ISSN 1392–1320 MATERIALS SCIENCE (MEDŽIAGOTYRA). Vol. 18, No. 1. 2012

Dependence between Reduction of Weighted Impact Sound Pressure Level and Specimen Size of Floating Floor Construction

Kęstutis MIŠKINIS *, **Vidmantas DIKAVIČIUS, Juozas RAMANAUSKAS, Rosita NORVAIŠIENĖ**

Institute of Architecture and Construction of Kaunas University of Technology, Tunelio 60, LT-44405, Kaunas, Lithuania

crossref http://dx.doi.org/10.5755/j01.ms.18.1.1350

Received 17 May 2011; accepted 18 June 2011

The aim of the research was to evaluate an influence of floating floor construction specimen size on weighted reduction in impact sound pressure level ΔL_W. The large size (area ≥ 10 m^2) specimens should be used according to LST EN ISO 10140 series standards. The problem is that produce large specimens is expensive and time-consuming process. So more rapid and cheaper way is to use smaller size (area < 10 m^2) specimens and perform measurements in real buildings with similar test conditions as in laboratory. For evaluation of the specimen size influence on reduction in impact sound pressure level ΔL_W value sand/cement screed area discreetly was reduced from 13.4 m^2 down to 0.5 m^2. The test results showed strong dependence of reduction in weighted impact sound pressure level from specimen size. Relying on the test data it was derived relationship which could be applied for the correction of the determined ΔL_W values when smaller size specimens (area < 10 m^2) of floating floor constructions are used.

Keywords: reduction, impact sound insulation, floating floor, specimen size.

1. INTRODUCTION

Various constructive solutions for protection from noise and fulfilment of mandatory requirements for sound insulation in dwellings are used. To evaluate the impact sound insulation of floor between flats normalized weighted impact sound pressure level is determined. The impact sound insulation of the floor could be improved adding special construction on the bare base concrete floor. This improvement is expressed by weighted reduction in impact sound pressure level ΔL_W (dB) which value shows how much impact sound pressure level is reduced by added floating floor construction to the bare base concrete floor with respect to the bare base concrete floor. The methodology for determination of ΔL_W is given LST EN ISO 717-2:2001 standard. For determination of ΔL_W it needs to perform measurements according to LST EN ISO 10140 series standards [1 – 4]. The existing laboratory test method to determine impact sound insulation descriptors requires large scale test facilities – at least 10 m^2 area of test specimen. The specimen preparation for laboratory test is quite expensive and time-consuming process [5 – 9]. The development of new constructive solutions usually needs quick evaluation and comparison of them in the research stage. Therefore researchers and builders for testing different floor constructions are interested to have quick measurement process, which saves time and money. Consequently they prefer perform the tests in real buildings choosing conditions similar to those in the laboratory using small size (area 1 m^2 – 2 m^2) specimens [10 – 12].

The generated vibration fields in small specimens (≤ 2 m^2) presumably are different from those in large one (≥ 10 m^2). So the question regarding small specimens is: are the determined impact sound insulation descriptor values true (equal to the results of the laboratory test with large size specimen)? This led to look for information in scientific literature how the measurement results depend on specimen size and what is the relationship between them. In the reviewed scientific literature [5, 7, 13 – 16] researchers mostly focus only on the comparison between measured and calculated values according to the standards. The lack of information about specimen size influence on measurements results led to perform this experiment. The main goal of the experiment was to evaluate the dependence between specimen size and weighted reduction in impact sound pressure level. The comparison of determined ΔL_W values from measurement data with calculated ones was done.

Nowadays builders mostly use floating floor constructions for minimization of transmission of impact sound between flats in multi-storeyed buildings [5, 7, 11]. Therefore floating floor construction has been chosen as the research object. Such floor consists of the sand/cement screed and resilient material layer. The derived relationship of correction is valid for such type floating floor construction laid on the heavyweight base concrete floor.

2. METHODS AND EQUIPMENT

All the measurements were carried out in accordance with LST EN ISO 10140 series standards. The sequence of experiment is presented in Fig. 1.

