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NEW COMPOSITE STRUCTURES DESIGNED FOR BUILDING ACOUSTIC INSULATION

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Abstract:
Investigations conducted so far to find sound and thermal proofing materials have shown the possibility of designing composites containing biodegradable materials, which can be used as sound and thermal insulators for buildings. The basic idea is to find the most inexpensive and effective solutions so that these composites to incorporate in their structure plant wastes (wood chips and fibers, twigs and bark, textile, jute, cork, etc.) and animal wastes (wool), recently considered as unused products. The authors have developed in the present paper eight new composite structures and have determined the coefficient of sound absorption. The materials used to manufacture the composites were wood fibers, wood chips, host of hemp, reed, textile fibers, wool and hemp fibers which were mixed with cement. Two specimens were cut from each designed composite board. They were tested into a Kundt impedance tube, at a frequency ranged between 50 and 1390Hz and for a noise level of 75dB. The results obtained after the testing measurements have shown that the highest sound absorption coefficient values were obtained for sample which contains equal amounts of wood chips, host of hemp and wool, as well as for the composite which has in its structure equal amounts of wood fibers, wood chips and wool. Because of these results, it can be said that the proposed composites are able to soundproof the buildings in urban areas where a high level of noise is noticed.

Key words: *sound absorption; composite; bio-degradable materials; impedance tube.*

INTRODUCTION

The process of industrialization and the technical progress had as result the emergence of modern machinery and equipment with the effect of sound disturbing of the settlements, fact that determined the researchers to think and design insulation materials in order to reduce the above mentioned effect.

According to the statistics of the World Health Organization, the noise defined as „noise emitted from all sources except for noise at the industrial workplace”. European Directive 2002/49/CE defined environmental noise as “unwanted or harmful outdoor sound created by human activities, including noise from road, rail, airports and from industrial sites” (http://www.euro.who.int/__data/assets/pdf_file/0003/142077/e95004.pdf).

Noise is considered as a stress factor that can cause long-term adverse effects on human health. The studies presented by WHO in 2011 (http://www.euro.who.int/__data/assets/pdf_file/0003/142077/e95004.pdf) have shown that noise has a greater risk of developing cardiovascular disease, including hypertension and myocardial infarction. Thus, according with WHO studies (Mathers et al. 2003), the ischemic heart disease is the leading cause of death in developed and developing countries (22.8% and 9.4% of all deaths). Worldwide, 12.6% of deaths are due to ischemic heart disease, cerebrovascular disease 9.6% and 1.6% of heart disease (http://www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf).

Approach methods outlined in the WHO (Environmental Burden of Disease Associated with inadequate housing. A guide to the quantification method of health effects of selected housing Risks in the WHO European Region 2011) on the protection of housing traffic noise are: reducing sources noise from vehicles, acoustic insulation housing and reducing the possibility of noise reaching residential buildings by barriers or through adequate urban planning measures.

All over the world, including European Union, from which Romania takes part, there are legal provisions to limit noise and Romania is obliged to comply them. Among the materials commonly used in the building thermal and acoustic insulation purpose, the polystyrene is the first one included, but it is considered by the Agency for Research on Cancer as a possible factor in triggering that human disease (Coşereanu *et al*. 2012). A green solution, proved to be also profitable, is the development of composite materials that contain bio-degradable materials in their structure. Using such materials like jute (Fatima and Mohanty 2011, Oldham *et al*. 2011)) and cork (Fernandes *et al*. 2011) in the structure of the composites revealed that their acoustic properties are superior to other materials currently used in sound insulation of buildings and of other products.

Comparative studies performed on three types of materials (Zhao *et al*. 2010) namely composite structure having the wood waste and rubber (tire rubber composite wood-East), commercial compound wooden floorboard and wood-based particleboard, have revealed that the acoustic properties of composite wood and rubber are superior to the other two types. The authors have also determined that the acoustic properties improve with the increasing of content of rubber and polmeric methylene disocyanate adhesive in the composite.

