RESEARCH REGARDING THE ACOUSTIC PROPERTIES OF COMPOSITE MATERIALS COMPRISING SHEEP WOOL AND A MINERAL MATRIX

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REZUMAT. În epoca noastră modernă, când realizările tehnico-ştiinţifice îşi găsesc aplicaţii importante în diverse domenii, zgomotul ca factor secundar rezultat din utilizarea dispozitivelor, instalaţiilor şi echipamentelor a cunoscut o creştere rapidă. Dezvoltarea industriei, a transporturilor şi a altor dotări tehnice creează un amestec de zgomote şi vibraţii care însoţesc oamenii pe străzi, la serviciu, acasă sau în timpul orelor de odihnă, având efecte mai mult sau mai puţin importante asupra confortului, sănătăţii şi productivităţii în munca. Datorită naturii sale dăunătoare şi a prezenţei în orice aspect al vieţii, poluarea fonică constituie o problema majoră pentru toţi locuitorii zonelor urbane, motiv pentru care măsuri de izolare fonică şi de diminuare a zgomotului sunt intens studiate şi analizate. În Uniunea Europeană, aproximativ 80 milioane de oameni sunt expuşi la niveluri ridicate de zgomot care cauzează tulburări de odihnă şi alte influenţe nedorite. Se acordă o atenţie în faza de proiectare şi producţie a materialelor de construcţii ce intenţionează să se reducă efectele poluării fonice la serviciu şi mai ales în zonele rezidenţiale ale oraşelor afectate. Principalele surse de poluare fonică sunt industria şi transportul. Directiva europeana 70/157/EEC pentru controlul şi reducerea zgomotului este concentrată pe crearea unui mediu mai plăcut şi mai puţin zgomotos prin „Dezvoltare Durabilă în Europa". Scopul acestei lucrări este de a prezenta realizarea unei instalaţii care să permită măsurarea parametrilor izolării fonice ale unor materiale compozite din textile în strat fibros cu lâna ţurcană şi matrice minerală.

Cuvinte cheie: lână ţurcană, coefficient de absorbţie, izolare fonică.

ABSTRACT. In our modern age, when the science conquests and technical breakthroughs find important applications in many fields, noise as a complementary factor for the use of devices, installations and equipment witnessed a rapid growth. The development of industry, transportation and various technical endowments create a crowd of noises and vibrations that accompany people on the streets, at work, at home or during resting hours, having more or less significant effects on the comfort, health and work performance for those people. Because of its harmful nature and its presence in every aspect of life, noise pollution constitutes a major problem for all city dwellers, the reason for which sound proofing and effect mitigation means are studied and analysed by researchers. In the European Union, about 80 million people are exposed to high noise levels which are the cause for sleep disorders and other undesirable influences. Attention is given to the design and production of construction materials that aim to mitigate the effects of noise pollution at work and mostly in the residential areas of the cities that are affected. The primary causes are industry and transportation. The EU Directive 70/157/EEC for controlling and mitigating environmental noise is focused on creating a less noisy and a more pleasant environment for European citizens within the "Sustainable Development in Europe".

Keywords: Turcana wool, absorption coefficient, sound proofing.

1. INTRODUCTION

Noise is defined as an unwanted sound without harmony which can actually serious harm to humans causing psychological and physiological symptoms like hearing loss, increase of blood pressure, loss of focus and low productivity at work. So the classical method to reduce the noise level is to properly insulate using materials with a good acoustic absorption coefficient. [1] [2]

The absorption coefficient is the most important characteristic of a material from an acoustic engineer's point of view, the materials being classified as absorptive or reflective.

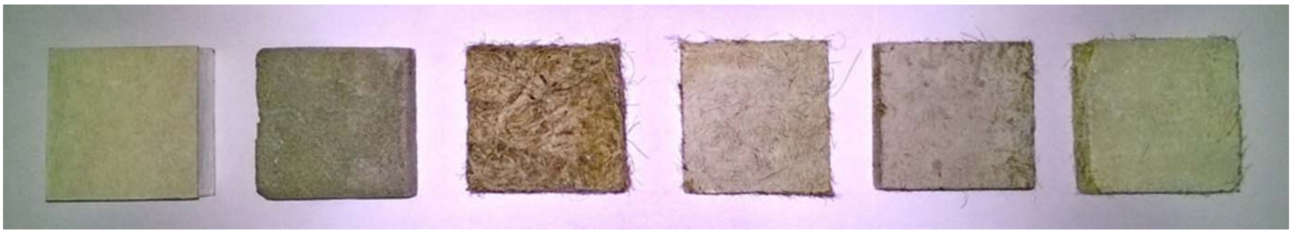
The aim of this paper is to present an installation that allows the measurement of the acoustic parameters of the studied composite materials comprising a mineral matrix and Turcana wool fibres.

