MOKSLAS – LIETUVOS ATEITIS
SCIENCE – FUTURE OF LITHUANIA
ISSN 2029-2341 print / ISSN 2029-2252 online
2012 4(5): 415–422 doi:10.3846/mla.2012.67

EXPERIMENTAL INVESTIGATION INTO NOISE INSULATION OF STRAW AND REEDS

Saulė Deveikytė[1], Jurgis Mažuolis[2], Petras Vaitiekūnas[3]
Vilnius Gediminas Technical University
E-mails: [1]s.deveikyte@yahoo.co.uk; [2]jurgis.mazuolis@vgtu.lt; [3]petras.vaitiekunas@vgtu.lt

Abstract. Sound insulation is mainly affected by the mass or density of the wall. Therefore, in order to compare their effectiveness depending on thickness, the specimens of the same density have been made. Sound insulation also depends on sound frequency, and therefore frequency dependent analysis has been conducted. Considering all positions of thickness, the effectiveness of sound reduction has been dispersed with deep dips in some specific frequencies. Besides, the effectiveness of straw and different configurations of reeds has been compared with respect to frequency bands.

Keywords: noise insulation, reduction in sound level, noise suppression chamber, straw, reeds, sustainable material.

Introduction

An increase in noise level affects people not only in industry but also in the living environment. The need for new applications of addressing acoustic problems has been constantly growing. New or forgotten materials, which get the necessary qualities while processing less, are investigated.

The effective treatment of waste is an important issue throughout the world, including Lithuania. Priority is given to a reduction in waste generation or stuff necessary to be reused. Waste having no possibilities of being effectively applied under original characteristics is processed into secondary raw materials. The last option – energy recovery – should be used only for unrecyclable waste, since relevant energetic processes are not possible without by-products – gaseous environmental pollutants.

Waste-free production is not yet possible, but a tendency towards the process of reusing waste in industry is getting stronger. This is a solution not only to the problem of waste, but also to the conservation of resources. Although the use of waste materials is still under development, it is a promising area of processing a wide range of products. If waste is also natural material, the product becomes even more sustainable.

One of the potential merits of biobased products is the utilization of renewable resources instead of non-renewable resources (Kim, Dale 2004). The variety of usage reduces the problem of waste deposition. In addition, natural features of such natural materials can be directly used without polluting production.

Straw could be one of the examples of potential natural material. In times of independent Lithuania between two world wars, 4 million tons of straw were produced (Lietuvos kaimo... 2009). The amount of straw made in Lithuania is calculated according to the grain crop area, yield and individual plant species in grain and straw ratio (Gurskis, Juodis 2007). Our production annually makes around 3.5 to 4 million tons of straw a part of which is used for animal feed, bedding, gardening, etc. Another part suffers from the loss of harvest (Studijos šiaudų... 2007). However, about 0.5 to 1.5 million tons of straw remain unused. These by-products are often not valuated by farmers and disposed of as waste by incineration or digestion in the field. Even rural areas can often face burned crops of cut loose straw or unused straw stack, although this is prohibited by the law and such conduct at the penalty. A large part of straw (practically all crop farms are engaged) is crushed and spread in the fields during harvest time, although it is a low value fertilizer (Gurskis, Juodis 2007).

Reeds could be another example of potential natural material. They compose overgrowths of river and lake shores, wetlands and coasts and are not frequently found in dry sandy soil. They have long rhizomes with roots intertwining with each other and form a dense water network. During winter, their stems dry out leaving only underwater roots alive. Naturally, only one type of reeds – the common reed (*Phragmites australis*) (ŽŪE 2003) can be observed in Lithuania.

Only the coast of the Curonian lagoon in Lithuania can offer 8.5 thousand tons of reeds. When reeds reach a height of 2 m, from 8 to 12t of dry weight reeds can be obtained from one hectare (Kazragis, Gailius 2006).

Reeds naturally growing in lakes create wildlife habitats (Raudonikis 2010). However, in some places, their population has to be regulated in order not to succeed other important species and to support the biodiversity of the place. Reed cutting is a common option of managing seaside and coastal habitats (Eglīte 2005). If a sufficient market for reed production were created considering various demands, it would be easier and cheaper to plan and conduct the restoration and maintenance of habitats.

Reeds have been used as construction material for more than a thousand years. In the end of the 9th century, first reed pressing machines were designed. Then, reed blocks were used for building houses and churches in Nebraska. Roofs made of reeds and straw (thatch) have become popular all over world, including Lithuania (Pčelina 2008). Nowadays, reeds are being investigated as thermo-isolating (Vėjelienė *et al.* 2011) and noise absorbing material (Chilekwa *et al.* 2006; Oldham *et al.* 2011).