When using plants resources (Gle *et al*. 2012), it was shown that the particle size have influence on the acoustic properties of the composites. Such structural composites containing small particles of hemp 4 x 1 x 0.5mm, are superior to those containing larger particles. Using wood chips and fibers with wool and jute in the structure of the composite (Curtu *et al*. 2012), brought a higher sound absorption capacity of these materials compared to other wood-based materials.

In the present paper, the authors assessed the acoustic properties of the ecological composites containing bio-degradable materials such as: fiber and wood chips, host of hemp, reed and wool and cement used as binder material. The test results were compared with another frequently insulation material used in building, which is the polyester. The results have clearly demonstrated the superiority of these composites, the authors offering solutions of buildings soundproofing in certain areas of Brasov, according to the results of measured noise in the city.

OBJECTIVES

This paper intends to present eight new structures of ecological composites resulted after various mixing of wood chips and fibers, hemp, reed and wool fibers in the addition of cement. The determination of acoustic properties was done in parallel for new structures and polystyrene. The obtained results allowed recommendations about using these materials for sound insulation of buildings in certain areas of Brasov, depending on the noise level recorded during the day.

METHOD, MATERIALS AND EQUIPMENT

The materials proposed in this paper for the new composite boards designed for sound insulation of buildings are reinforced materials as wood chips and fibers, hemp flakes, reed and wool waste fibers (Fig. 1), embedded in cement as binding material.

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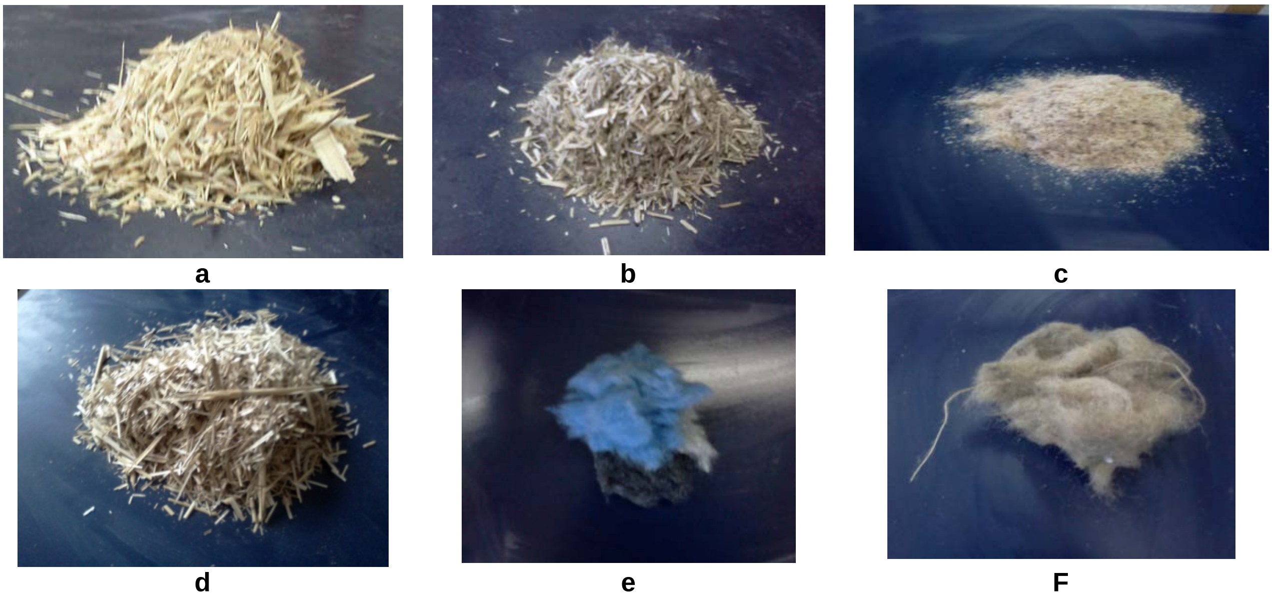


Fig. 1
Bio-degradable materials used for the composites:
a - wood chips; b - hemp flakes; c - wood fibers; d - reed; e - wool waste fiber; f - hemp textile fiber.

