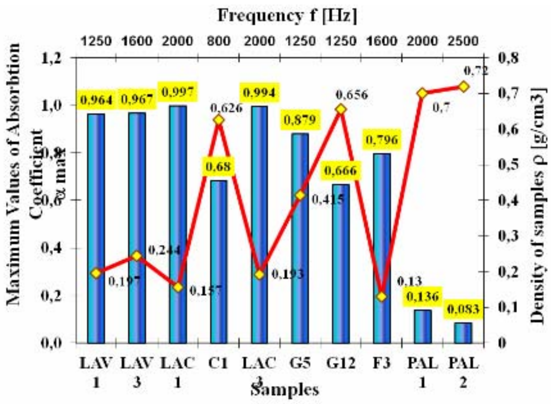

Fig. 5. The variation of sound absorption coefficient versus density of materials

For example, the samples L1, L2 and A1 have low density (range between 0,150 to 0,200 g/cm^3) and high absorption (over 0.9). For high densities as PAL 1 and PAL 2 have (ρ=0,700...0,750 g/cm^3), the absorption capacity of materials is lower. The most reflective materials are the composites PAL 1 and PAL 2, characterized by flat and smoth surfaces and a high degree of compaction of wood particles and chips.The tendency of all materials is to have a negative value of the reflection coefficient for the frequencies in the range of 1200 – 3000, which correspond to the maximum acoustical absorption.

3. CONCLUSIONS

The experimental investigation aimed to determine the acoustical properties of new materials obtained by waste textile and wood residues. These materials were designed for assuring a good acoustic and thermal insulation. Six types of materials were tested. The composition of binders (matrix) had a great influence upon the acoustical properties of the samples (absorption coefficient, impedance ratio, reflection coefficient). Concerning the sound absorption coefficient, the samples based on WAC, EAC and GSW present a very good sound absorption at high frequencies, fact that recommends the materials for sound insulation application. The other ones, as PAL 1 and PAL 2 are, have recorded a lower value of absorption coefficient against the frequency. An interesting acoustic behavior was performed by sample C1 (clay solved in water), due to its relative constant sound absorption at different frequencies, even the sample recorded only a medium value of absorption (around 0.683 at 600 Hz). For this reason, the research results of composites WAC (white acrylic copolymer), EAC (ecological acrylic copolymer) and GSW (Gyps solved in water) concluded to the fact that they can be used for sound absorbent panels for highways, railways and airports.

The study of sample C1 made of wood flakes, wool and clay binder can be continued in order to improve the sound absorption for a large frequency domain. Comparing the experimental results with others from literature (Fig. 6), it can be noticed that the biodegradable composite materials with textile inserts as new structures, present a very good absorption capacity that will be used for future researches regarding their applications. The others materials studied by Bratu, 2007 and Bratu 2011 are composites based on residues as textile waste, synthetic leather, wood chips, pet pellets, furnace slag and sterile municipal waste [7,8, 15].

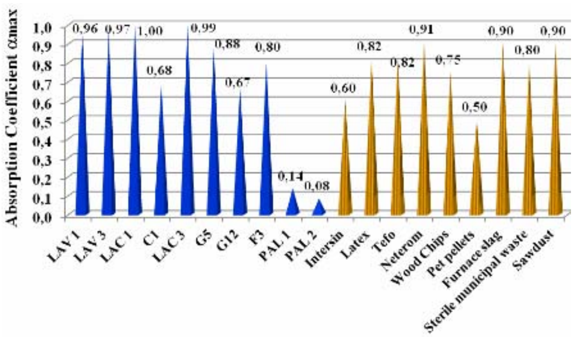

Fig. 6. Comparison between experimental and literature results

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