2. MATERIALS AND METHODS

Composite boards were developed as an environmental friendly alternative for replacing conventional methods of plastering structural walls and execution of interior partitioning walls for housing (Figure 1).

Conventional methods include a mix of cement and sand for the plaster and gypsum boards for the partitioning walls.

To manufacture these boards *Ţurcana* wool fibres were used in combination with conventional construction materials: cement, sand, gypsum.



1	2	3	4	5	6
gypsum board	cement plaster	25% wool	2.95% wool	5.99% wool	12.88% wool

Fig. 1. Test samples [5] [6]

The targeted result was to obtain a composite board with superior thermal performance.

The materials used for the manufacture of the composite boards were weighted and mechanically mixed. The components characteristics are presented in *Table 1*.

The wool is sorted, washed, dried, then cut to an average length from 3 mm to 10 mm as follows: R1 – 10 mm, R2 – 5 mm and R3 – 3 mm. The weight percentage for the wool fibres varies from 2% to 13% according to *Table 2*.

Table 1. **Characteristics of the components**

Raw materials	Density [g/cm^3]	Characteristics
Cement	3.20	CEM II B-V 32.5R
Gypsum	1.00	Construct Gips
Sand	1.60	0÷1 mm
Wool	1.31	20 μm÷60 μm

Table 2 **Components percentage (weight) in mixtures**

	Wool	Cement	Gypsum	Sand	Water	Animal glue
	wt.[%]					
R1	2.95	19.56	16.98	32.85	27.68	-
R2	5.99	18.72	16.47	31.83	26.97	-
R3	12.88	17.56	15.22	29.27	24.98	-
R4	25.00	-	-	-	56.25	18.75

The mix is then poured in a formwork with the dimensions 100 mm x 100 mm x 12 mm. After curing and stripping, the specimen is then cut to the dimensions 40 mm x 40 mm x12 mm.

When measuring the absorption coefficient there are three standardised methods: reverberation chamber (described in ISO354) and two impedance tube methods that are broadly described in ISO 10534-1 and ISO10534-2. There is a fourth method – in situ.

First method (Figure 2) description: A sound source (loudspeaker) is mounted at one end of the impedance tube and a sample of the material is placed at the other end. The loudspeaker generates broadband, stationary random sound waves. These waves propagate as plane waves in the tube, hit the sample and are reflected. Therefore, a standing-wave interference pattern results due to the superposition of forward- and backward-travelling waves inside the tube.

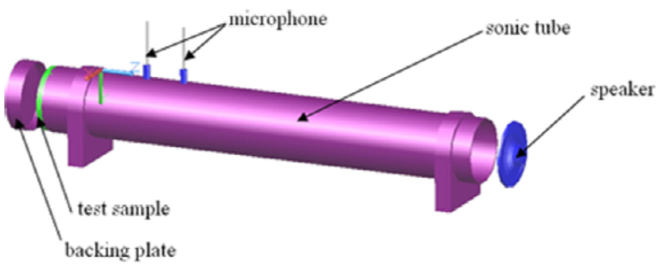


Fig. 2. First type method.

By measuring the sound pressure at two fixed locations and calculating the complex transfer function using a two-channel digital frequency analyzer, it is possible to determine the complex reflection coefficient, the sound absorption coefficient and the normal acoustic impedance of the material. The usable frequency range depends on the diameter of the tube and the spacing between the microphone positions.

A sound source (loudspeaker) is mounted at one end of the impedance tube and a sample of the material is placed in a holder. The loudspeaker generates broadband, stationary random sound waves that propagate as plane waves. The plane waves hit the sample in the holder with part of the wave reflected back into the source tube, part absorbed by the material, and part passing through the material to the receiving tube.