The eight new structures were symbolized with C1, C2, C3, C4, C5, C6, C7, C8 code numbers. The components of each structure are presented in Table 1.

Table 1

The structure of the eight designed composites

Code number of the structure	Structure components
C1	Wood fibers, wood chips, wool, cement and water
C2	Wood chips, wool, cement and water
C3	Wood fibers, wool, cement and water
C4	Wood chips, wool, hemp textile fibers, cement and water
C5	Wood chips, hemp flakes, wool, cement and water (wood chips and hemp flakes have the same weight)
C6	Wood chips, hemp flakes, wool, cement and water (more hemp flakes - 6% than wood chips – 3%)
C7	Wood chips, hemp flakes, wool, cement and water (more wood chips – 6% than hemp flakes – 3%)
C8	Reed, wool, cement and water

As can be seen in Table 1, the structures, C5, C6 and C7 have the same components, but the share of the biodegradable materials differs from one receipt to another.

The formed mixture was placed in a rectangular shape with a square section of 450x450x30mm, and were cold-pressed for 24 hours. Hot drying was carried out at a temperature in the range 40÷50^{0}C for 5 hours and after that they have still left outside the form for another 5h. After completion the drying process, it was found that the composite C4 had a weak internal cohesion. So, this composite was not further investigated for its sound absorption properties (Fig. 2).

Two square cross section specimens were cut from each type of composite, having the dimensions of 120x120mm and then circular shapes were cut using a round pattern of 100mm diameter (Fig. 3). The specimens were coded, measured and weighed (Table 2).