The paper has investigated another important feature of potential materials which is a reduction in the sound level of dry straw and reed stems composed without additives.

Methodology

A laboratory method of measuring airborne sound insulation of building elements such as walls is specified by standard LST EN ISO 10140-2:2010.

Investigation was carried out in a noise suppression chamber at the Department of Environmental Protection of Vilnius Gediminas Technical University (VGTU). The entire surface area (walls, flooring, ceiling, partition) of the interior of the noise suppression chamber totals 70 m^2 and is covered with 0.25 m of layer boards of cut acoustic foam (cutting step of 0.15 m) of a conical form (Grubliauskas, Butkus 2009). The rooms of the noise suppression chamber are insulated from noise, vibration and thermal and hydro effect from each other with regard to an external building (Grubliauskas 2009).

Acoustic properties of reed specimens in the noise chamber were analysed applying measuring equipment produced by Danish company Bruel & Kjaer and consisted of:

- real time-sound spectral analyser (Brue & Kjaer mediator 2260);
- microphone 4189 (Bruel&Kjaer - 2 pcs.);
- power amplifier (Bruel & Kjaer - 300 W);
- omni-directional source with twelve speakers (producer - Bruel & Kjaer; frequency characteristics - from 100 to 3150 Hz) with a tripod the regulated height of which varied from 1.3 to 2.0 m (Fig. 2, 3).

The levels of sound pressure were measured employing a noise-and-vibration-recording device – Bruel & Kjaer mediator 2260. A relative measuring error of this device is ±1.5%. The instrument records sound in the frequency range from 6.3 to 20 kHz, has two measuring channels, and therefore can simultaneously record sound at different points using two microphones one of which is positioned in the source room, whereas another – in the target room. As the device is pre-installed with a processor and special software, it statistically processes the measurement results (Grubliauskas, Butkus 2009).

Reduction in sound level between two rooms separated by specimens is evaluated according to the formula

$$\Delta L = L_1 - L_2 \text{, dB;} \tag{1}$$

where L_1 – medium equivalent sound pressure level in the source room, dB; L_2 – medium equivalent sound pressure level in the target room, dB.

Preparation of Specimens

Specimens of chopped straw

A mix of chopped rye straw was used in the first experiment. A diameter of straw varied from 1 to 5 mm (Vėjelienė *et al.* 2011) and their length made approximately 100 mm. For convenient storage and transportation, they had been pressed and tightened in the harvesting place. Straw-bale (0.7×0.5×0.3 m) was separated in its own step – every 50 mm (Fig. 1).

Straw were put in the special frames made of fine mesh. The used frames differed in thickness: 50 mm, 100 mm 150 mm and 200 mm. The filler was naturally pressed not damaging the structure of straw and maintaining the same density (~ 88 kg/m^3) of every specimen.

Specimens of whole reeds

The specimens of whole reeds were designed as stems perpendicular to the source of noise. The specimens were cut

Fig. 1. Straw-bale and specimen preparation

to a height of 1 m and placed in the frame next to each other. The diameter of reeds varied in a range of 5–10 mm (Fig. 2). Reed mats are porous in nature and have gaps along the length of reeds due to the irregularity of diameters. These are connected with large voids between reeds, which results in air paths through reed mats. Recent research has established that due to a specific structure of pores, thick reed mats have good characteristics of sound absorption, including excellent performance at medium-high frequencies (Jiménez Espada *et al*. 2009). The prepared specimens of whole reeds had four types of thickness: 50 mm, 100 mm, 150 mm and 200 mm (Fig. 2).

The filler was pressed with natural force not damaging the structure of reeds and reaching the same highest naturally possible density (~ 125 kg/m^3) of every specimen.

Specimens of chopped reeds

The specimens of chopped reeds were designed as stems parallel (end-on) to the source of noise. The idea comes from the wall of tiny end-on tubes with the length of the thickness of the wall.

Reed stems (diameter varies in a range of 5–10 mm) were cut into the length of 200 mm (maximum possible thickness of specimens in the noise-suppression chamber) and put together into small agile bundles. Directing the stems parallel to the source of noise, the bundles were put regularly next to each other and naturally pressed into the equally distributed volume of the frame (Fig. 3). The filler was naturally pressed not damaging the structure of reeds and reaching the highest naturally possible density (~ 150 kg/m^3) of specimens.

At a later stage, the same bundles of reeds were cut into the length of 150 mm and put together in the frame in the same manner (Fig. 4). The filler was pressed with natural force not damaging the structure of reeds and reaching the highest naturally possible density (~ 164 kg/m^3) of specimens.

The leftovers from cutting were 50 mm long. This size of the stem particle is too small for parallel design. Therefore, the residuals were put into special frames (50 and 100 mm thickness) as a random mix (Fig. 5). The filler was naturally pressed not damaging the structure of reeds and reaching the density (~ 164 kg/m^3) of specimens.