The portion of the plane wave that passes through the material then encounters the end of the receiving tube where some of it is reflected and some exits the tube. By measuring the sound pressure at four fixed locations (two in the source tube and two in the receiving tube) and calculating the complex transfer function using a four-channel digital frequency analyzer, it is possible to determine the transmission loss of the material. The usable frequency range depends on the diameter of the tube and the spacing between the microphone positions. [7]

The installation requires the following devices:

1. An impedance tube with the following characteristics:
   - diameter 100 mm;
   - length 700 mm.

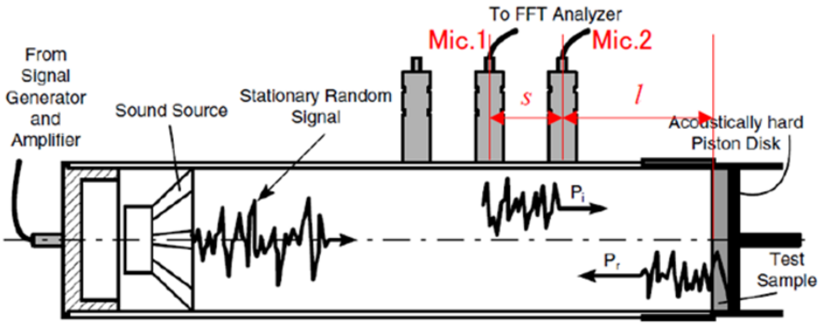


Fig. 3. The principle of the first method.

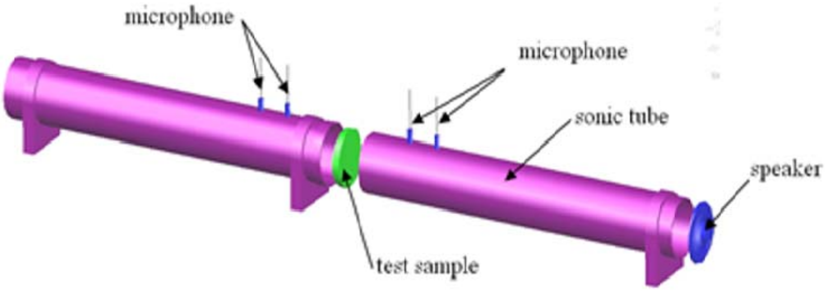


Fig. 4. The second method.

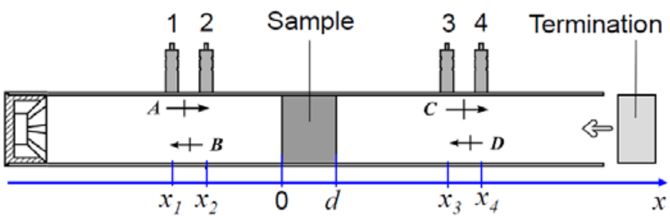


Fig. 5. The second method principle.

2. Two sonometers with the following characteristics:
   - frequency range 31,5 Hz - 8 kHz;
   - measurement step 0.01dB;
   - precision ±1,4 dB;
   - noise level range 30 - 130 dB;
   - response time 125 ms/s;
   - datalogger for 129900 values;
   - USB interface;
   - processing software.
3. A loudspeaker with the following characteristics:
   - Max. Average Power: 10 W at 20°C (68°F);

− Max. Pulsed Power: 50 W for 2 s (limited by protection circuit);
− impedance: 4Ω;
− diameter: 80 mm (3.2″).

4. A standardised signal with varying frequency.
5. A computer

The impedance tube will be realised in the laboratory (Figure 6).

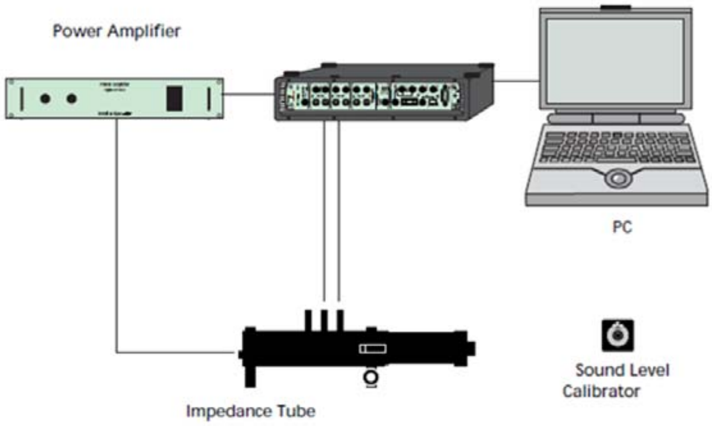


Fig. 6. Installation scheme.

3. CONCLUSIONS

The acoustic parameters of the composite boards should be directly influenced by the fibre percentage. The fibres act as reinforcement too. This leads to the reduction of the necessary board thickness.

Thinner boards mean lower self-weight for the panels, decreasing the dead loads.

Fire testing should be performed also; the wool fibres may contribute to a good fire resistance.

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