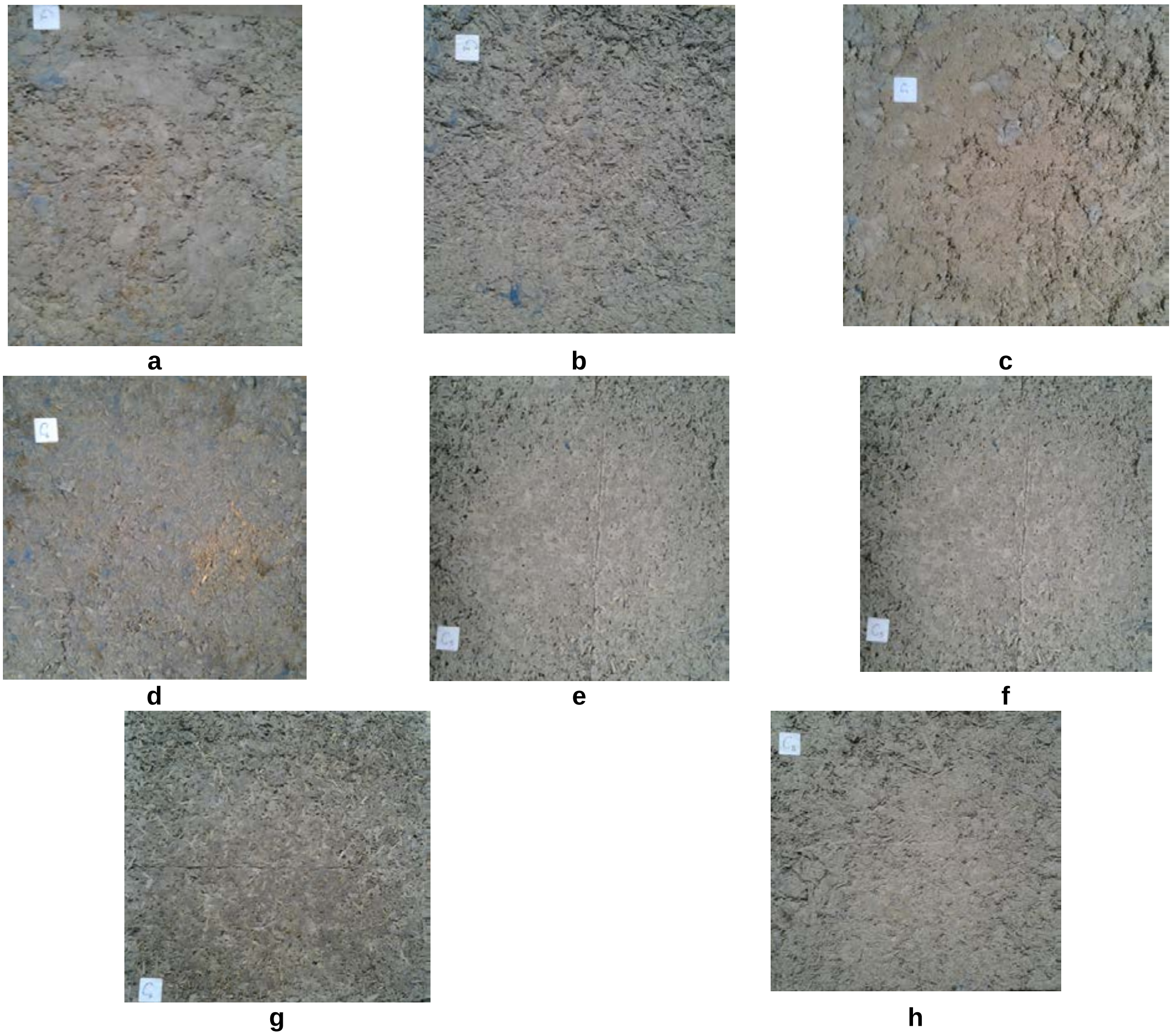


Fig. 2
Biodegradable composite panels obtained:
a - C1structure; b - C2 structure; c - C3 structure; d - C4 structure; e - C5 structure; f - C6 structure; g - C7 structure; h - C8 structure.

Fig. 3
The samples subjected to sound tests.

Table 2

Code numbers, sizes and densities of the specimens cut from the eight proposed composite boards

Code number of the structure	*Specimen code number*	*Sizes of specimen [mm]*		*Density [Kg/m³]*
		Diameter	Thickness	
C1	C1.1 and C1.2	100	30	528.89
C2	C2.1 and C2.2			765.17
C3	C3.1 and C3.2			658.10
C5	C5.1 and C5.2			708.69
C6	C6.1 and C6.2			632.60
C6	C7.1 and C7.2			547.82
C8	C8.1 and C8.2			613.04
Softwood	R1			403.29
Polystyrene	P1			30.43

The specimens were tested using an impedance tube - Kundt tube (Fig. 4), on which two microphones have transmitted the measured data to a specialized software. In order to measure the sound absorption coefficient, the frequency ranged between 50 and 1390Hz and the sound level tested was of 75dB.