The specimen (1 m × 1 m) was mounted in the orifice of the dividing wall of the noise suppression chamber. Measurements were done in the frequency bands of 1/3 octave (in the range from 100 Hz to 3150 Hz).

Fig. 2. The specimens of whole reeds are presented by four types of thickness

Fig. 3. The process of preparing the specimens of chopped reeds (200 mm thickness)

Fig. 4. The process of preparing the specimens of chopped reeds (150 mm thickness)

Fig. 5. Chopped reeds as the specimens of a random mix (thickness of 50 mm)

Results and Analysis

All specimens of straw had the density of approximately 88 kg/m^3 and the thickness of 50 mm, 100 mm, 150 mm and 200 mm. It was predicted that thicker specimens should have better sound insulation. It turned out to be true and the trends towards every type of thickness were quite similar.

Straw specimens were the most effective at lower frequencies. A reduction in sound level reached the peak at the frequency of 125 Hz considering all types of thickness. Then, a trend indicated a decrease in up to 1250 Hz where an increase in effectiveness started in all types of thickness (Fig. 6).

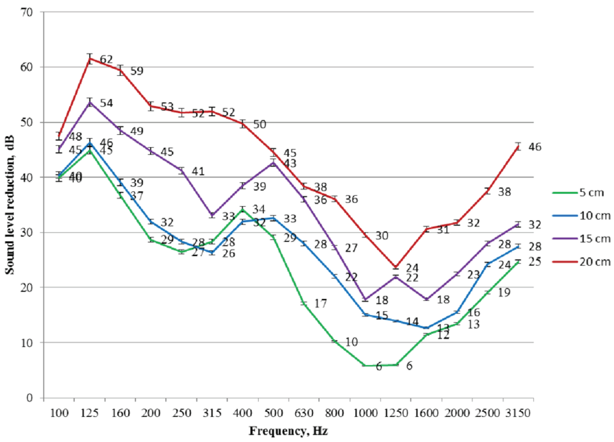

Fig. 6. The dependance of reduction in sound level on the thickness of straw specimens within frequency bands

The specimens of 200 mm thickness were the most effective and reached 62 dB at the frequency of 125 Hz. The lowest value of 24 dB at the frequency of 1250 Hz was still good enough for noise barrier.

The specimens of 150 mm thickness reached the effectiveness of 54 dB at the frequency of 125 Hz. Then, a few trends followed: a decrease in up to 33 dB at the frequency of 315 Hz, an increase in up to 43 dB at the frequency of 500 Hz and a drop again in up to 18 dB at the frequency of 1000 Hz. However, at the frequency of 1250 Hz, effectiveness increased up to 22 dB. A similar situation was observed at the frequency of 1600 Hz.

The specimens of 100 mm thickness reached the effectiveness of 46 dB at the frequency of 125 Hz. Next, the following trends could be observed: a decrease in 26 dB at the frequency of 315 Hz, an increase in up to 33 dB at the frequency of 500 Hz and a drop again in up to 13 dB at the frequency of 1600 Hz where a growth in effectiveness started.

The specimens of 50 mm thickness had similar effectiveness to that shown by the specimens of 100 mm. They reached the effectiveness of 45 dB at the frequency of 125 Hz differing from specimens thicker than 50 mm in only 1 dB. The thinnest specimens even had the superiority of 2 dB at the frequencies of 315 Hz and 400 Hz compared to specimens thicker than 50 mm. However, effectiveness was dipping very fast to 6 dB at the frequencies of 1000 Hz and 1250 Hz. Still, it increased fast enough differing in only 1–5 dB from specimens thicker than 50 mm.

Difference in 8 dB between the highest values of the straw specimens of 200 mm and 150 mm thickness and those of 150 mm and 100 mm thickness can be noticed. Further difference in comparing these types of thickness may vary from 2 dB to 19 dB.

The specimens of whole reeds had the density of about 125 kg/m^3. All types of thickness (5 cm, 100 mm, 150 mm and 200 mm) reached the greatest degree of effectiveness in the range of high frequency varying from 2000 to 3150 Hz. The influence of thickness was not as obvious in the range of low frequency (100–500 Hz) as that in the range of high frequency (Fig. 7).