The measurements of the impact sound insulation were performed using wireless building acoustics system Nor1516 (“Norsonic”). The sound pressure level (L'_n) was measured in 100 Hz – 5000 Hz frequency range in one third octave bands. The standard tapping machine Nor211A (“Norsonic”) was used as impact sound source. Special programs “CtrlBuild” and “NorBuild” for the measurements control and the data evaluation were used.

*Corresponding author. Tel.: +371-37-350799; fax.: +371-37-451810.
E-mail address: *kestutis.miskinis@ktu.lt* (K. Miškinis)

The measurements were performed and data evaluation was done in accordance with LST EN ISO 140-7:2001 and LST EN ISO 717-2:2001 standards appropriately. The standard deviation of the measurements is up to 4 dB in 100 Hz – 160 Hz frequency range and up to 2 dB in 200 Hz – 5000 Hz frequency range.

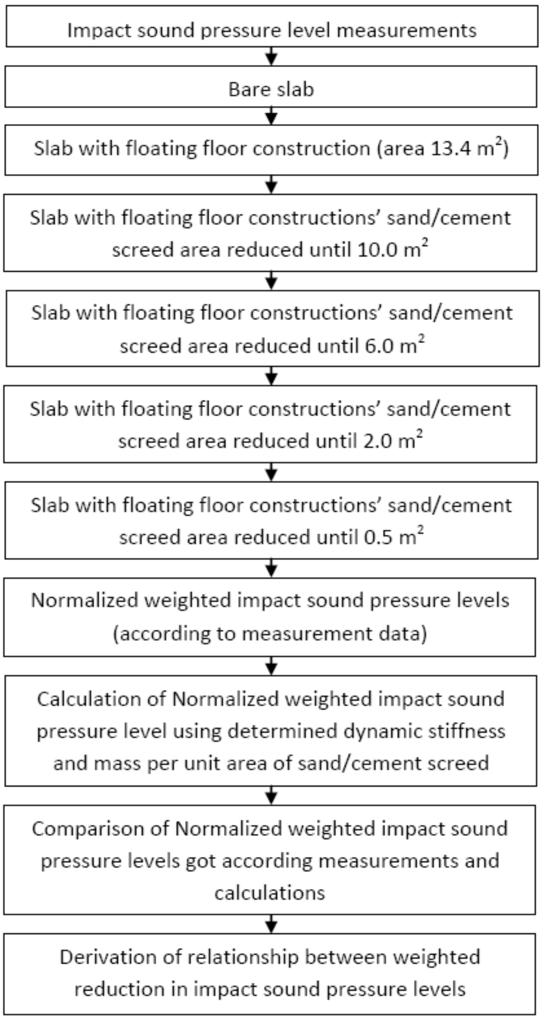

Fig. 1. Sequence of the experiment

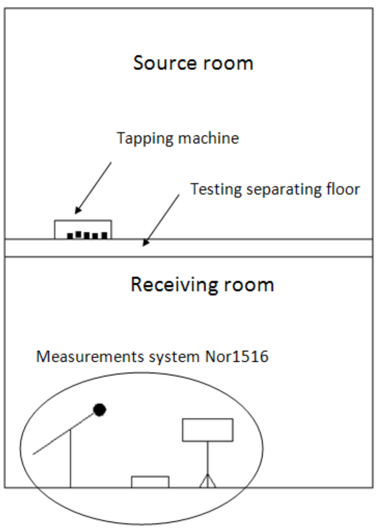

Fig. 2. Scheme of test rooms

The research was done in the real building. For this purpose two rooms – one above another were chosen (Fig. 2).

The main constructions of the building are heavyweight precast concrete columns and heavyweight monolithic concrete walls. It was considered that flanking sound transmission there was insignificant because of heavyweight constructions. The separating floor area is 13.4 m^2. The volume of the receiving room is 38.6 m^3.

The impact sound pressure level of bare base concrete floor (hollow reinforced concrete slab of 220 mm thick) was measured. Afterwards the floating floor was installed on the same base floor (Fig. 3).