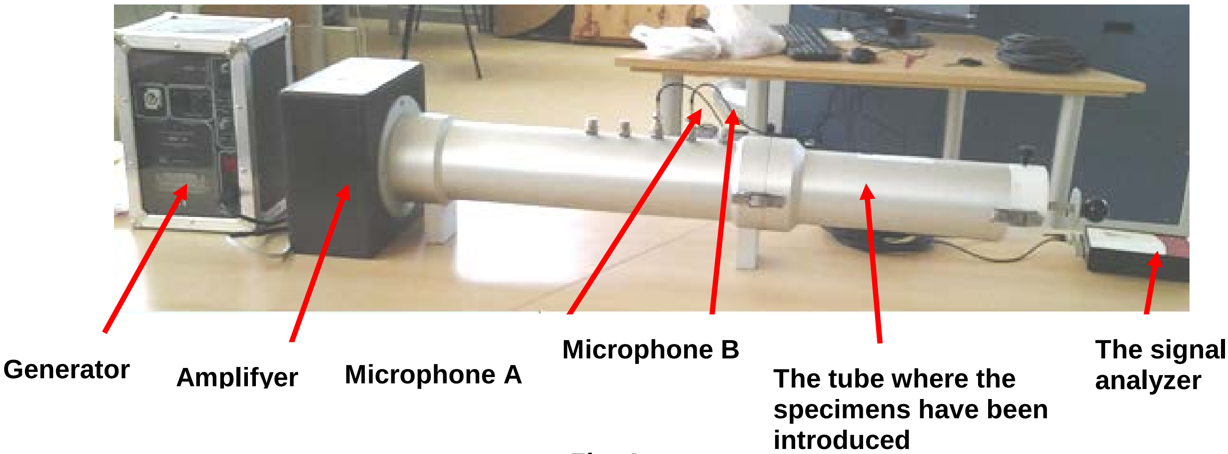
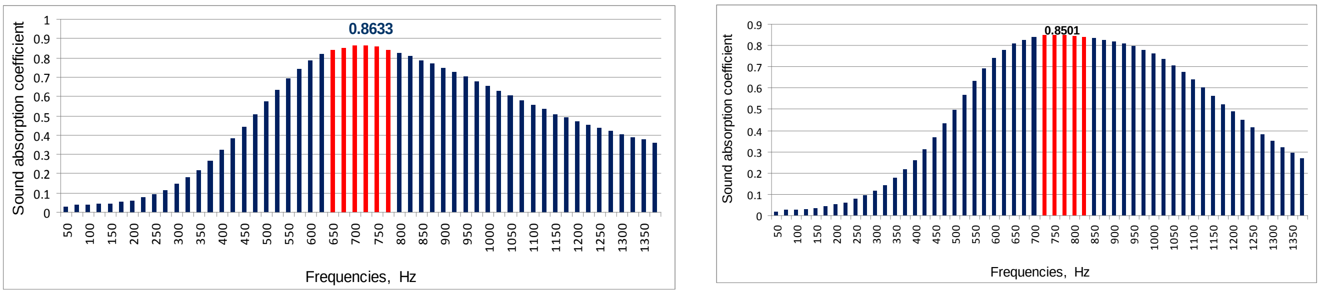


Fig. 4
The impedance tube used to measure the sound absorption coefficient.

The maximum values of the sound absorption coefficients, calculated by the software of the equipment, were taken into account for further calculation. Then, a mean value of the maximum sound absorption coefficients of the two specimens cut from each composite board was calculated and the obtained values were compared afterwards. In order to have a reference value, the sound absorption coefficient of polystyrene was also investigated and used for the comparison.

RESULTS

For the panels C1, C2, C3 and C5, the average value of the sound absorption coefficient α is in the range of 0.8 ÷ 0.9. The C5 panel has its α coefficient very close to 0.9 value, and the range of the frequencies where the sound absorption coefficient has a value above 0.8 is in the range of 650 ÷ 950Hz (Fig. 5).



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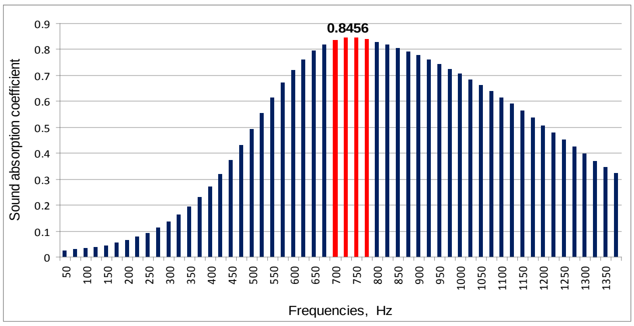