At the frequency of 125 Hz, all specimens reached the peak of efficiency in the range of low frequency. The difference between 50 mm (16 dB) and 100 mm (23 dB)

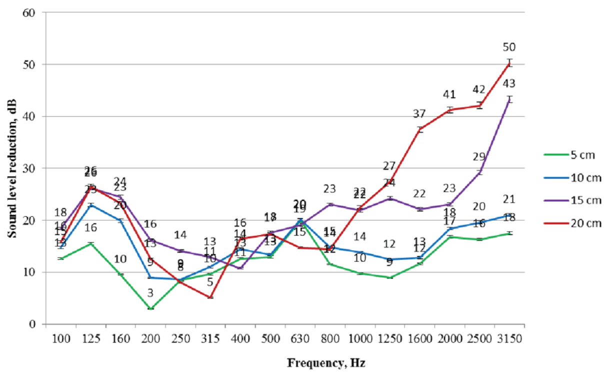

Fig. 7. The dependance of reduction in sound level on the thickness of the specimens of whole reeds within frequency bands

specimens was 6 dB; however, it made only 3 dB between 100 mm and 150 mm (26 dB) specimens and no difference was observed between the samples of 150 mm and 200 mm (26 dB).

The specimens of the whole reeds of 200 mm thickness showed even worse results than those of 150 mm thickness in low and middle frequency ranges up to 1000 Hz. At higher frequencies, the efficiency of specimens thicker than 50 mm was surpassing by 3–18 dB.

At the frequency of 3150 Hz, the specimens of the whole reeds of 200 mm reached the effectiveness of 50 dB, while that of 150 mm specimens made 43 dB, 100 mm – only 21 dB and 50 mm – 18 dB. Thus, a decrease in the thickness of the specimens of the whole reeds of 50 mm leads to a difference in 14%, 51% and 14% respectively.

All specimens of whole reeds had dips in their efficiency occurring at low frequency ranges. Additional dips in the end of middle frequency ranges occurred in the specimens of 50 mm and 100 mm thickness. Dips can be explained by resonance effect at low frequencies and coincidence effect at higher frequencies.

Resonance effect occurred on the specimens of the whole reeds of 50 mm (3 dB) and 100 mm (9 dB) thickness at the frequency of 200 Hz. For the specimens of 150 mm thickness, the lowest value (11 dB) was noticed at the frequency of 400 Hz. The efficiency of the specimens of the whole reeds of 200 mm thickness decreased to 5 dB at the frequency of 315 Hz. Coincidence effect was noticed only in the specimens of the whole reeds of 50 mm and 100 mm thickness. Their critical frequency seems to be 1250 Hz where efficiency decreased to 9 dB and 12 dB respectively. The coincidence effect of the specimens of the whole reeds of 150 mm and 200 mm might be postponed to higher frequencies, which are not taken into account in this research due to limitations on norms.

To sum up information on the specimens used in this research, an increase in the thickness of the composition of whole reeds generally gives a better reduction in sound, especially in high frequency range. However, compared to the composition of the whole reeds of 200 mm thickness, the composition of those of 150 mm thickness might be seen as a more convenient choice. The latter has more consistent growth and great efficiency of sound reduction (23–43 dB in 800–3150 Hz). The specimens of chopped reeds had the density of about 150 kg/m^3. All specimens had the highest efficiency in the frequency range from 2000 to 3150 Hz. The influence of thickness was obvious in all frequency ranges for 200 mm and 150 mm end-on configurations (Fig. 8). The specimens of the chopped reeds of 50 mm showed different trends reaching the effectiveness of the specimens of the chopped reeds of 150 mm in the range of low frequency, but were not as effective as those in the range of high frequency. The explanation for these different trends might be different orientation to chopped reeds in two specimens. Thus, the specimens of the chopped reeds of 100 mm surpassed the effectiveness of the specimens of the chopped reeds of 200 mm in the ranges of low and high frequency. However, in the range of middle frequency, 200 mm end-on specimens were more effective than those of 100 mm mixed configuration.

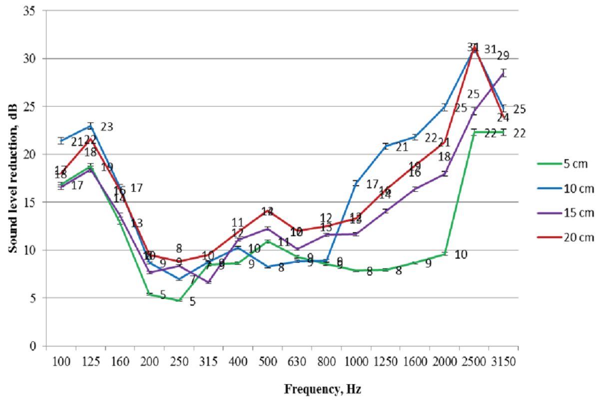

Fig. 8. The dependance of reduction in sound level on the thickness of the specimens of choppeed reeds within frequency bands

At the frequency of 125 Hz, all specimens reached the peak of efficiency in the range of low frequency. The difference between 150 mm (18 dB) and 200 mm (22 dB) specimens was 4 dB (20%). Those thinner than 100 mm (mixed configuration) had the efficiency of 19 dB at the frequency of 125 Hz compared to 150 mm end-on configuration having the efficiency of 18 dB.