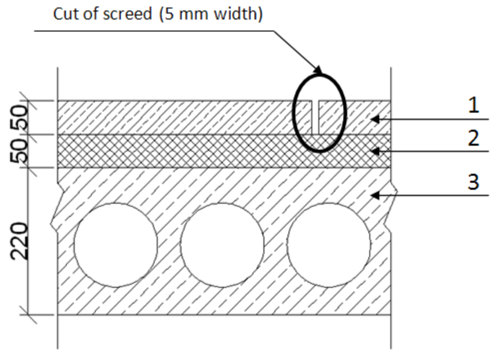

Fig. 3. Cross-section of the floating floor construction: 1 - sand/cement screed; 2 - resilient material layer; 3 - hollow reinforced concrete slab

The mass per unit area of the slab of the base floor is 350 kg/m^2. The 50 mm thick and 119 kg/m^3 of density stone wool layer was laid on the slab. The dynamic stiffness of the stone wool is 18 MN/m^3. The dynamic stiffness was measured in the laboratory according to LST EN 29052-1 standard. The 50 mm thick and 106 kg/m^2 mass per unit area sand/cement screed was made. The mass per unit area of the screed was determined from the hardened sand/cement mixture density.

In order to determine the dependence between the reduction in impact sound pressure level and specimen size the series of measurements were performed after 28 days when sand/cement screed was made. For this purpose floating floor construction (screed area) was reduced gradually from 13.4 m^2 (full floor area) to 0.5 m^2 as shown in Fig. 4. The dimensions 4.8 m × 2.8 m (area 13.4 m^2); 4 m × 2.5 m (10.0 m^2); 2 m × 3 m (6.0 m^2); 1 m × 2 m (2.0 m^2) and 0.5 m × 1 m (0.5 m^2) of the specimens' were chosen respectively.

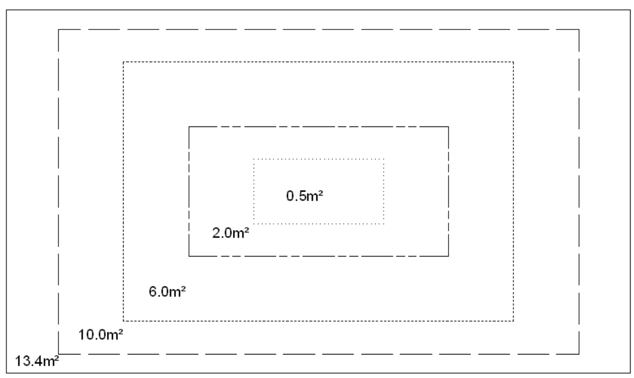

Fig. 4. Specimens' location in the room

The reduction of specimens' size was performed by cutting the sand/cement screed to the surface of the resilient material layer (Fig. 3). The outside parts of cut screed were left unmoved in order to have the same conditions of sound (generated by tapping machine) transmission to the room below during the experiment. The number of positions of the tapping machine was different depending on the size of the sand/cement screed: for 13.4 m^2 and 10 m^2 areas – four positions, for 6 m^2 area – three, for 2 m^2 and 0.5 m^2 – one position was used (Fig. 5).

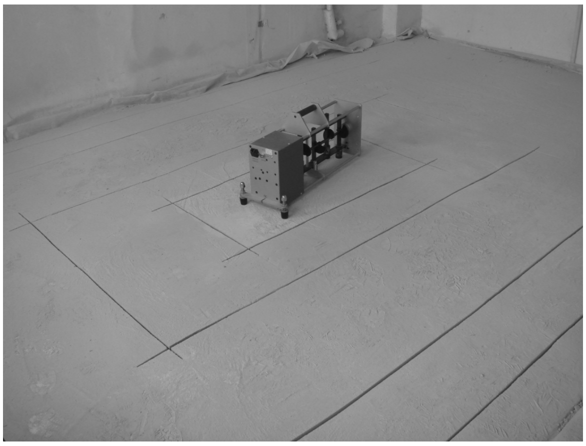

Fig. 5. The view of the source room with cut specimens

Five fixed microphone positions for the impact sound pressure level measurements in the receiving room were used for the each position of tapping machine. The duration of one measurement was 6 s. The background noise level was measured. The difference between impact sound pressure level and background level was more than 10 dB in all frequency range of interest. Therefore correction of results for background noise was not done.