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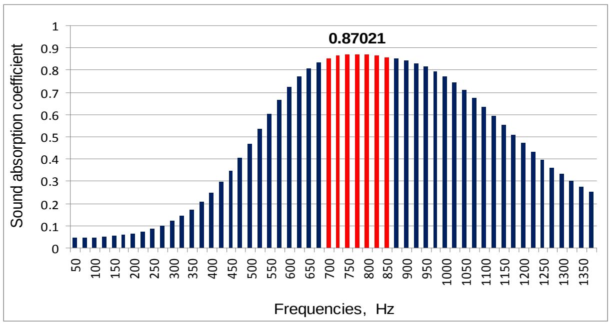

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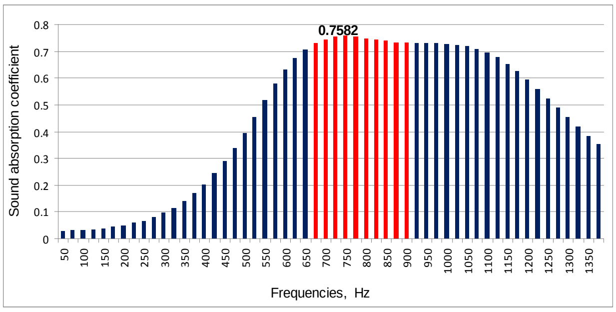

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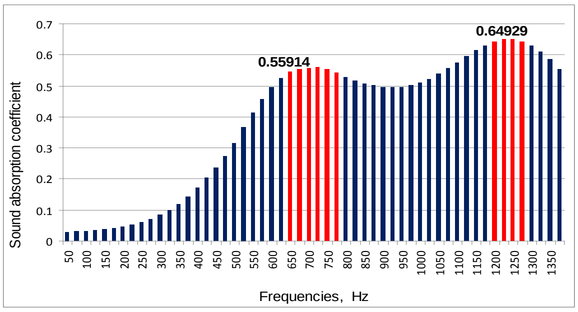

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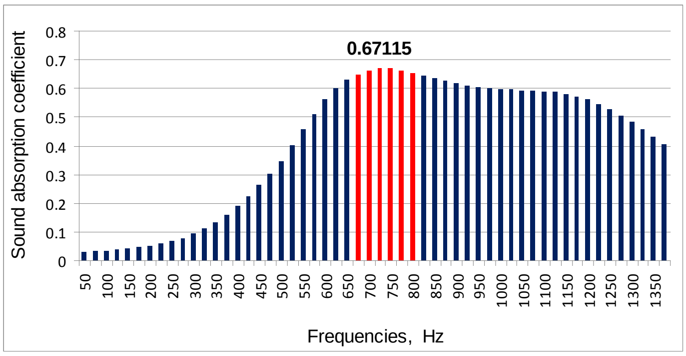

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Fig. 5

The values of the sound absorption coefficient α: a - C1structure; b - C2 structure; c - C3 structure; d - C5 structure; e - C6 structure; f - C7 structure; g - C8 structure.

Comparing the diagrams presented in Fig. 5a, Fig. 5b and 5c respectively, showing the sound absorption coefficient values of the composites symbolized with C1, C2 and C3, it can be noticed that the highest value belongs to C1 structure, which has both wood fibers and wood chips in its composition.

For C6 panel, the average value of sound absorption coefficient α is between 0.7 ÷ 0.8, for the range of frequencies between 650 ÷ 1050Hz.

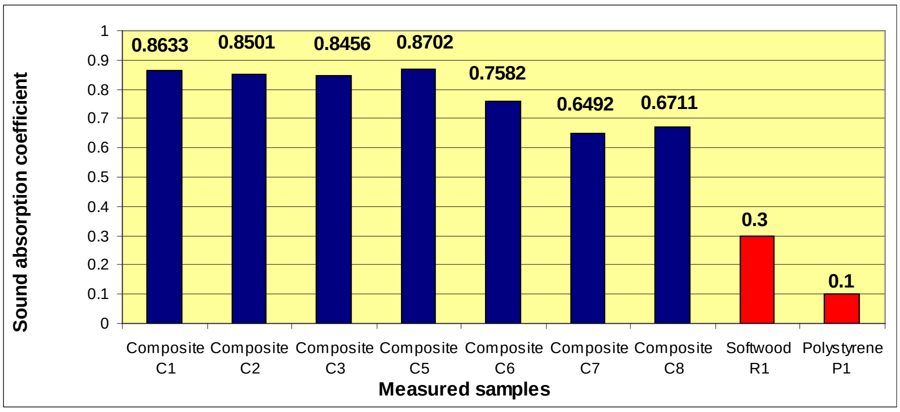

Fig. 6

The maximum values of the sound absorption coefficient for measured samples.