At the frequency of 2500 Hz, the specimens of the chopped reeds of 200 mm (end-on) reached 31 dB, differing by 20% from the specimens of chopped reeds (end-on) thinner than 50 mm. The latter reached the maximum efficiency (29 dB) at the frequency of 3150 Hz. Although the mix of the chopped reeds of 50 mm thickness was more effective at higher frequencies, it did not follow the trend towards end-on configurations and was less effective compared to the end-on reed specimens of 150 mm thickness.

All specimens of chopped reeds had dips in their efficiency occurring in the range of low frequency. Resonance effect on the specimens of chopped reeds occurred at the frequency of 200 Hz for 50 mm (5 dB), at the frequency of 250 Hz for 100 mm (7 dB), at the frequency of 315 Hz for 150 mm (7 dB) and at the frequency of 250 Hz for 200 mm (9 dB) samples.

Coincidence effect was postponed to higher frequencies and not taken into account in this research because of limitations on norms.

Concluding data on the specimens used in this research, an increase in the thickness of the composition of chopped reeds generally gives a better reduction in sound, particularly in the range of high frequency. However, the mixed configuration of 50 mm thickness gives as good results as those of 150 mm end-on configuration, but only in low frequency range. The mixed configuration of 100 mm thickness gives even better results than those of 200 mm end-on configuration at low and high frequency range.

The efficiency of different specimens (straw mix, whole reeds perpendicular to the source of noise and the mix of chopped reeds) of the same 50 mm thickness was analysed. The best choice of efficiency differed depending on frequency range (Fig. 9).

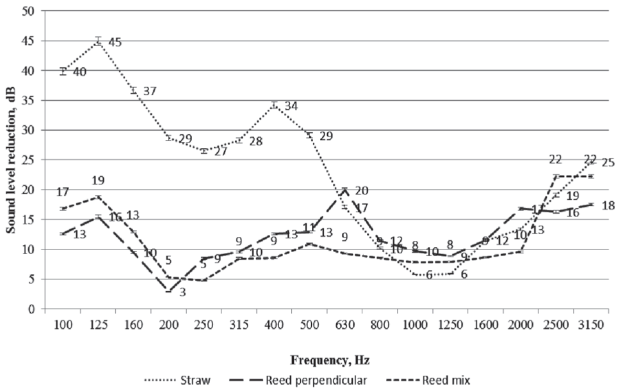

Fig. 9. The dependance of reduction in sound level on the material configurations of 50 mm thickness within frequency bands

The most effective specimens of the straw mix made 40–27 dB and were found in the range of low frequency. However, it was the least effective in middle frequency range dipping to 6 dB at the frequency varying from 1000 to 1250 Hz.

The specimens of whole reeds were generally more effective than those included in the mix of the chopped reeds of the same thickness. The highest peak at the frequency of 630 Hz was 20 dB compared to 9 dB for the mix of chopped reeds, which, however, was about 20% more efficient than whole reeds at the frequencies varying from 100 to 200 Hz and from 2500 to 3150 Hz.

A comparison of the specimens of the straw mix of 100 mm thickness, whole reeds perpendicular to the source of noise and the mix of chopped reeds indicate that the efficiency of straw was obvious in the range of low and middle frequencies (Fig. 10). As for high range frequency, the mix of chopped reeds surpassed other specimens reaching 31 dB at 2500 Hz. Still, when dipping to its coincidence frequency (1600 Hz), the specimens of the straw mix reached the same efficiency as those of whole reeds and made 13 dB.

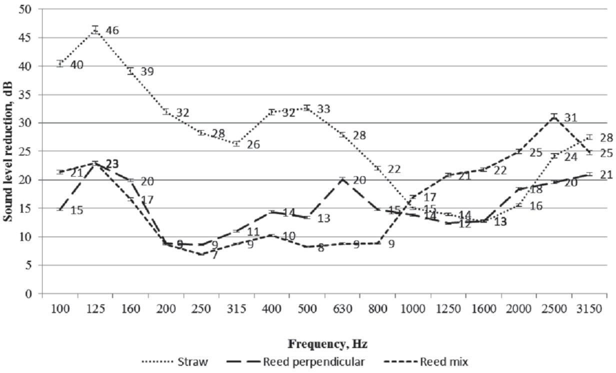

Fig. 10. The dependance of reduction in sound level on the material configurations of 100 mm thickness within frequency bands

Comparing the specimens of the straw mix of 150 mm thickness, whole reeds perpendicular to the source of noise and chopped reed end-on to the source of noise, the efficiency of straw was the highest in the range of low and middle frequency (Fig. 11).