For the assessment of improvement of impact sound insulation the weighted reduction in impact sound pressure level ΔL_W according to LST EN ISO 717-2:2001 was determined. Also the prediction of impact sound insulation improvement according to LST EN 12354-2:2001 and LST EN ISO 717-2:2001 was done.

3. RESULTS AND DISCUSSION

Referring to the results of the tests we can say, that measured normalized impact sound pressure level of the bare base concrete floor in the field was similar to level in the laboratory conditions [17]: from 500 Hz – 3150 Hz the difference was up to 3.2 dB and in low frequency range (100 Hz – 400 Hz) the difference was up to 14.8 dB. So we can say that field conditions we can consider similar to laboratory conditions.

The comparison of impact sound pressure levels (averaged values) are given in Fig. 6. From the results (Fig. 6) we can see that the character of impact sound pressure level curves for large specimens (13.4, 10.0 and 6.0 m^2) is similar. It shows that generated vibration fields by tapping machine in the screeds are analogous. The different character of curves occurs when the small size specimens (2.0 m^2 and 0.5 m^2) are used. Supposedly these resonances are influenced by specimen dimensions and vibration behaviour of the specimen itself. The concrete floating floor spreads vibrations to wide area of floor. When the specimen is quite small this spread changes and it may affect impact sound insulation level value.

The improvement of impact sound insulation of the bare base concrete floor with added floating screed in comparison with bare base concrete floor was calculated using field measurement data presented in Fig. 6. The weighted reduction in impact sound pressure level ΔL_W is used because using this descriptor we can easily compare different constructive solutions of the floor. The comparison of reduction in impact sound pressure levels in one third octave bands is given in Fig. 7. Also these values are compared with predicted impact sound pressure level.

From the results presented in Fig. 7 we can see the increasing variation character of reduction in impact sound pressure levels in one third octave bands by decreasing size of the specimens. The levels of 13.4 m^2 and 10.0 m^2 area are very close in all frequency range. Furthermore, the reduction in impact sound pressure level for specimen of 6.0 m^2 differ only by 2 dB – 4 dB from values of specimens with area of 13.4 m^2 and 10 m^2. However the difference between the large and small specimen is more noticeable.