The diagram for the C7 panel shows an increasing of the sound absorption coefficient α, between 600 ÷ 850Hz, the maximum value reached being 0.559. Starting with the frequency of 850Hz, the mean value of the sound absorption coefficient decreases, but increases again over the frequency of 1150Hz, reaching a maximum value of 0.649. Between 1150 ÷ 1300Hz, the sound absorption coefficient for C7 panel is above 0.6. A possible explanation for the shape of the graph of the C7 composite in the range of 800 ÷ 1150Hz is the non-homogeneous structure.

For C5, C6 and C7 composite structures, the maximum sound absorption coefficient was recorded for that structure where equal shares of wood chips and hemp flakes were included in the composition.

The C8 panel made of reeds, wool, cement and water has a mean value of the sound absorption coefficient above 0.6 for the frequencies range of 650 ÷ 900 Hz.

Analyzing Fig. 6, which shows the measured values of the sound absorption coefficient of polystyrene sample P1 and softwood sample R1, it can be noticed the extremely low values of α (the maximum being about 0.1 respectively 0.3) compared to those of the other seven measured samples. According to SR EN ISO 11654, the composites designed by the authors of the present paper are classified as follows: Composites Class B – the panels C1, C2, C3 and C5, Composites Class C – the panels C6, C7 and C8.

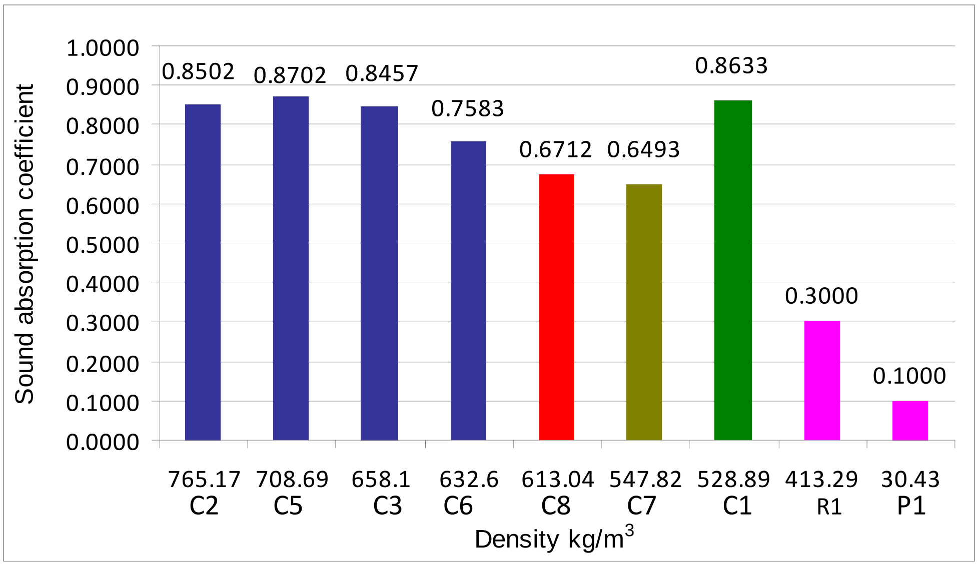

Fig. 7
Densities against the sound absorption coefficient values.

As shown in Fig.7, there is no rule between the increasing/decreasing of sound absorption coefficient values against the density values. In fact, the components of each structure have influence upon the sound investigated property. As seen, the softwood sample R1 has quiet a low sound absorption coefficient, so the wood chips are supposed to not contribute significantly to the sound absorption of the tested composites. Instead, the share of wool can affect the good results of investigation obtained for C1 structure.