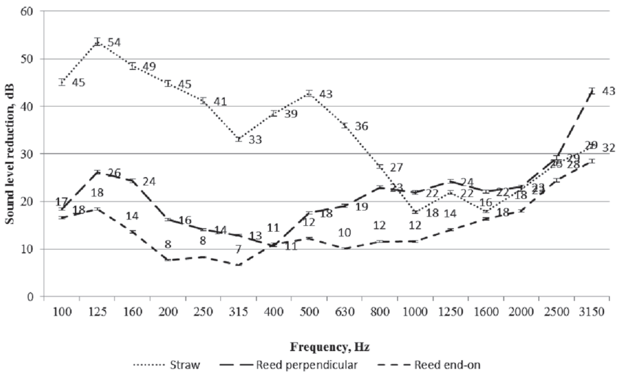

Fig. 11. The dependance of reduction in sound level on the material configurations of 150 mm thickness within frequency bands

Only in its coincidence frequency (1000 Hz) the efficiency of the specimens of the straw mix dipped to 18 dB and ended in worse results than those of the specimens of whole reeds. The specimens of whole reeds perpendicular to the source of noise were more efficient than the end-on configuration of chopped reeds in all frequencies. Only at the frequency of 400 Hz, the efficiency of perpendicular reeds dipped to the efficiency of end-on reeds (11 dB).

A comparison of the specimens of the straw mix of 200 mm thickness, whole reeds perpendicular to the source of noise and chopped reed end-on to the noise source discloses that the highest efficiency of straw was found in the range of low and middle frequency (Fig. 12).

Only dipping in its coincidence frequency (1250 Hz) straw specimens were surpassed by those of whole reeds that were generally more effective than chopped reed end-on configuration. Only a dip in resonance frequency (315 Hz) made perpendicular reeds 50% less effective than end-on reed.

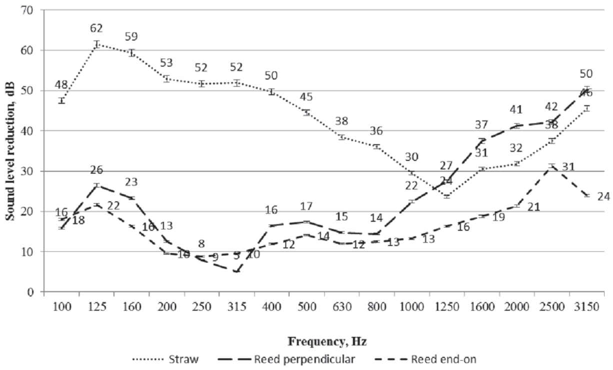

Fig. 12. The dependance of reduction in sound level on the material configurations of 200 mm thickness within frequency bands

Discussion

The obtained results are quite surprising because the previous researches have showed that walls made of straw are more effective in the range of middle and high frequency (Januševičius 2011; Aškelovič *et al.* 2011). Differences in the results could be explained by differences in the material itself and used constructions. First, straw can have different physical properties depending on their kind and the place of growing (Januševičius 2011). Second, the preparation of straw (pressure, density) can lead to different properties of the final material. In addition, the preparation of the testing sample and mounting can also affect the results. Therefore, every new suggestion of an element made of straw should be tested to find actual effectiveness.

Research on the absorption coefficient of incident sound considering the samples of reeds in the impedance tube (Chilekwa *et al.* 2006; Oldham *et al.* 2011) has also revealed that perpendicular configuration gives better results compared to end-on configuration.

Yet, no other research on the efficiency of reducing sound using the specimens of whole reeds have been carried out. However, some investigations into sound absorption involving the panels of whole reeds used in the reverberation room (Jiménez Espada *et al.* 2009) have been conducted. The coefficient of reverberant sound absorption shows the efficiency of controlling the field of reverberant sound in enclosed spaces (LST EN ISO 354:2006). A reduction in sound level is gained between two rooms separated by specimens. Thus, these two values are not really comparable. Nevertheless, they both are important for evaluating a possible application of the composition of whole reeds. Research done in the reverberation room (Jiménez Espada *et al*. 2009) has showed that the resonance frequency of the system moves to low frequencies when the thickness of the material increases and that the coefficient of reverberant sound absorption does not depend on the thickness of the material at high frequencies above 1000 Hz.

Thus, considering the specimens of whole reeds, the trend towards the coefficient of reverberant sound absorption completely differs from the trend to reducing sound level where the dependence of efficiency on thickness increases at high frequencies.