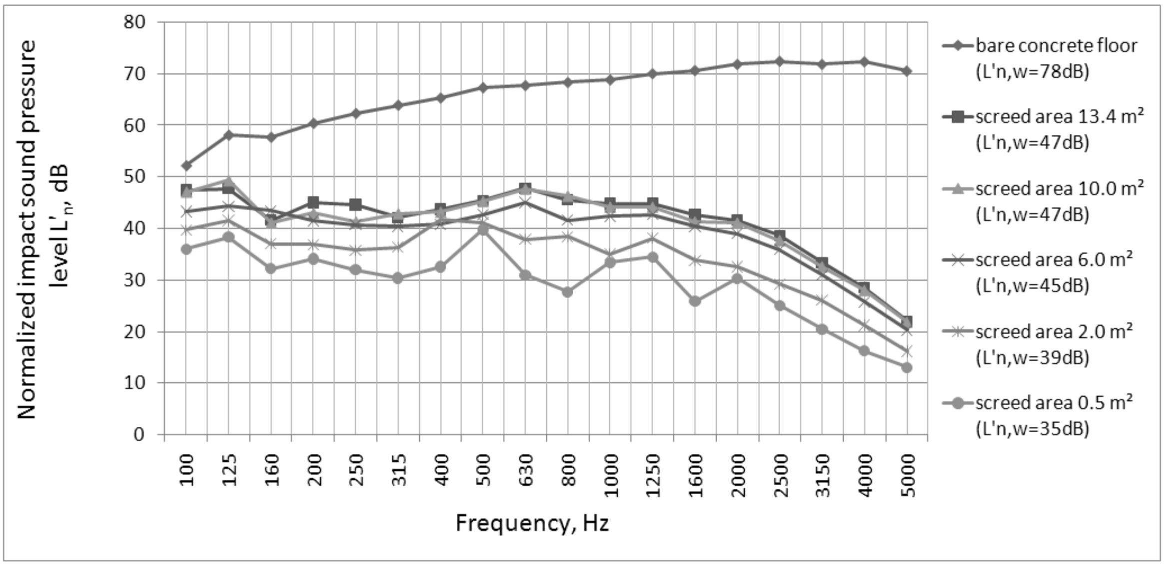

Fig. 6. Comparison of impact sound pressure levels

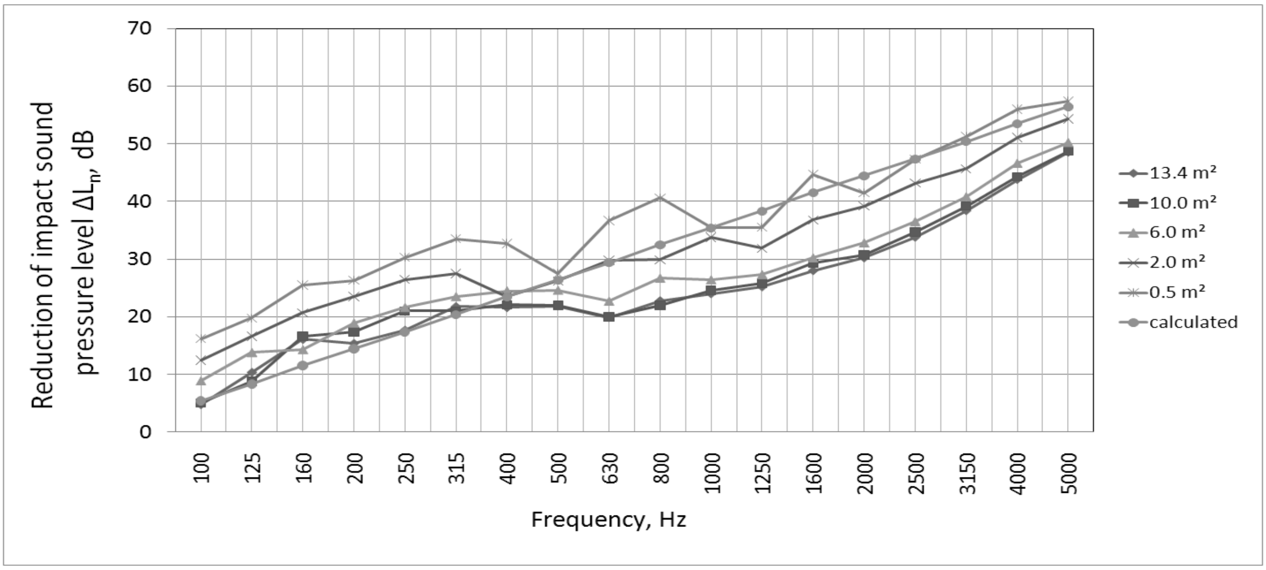

Fig. 7. The comparison of reduction in impact sound pressure levels

The difference of 4 dB – 10 dB (area 2.0 m^2) and of 6 dB – 8 dB (area 0.5 m^2) comparing to the specimen of 10 m^2 area was determined. These reduction differences clearly show the influence of specimen size on the test results.

The single parameter – weighted reduction in normalized impact sound pressure level ΔL_W – was calculated from one third octave values. The comparison of ΔL_W for different specimen areas is presented in the Fig. 8. In the brackets are given values of spectrum adaptation term $C_{I,\Delta}$. Predicted value of ΔL_W is presented in the Fig. 8 as well.