CONCLUSIONS

The aim of this study was to demonstrate that the use of the composites made of bio-degradable materials in buildings sound insulation are effective and it was proved by the good results obtained from the tests carried out for determining the sound absorption coefficient. Thus, it was proved that the C5 structure, containing equal amounts of wood chips, hemp and wool waste fibers, had the highest values of the coefficient α. The presence of wood fibers, wood chips and wool fiber in the structure of the C1 composite, brought values of α coefficients very close to those of the C5 composite.

For the C8 composite, which showed the lowest value of the sound absorption coefficient, it was found that a large amount of wood chips combined with a medium amount of wool and a small amount of hemp flakes is not very effective, compared with C5 and C1 composites, where the proportion of bio-degradable material was equal.

As the results of the investigation revealed, the density of the studied composites has no influence upon the value of the sound absorption coefficient. Instead, some of the components (especially the wool) have a positive contribution.

According to the noise map of Brasov, the C5, C1, C2 and C3 panels can be successfully used as sound insulation materials for the buildings on the streets most affected by the urban traffic (Calea Bucureştilor, B-dul Griviţie, Str. Lungă, B-dul Gării, Calea Făgăraşului).

The C6, C7 and C8 panels can be used as buildings soundproofing materials in the areas where the noise value is below 70dB, ie. the back streets of those mentioned above.

For a future research, the authors intend to submit the new composites to other tests, in order to determine their thermal conductivity coefficient, thus to have an overview on the structures that offer the best protection for sound and thermal insulation of the buildings in urban areas.

REFERENCES

Burden of disease from environmental noise. Quantification of healthy life years lost in Europe (2011) http://www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf

Curtu I, Stanciu MD, Coşereanu C, Vasile O (2012) Assessment of acoustic properties of biodegrabable composite materials with textile inserts. Materiale Plastice 49(1):68-72

Coşereanu C, Lăzărescu, C-tin, Olărescu C, Laurenzi W (2012) Ecological solutions for low energy buildings walls. PRO LIGNO 8(1):28-34

Environmental burden of disease associated with inadequate housing. Methods for quantifying health impacts of selected housing risks in the WHO European Region (2011) http://www.euro.who.int/__data/assets/pdf_file/0003/142077/e95004.pdf

Fatima S, Mohanty AR (2011) Acoustical and fire resistance properties of jute composite materials. Applied acoustic 72:108-114

Fernandes ME, Correlo VM, Chagas JAM, Mano JF, Reis RL (2011) Properties of new cork-polymer composites: Advantages and drawbacks as compared with commercially available fiberboard materials. Composite Structure 93:3120-3129

Glé P, Gourdon E, Arnaud L (2011) Acoustical properties of material made of vegetable particles with several scales of porosity. Applied Acoustic Journal, 72:249-259

Mathers CD, Bernard C, Iburg KM, Inoue M, Ma Fat D, Shibuya K, Stein C, Tomijima N, Xu H (2003) Global burden of disease in 2002: data sources, methods and results. Geneva, World Health Organization (Global Programme on Evidence for Health Policy discussion paper No. 54) (http://www.who.int/healthinfo/paper54.pdf, accessed 31 May 2012).

Oldham DJ, Egan CA, Cookson RD (2011) Sustainable acoustic absorbers from the biomass. Applied Acoustics 72:350-363

SR EN ISO 10534-2/2005 Acoustics. Determination of sound absorption coefficient and impedance in impedance tubes. Part 2: Transfer-functions methods

SR EN ISO 11654/2002 Acoustics. Acoustic absorbers for use in buildings. Evaluation of acoustic absorption

Zhao J, Wang XM, Chang JM, Yao Y, Cui Q (2010) Sound insulation property of wood-waste tire rubber composite. Composits Science and Technology, 70:2033-2038