Also, no studies on the efficiency of reducing sound applying the specimens of chopped reeds have been undertaken yet apart from those conducted in the impedance tube (Chilekwa *et al.* 2006; Oldham *et al.* 2011). The incident coefficient of sound absorption shows the ratio of sound power entering the surface of the tested object to the power of incident sound for a plane wave at normal incidence (LST EN ISO 10534-2:2002). A reduction in sound level is gained between two rooms separated by specimens. Thus, these two values are not really comparable. However, they both are important for evaluating a possible application of the composition of chopped reeds. Research done in the impedance tube (Chilekwa *et al.* 2006; Oldham *et al.* 2011) has disclosed that an increase in the thickness of specimens shows higher values of the incident sound absorption coefficient at all frequencies and the peak of efficiency occurs at lower frequencies.

Thus, taking into account the specimens of chopped reeds, the trend towards the incident sound absorption coefficient is similar to that of a reduction in the sound level where efficiency at all frequencies also depends on increased thickness.

Conclusions

1. In low frequency range the most effective of the researched specimens was the 200 mm straw mix (88 kg/m^3) – 62 dB in 125 Hz frequency.
2. In middle frequency range the most effective of the researched specimens was the 150 mm chopped end-on reeds (88 kg/m^3) – 23 dB in 800 Hz frequency.
3. In high frequency range the most effective of the researched specimens was the 200 mm whole reeds perpendicular to the noise source (125 kg/m^3) – 50 dB in 1350 Hz frequency.

References

Aškelovič, V.; Januševičius, T.; Butkus, D. 2011. Garso dažninės charakteristikos triukšmo slopinimo kameroje tyrimai, iš *Aplinkos apsaugos inžinerija: 14-osios Lietuvos jaunųjų mokslininkų konferencijos „Mokslas – Lietuvos ateitis" straipsnių rinkinys (2011 m. balandžio 14 d.)* Vilnius: Technika, 223–226.

Eglīte, L. 2005. *Baltijos LIFE-Nature projektų patirtis: planavimas-įgyvendinimas-tęstinumas*. Buveinių tvarkymo patirties pasidalijimas tarp LIFE-Nature projektų. Riga: Baltic Environmental Forum. 64 p.

Chilekwa, V.; Sieffert, G.; Egan, C.A.; Oldham, D. 2006. The Acoustical Characteristics of Reed Configurations, in *Proceedings of the 6th European Conference on Noise Control* (*Euronoise 2006, 30 May – 1 June 2006 Tampere, Finland).* Tampere: European Acoustics Association, 6 p. [online], [cited 10 March 2011]. Available from Internet: www.holiwood.org/fileadmin/ablage/04_publications/.../Chilekwa-et-al.pdf

Grubliauskas, R. 2009. *Aplinkos triukšmo ir jo mažinimo, taikant lengvas konstrukcijas, tyrimai bei skaitinis modeliavimas* [Research and digital modelling of environmental noise and its reduction by applying light stuctures]. Daktaro disertacija. Vilnius: Technika. 138 p. http://dx.doi.org/10.3846/1648-6897.2009.17.97-105

Grubliauskas, R.; Butkus, D. 2009. Chamber investigation and evaluation of acoustic properties of materials, *Journal of Environmental Engineering and Landscape Management* 17(2): 97–105.

Gurskis, V.; Juodis, J. 2007. *Presuotų šiaudų ryšulių tinkamumas pastatų statybai* [online] 2007. [Cited 18 September 2010]. Available from Internet: http://www.siaudunamai.lt

Januševičius, T. 2011. *Statybinių medžiagų ir konstrukcijų akustinių savybių tyrimas ir panaudojimas triukšmui mažinti patalpose* [Research on the acoustic qualities of building materials and structures and their use for noise reduction in premises]. Daktaro disertacija. Vilnius: Technika. 152 p.

Jiménez Espada, M.; Díaz Sanchidrián, C.; Navacerrada Satu–rio, M. 2009. Noise absorbers properties of reed for using in fitting acoustic enclosures, in *Proceedings of the 1st International Conference on Construction and Building Research*, 24–26 June 2009, Madrid (Spain), pp 8 [online] [cited 13 April 2011]. Available from Internet: www.holiwood.org/fileadmin/publications/2009/UPM_090624_Proceedings_Acoustic_properties_of_reed_NPBS.pdf

Kazragis, A.; Gailius, A. 2006. *Kompozicinės medžiagos ir dirbiniai su gamtiniais organiniais užpildais*. Vilnius: Technika. 256 p.

Kim, S.; Dale, B. E. 2004. Global potential bioethanol production from wasted crops and crop residues, *Biomass and Bioenergy* 26: 361–375. http://dx.doi.org/10.1016/j.biombioe.2003.08.002

Lietuvos kaimo plėtros 2007–2013 metų programos galimybės atsinaujinančiai energijai plėtoti [online] 2009. [Cited 18 September 2010]. Available from Internet: <http://www.zum.lt>.