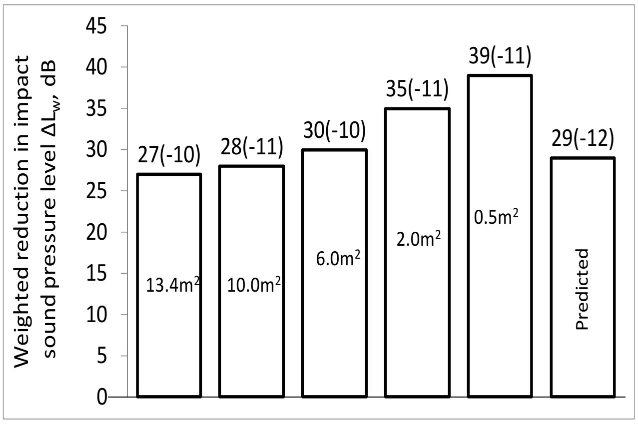

Fig. 8. The comparison of ΔL_W values

The values of weighted reduction in impact sound pressure level ΔL_W of large specimens are similar in comparison with each other - the difference is up to 2 dB. The difference between small (0.5 m^2 – 2.0 m^2) and large specimens is up to 11 dB. To evaluate whether the measured values are right the comparison with predicted value was done. From Fig. 8 we can see that the predicted value good enough matches (within 1 dB) the measured value for the specimen with an area of 10.0 m^2 but differs up to 11 dB when we use other areas.

According to these results we can say that it is not possible to determine correctly the reduction in impact sound pressure level using small specimens. It was considered to derive the relationship between specimen size (screed area) and the difference of determined ΔL_W values with respect to the reference $\Delta L_{W,ref}$ value corresponding to the chosen area of 10 m^2 (requirement of standard) is given in Fig. 9.

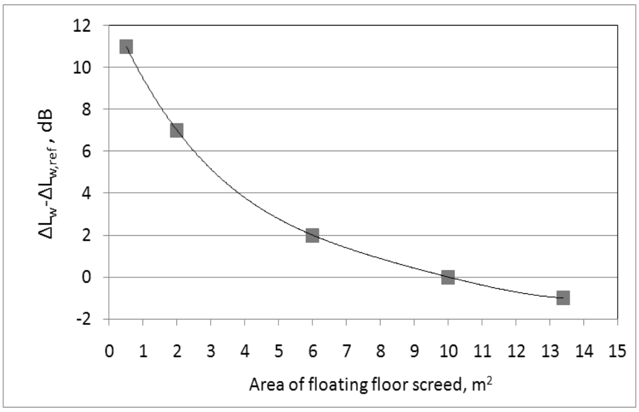

Fig. 9. The difference between determined values of ΔL_W and reference value $\Delta L_{W,ref}$

Comparing ΔL_W values of different specimens with reference $\Delta L_{W,\ ref}$ value we got the differences from –1 dB up to 11 dB. So there is a risk to get not correct measurement results using small specimens. Therefore we must to take into account these corrections evaluating the reduction in impact sound insulation. The correction value may be determined using expression $k = 0.0009a^4 - 0.0337a^3 + 0.4939a^2 - 3.7340a + 12.7477$ (a – area of the specimen). The determination coefficient R^2 of the relationship is 1. This shows strong relation between specimen size and correction value. So true (corrected) value of weighted reduction in impact sound pressure level can be calculated using expresion $\Delta L_{W(corr.)} = \Delta L_{W(meas.)} - k$ ($\Delta L_{W(corr.)}$ – true value; $\Delta L_{W(meas.)}$ - value determined using measurement data; k – correction value). The derived relationship and expression for calculation of $\Delta L_{W(corr.)}$ is valid for heavyweight floor construction analysed in this paper.

4. CONCLUSIONS

1. The research showed that size of the test specimen (in this case area of sand/cement screed) has significant influence on the test results. In accordance with test results this influence is up to 11 dB for weighted reduction in impact sound pressure level.
2. The research showed that small specimens (area $< 10\ m^2$) could be used for determination of ΔL_W but this value should be corrected using derived expression.