LST EN ISO 10140-2:2010. *Akustika. Laboratorinis pastato elementų garso izoliacijos matavimas*. 2 dalis. *Ore sklindančio garso izoliacijos matavimas* [Acoustics – Laboratory measurement of sound insulation of building elements – Part 2: Measurement of airborne sound insulation]. 16 p.

LST EN ISO 10534-2:2002. *Akustika. Garso sugerties koeficiento ir pilnutinės varžos nustatymas interferometrais*. 2 dalis. *Perdavimo funkcijos metodas* [Acoustics – Determination of sound absorption coefficient and impedance in impedances tubes – Part 2: Transfer-function method]. 29 p.

LST EN ISO 354:2006. *Akustika. Garso sugerties matavimas aidėjimo kameroje* [Acoustics – Measurement of sound absorption in a reverberation room]. 28 p.

Noise Transmission. 1999. [Online], [cited 10 February 2012]. Available from Internet: http://www.kemt.fei.tuke.sk/Predmety/KEMT320_EA/_web/Online_Course_on_Acoustics/transmission.html

Oldham, D. J.; Egan, C. A.; Cookson, R. D. 2011. Sustainable acoustic absorbers from the biomass. *Applied Acoustics* 72: 350–363. http://dx.doi.org/10.1016/j.apacoust.2010.12.009

Pčelina, M. 2008. Mediniai ir nendriniai stogai, iš *Statyba: 11-osios Lietuvos jaunųjų mokslininkų konferencijos „Mokslas – Lietuvos ateitis", įvykusios Vilniuje 2008 m. balandžio 2–4 d., pranešimų medžiaga.* Vilnius: Technika, 56–62.

Raudonikis, L. 2010. *Europos bendrijos svarbos paukščių rūšių, kurių apsaugai būtina steigti teritorijas, būklės įvertinimas 2009 m.* Mokslinio tyrimo darbo ataskaita [interaktyvus]. Vilnius: Gamtos tyrimų centras. 206 p. [žiūrėta 2011 m. sausio 11 d.] Prieiga per internetą: http://gamta.lt/cms/index?rubricId=33722356-5222-409d-89f7-05f31ef1c06e

STR 2.01.01(5):2008 Esminis statinio reikalavimas. Apsauga nuo triukšmo

Studijos *Šiaudų kuro naudojimo technologijų įvertinimas ir rekomendacijų tolimesniam jų naudojimui bei biokuro briketų iš smulkių šiaudų ir žolinių augalų paruošimo technologijos parengimas* ataskaita [online] 2007. [Cited 18 September 2010]. Available from Internet: http://www.enmin.lt/lt/activity/veiklos_kryptys/atsinaujantys_energijos_saltiniai/darbai.php

Vėjelienė, J.; Gailius, A.; Vėjelis, S.; Vaitkus, S.; Balčiūnas, G. 2011. Evaluation of Structure Influence on Thermal Conductivity of Thermal Insulating Materials from Renewable Resources, *Materials Science (Medžiagotyra)* 17(2): 208–212.

Žemės ūkio enciklopedija, T. 2. 2003. Red. tarybos pirm. A. Kusta. Vilnius: Mokslo ir enciklopedijų leidybos institutas, p. 579 (Nendrė).

ŠIAUDŲ IR NENDRIŲ TRIUKŠMO IZOLIACIJOS EKSPERIMENTINIAI TYRIMAI

S. Deveikytė, J. Mažuolis, P. Vaitiekūnas

Santrauka

Ieškoma vis naujų akustinių problemų sprendimo būdų. Tyrinėjamos naujos ir pamirštos medžiagos, kurių apdorojimo procesas galėtų būti darnus aplinkai. Natūralių atliekinių medžiagų panaudojimas gali būti tvarus sprendimas. Nendrės, apaugančios ežerų, upių ir marių krantus, gali būti pjaunamos natūraliai išdžiūvusios žiemą ir naudojamos kaip konstrukcinė, šilumos izoliacinė arba garso sugerties medžiaga. Šis tyrimas siekė nustatyti šiaudų ir nendrių kaip triukšmo izoliavimo medžiagų galimybes. Triukšmo slopinimo kameroje tirti vienodo tankio (88, 125, 164 kg/m^3) skirtingų storių (5, 10, 15, 20 cm) šiaudų ir nendrių bandiniai. Nendrių bandiniai turėjo ryškų rezonanso efektą žemų dažnių srityje. Šiaudų bandiniai efektyviausiai sumažino garso lygį žemų dažnių srityje. Garso lygio sumažėjimo vertės augo didėjant bandinio storiui ir pasiekė 43 dB 3150 Hz srityje 20 cm pailgų nendrių bandinyje.

Reikšminiai žodžiai: garso lygio sumažėjimas, triukšmo slopinimo kamera, šiaudai, nendrė, tvari medžiaga.