REFERENCES

1. LST EN ISO 10140-1:2010. Acoustics – Laboratory Measurement of Sound Insulation of Building Elements – Part 1: Application Rules for Specific Products (ISO 10140-1:2010).
2. LST EN ISO 10140-3:2010. Acoustics – Laboratory Measurement of Sound Insulation of Building Elements – Part 3: Measurement of Impact Sound Insulation (ISO 10140-3:2010).
3. LST EN ISO 10140-4:2010. Acoustics – Laboratory Measurement of Sound Insulation of Building Elements – Part 4: Measurement Procedures and Requirements (ISO 10140-4:2010).
4. LST EN ISO 10140-5:2010. Acoustics – Laboratory Measurement of Sound Insulation of Building Elements – Part 5: Requirements for Test Facilities and Equipment (ISO 10140-5:2010).
5. **Kim, K. W., Jeong, G. C., Yang, K. S., Sohn, J. Y.** Correlation between Dynamic Stiffness of Resilient Materials and Heavyweight Impact Sound Reduction Level *Building and Enviroment Volume* 44 (8) 2009: pp. 1589 – 1600.
6. **Seddeq, H.** Controlling the Impact Sound Insulation of Concrete Slab Floors *Building Acoustics* 13 2006: pp. 243 – 251.
7. **Stewart, M., Craik, R.** Impact Sound Transmission Through a Floating Floor on a Concrete Slab *Applied Acoustics* 59 2000: pp. 353 – 372.
8. **Jeon, J. Y., Jeong, J. H.** Evaluation of Floor Impact Sound Insulation in Reinforced Concrete Buildings *Acta Acustica United with Acustica* 90 2004: pp. 313 – 318.
9. **Asdrubali, F., D'Alessandro, F.** Impact Sound Insulation Performance of Access Floors *Euronoise 2008* June 29 – July 4, Paris.
10. **Asdrubali, F., Baldinelli, G., D'Alessandro, F., Schiavoni, S., Kenny, J. M., Iannoni, A.** Manufacturing Process Optimization of Resilient Materials Made from Recycled Tire Granules *The Sixteenth International Congress on Sound and Vibration Krakow, 5 – 9 July 2009*.
11. **Hui, C. K., Ng, C. F.** New Floating Floor Design with Optimum Isolator Location *Journal of Sound and Vibration* 303 2007: pp. 221 – 238.
12. **Godinho, L., Masgalos, R., Pereira, A., Branco, F. G.** On the Use of Small-sized Acoustic Chamber for the Analysis of Impact Sound Reduction by Floor Coverings *Noise Control Engineering Journal* 58 (6) 2010: pp. 658 – 668.
13. **Buratti, C., Moretti, E.** Impact Noise Reduction: Laboratory and Field Measurements of Different Materials Performances *Proceedings of Euronoise 2006* Tampere, Finland.
14. **Sousae Neves A., Gibbs, B. M.** Low Frequency Impact Sound Transmission in Dwellings through Homogeneous Concrete Floors and Floating Floors *Applied Acoustics* 72 2011: pp. 177 – 189.
15. **Tadeu, A., Pereira, A., Godinho, L., António, J.** Prediction of Airborne Sound and Impact Sound Insulation Provided by Single and Multilayer Systems using Analytical Expressions *Applied Acoustics* 68 (1) 2007: pp. 17 – 42. http://dx.doi.org/10.1016/j.apacoust.2006.05.012
16. **Hui, C. K., Ng, C. F.** Improvement of Lightweight Floating Ceiling Design with Optimum Stiffener and Isolator Locations *Journal of Sound and Vibration* 327 2009: pp. 333 – 353.
17. LST EN ISO 717-2:2:2001. Acoustics – Rating of Sound Insulation in Buildings and of Building Elements – Part 2: Impact Sound Insulation.

Presented at the 20th International Baltic Conference "Materials Engineering 2011"
(*Kaunas, Lithuania, October 27–28, 2011*)