Satisfaction with sound insulation in residential dwellings – heavy versus light wall construction

Valtteri Hongisto and Maija Suokas
Finnish Institute of Occupational Health, Indoor Environment Laboratory, Lemminkäisenkatu 14-18 B, 20520 Turku, Finland. forename.surename@ttl.fi.

Summary

The aim of this study was to compare the acoustic satisfaction in two building types having different airborne sound insulation in horizontal direction. Four buildings with concrete walls (Heavy) and two buildings with lightweight double walls (Light) were chosen. Seventy two and eighty-seven respondents were obtained from Heavy and Light building types, respectively. The corresponding response rates were 62 and 54 %. The sound insulation measurements revealed that the airborne sound insulation of double walls was significantly worse below 160 Hz. However, both building types were in conformance with the building code, i.e. R'_w=56 dB. The satisfaction with sound insulation was, however, equal in both building types. Several other noise-related measures supported this finding. The results suggest that when the airborne sound insulation requirements are at a level of 55 dB R'_w, which is the case in many countries, it does not affect the residential acoustic satisfaction, whether the partition walls are constructed using light or heavy constructions providing the same R'_w value. The use of $R'_w+C_{50\text{-}3150}$ instead of R'_w in Building Codes was not supported at such sound insulation levels.

PACS no. 43.50.Qp

1. Introduction

National sound insulation requirements of Finland can be achieved by various construction types. Most extreme examples are light constructions (drywalls) and heavy constructions (e.g. steel-reinforced concrete). It is well-known that light constructions provide much lower airborne sound insulation at low frequencies (below 100-200 Hz) than heavy constructions.

The aim of this study was to compare the acoustic satisfaction in two *building types* with either Heavy or Light walls between the dwellings. Our focus was to investigate the perception of neighbour noises. Both building types conformed the Finnish Building Code regarding airborne (55 dB R'_w) and impact sound insulation (53 dB $L'_{n,w}$).

Based on the recent laboratory studies of Rychtáriková et al. (2012), Hongisto et al. (2014) and Bailhache et al. (2014), we hypothesized that the *building type* would not affect the acoustic satisfaction among the residents.

The full results have been published in Hongisto et al. (2015). The data is based on a larger national survey described in Hongisto et al. (2013).

2. Materials and Methods

The independent variable (a grouping variable) was the *building type* which had two values: **Heavy** and **Light**:

- Heavy constructions: steel-reinforced load-bearing concrete walls and floors.
- Light constructions: staggered double walls, floating floors on load-bearing concrete.

The floors were not very much different from each other. The main difference between the *building types* was the wall construction (Fig. 1).

The multi-storey buildings were selected in collaboration with the building inspection office of Turku. The buildings were selected from areas where the environmental noise level was not high ($L_{Aeq07\text{-}22}$ below 60 dB) so that neighbour noises were not masked by environmental sounds.

Each dwelling was informed one week beforehand about the forthcoming survey. The 7-page-long questionnaire was distributed to each dwelling. One response per dwelling was requested. The responses were returned to a mailbox downstairs. The results were analyzed in SPSS using mainly Mann-Whitney U test (two independent groups).

The dependent variables consisted of various subjective measures related to the perception of noise. In addition, several control variables were used to evaluate the equality of the two groups before performing the statistical analyses between the groups.

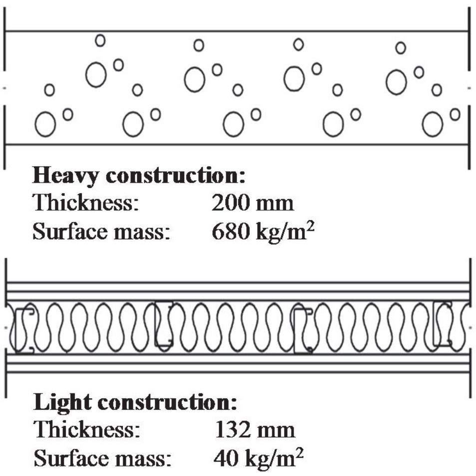

Figure 1. Wall constructions of the two *building types*.

3. Results

The impact and airborne sound insulation was measured in vertical and horizontal directions according to ISO 16283. The difference between *building types* was prominent for airborne sound insulation in horizontal direction at low frequencies (Fig. 2, Table 1).

The basic description of the building types and respondents are shown in Table 2.

The *building types* were equal with respect to gender distribution, age, time of residency, type of ownership, occupation and hearing ability. The groups were different with respect to education and extraversion. However, these two measures did not affect noise-related measures. Thus, the groups could be considered to be sufficiently equal and further comparisons between the groups were justified.

The *building types* did not differ with each other with respect to most measures dealing with neighbour noise (p-values above 0.05): willingness to move due to neighbour noise, inconvenience from neighbour noises, disturbance caused by various noise sources, difficulties to fall asleep due to neighbour noises, and satisfaction with sound insulation (Fig. 3). Only a couple of differences could be found: The wakenings due to neighbour noise was significantly larger in *building type* Heavy. The disturbance of building service sounds was significantly larger in *building type* Heavy.

In the end of the questionnaire, an open question was presented enquiring typical situations where disturbing noise occurred. Quantitative analysis cannot be presented since the respondents of *building type* Light were more diligent. Qualitatively, the respondents of *building type* Light reported more situations where airborne sounds from neighbours and outdoors were disturbing. Vice versa, respondents from *building type* Heavy reported more situations where sounds from plumbing and building services were disturbing. Eleven respondents from *building type* Light mentioned about disturbing bass sounds while nobody reported about such situations from *building type* Heavy. We cannot know whether the reason for this difference was the difference in airborne sound insulation or in the prevalence of bass sounds: *building type* Light included more students than *building type* Heavy. It is probable that both reasons could explain the difference.

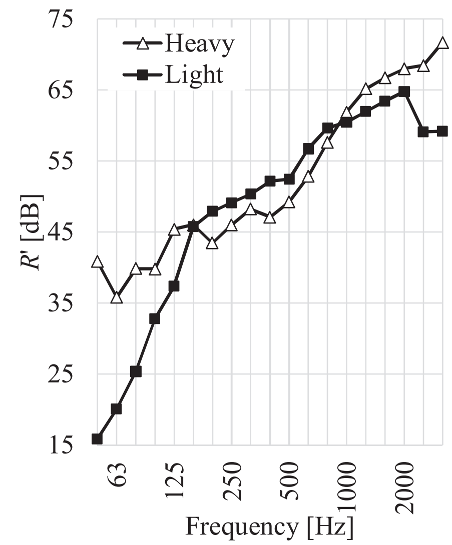

Figure 2. Airborne sound insulation in horizontal direction in both *building types*.

Table 1. Results of the sound insulation measurements.

Direction	Vertical		Horizontal	
Building type	Heavy	Light	Heavy	Light
R'_w	66	63	56	57
$R'_w+C_{50\text{-}3150}$	63	60	55	50
$L'_{n,w}$	47	42	42	45
$L'_{n,w}+C_{I,50\text{-}2500}$	47	45	43	47

Table 2. Description of the respondents and buildings.

	Building type	
	Heavy	Light
Number of buildings	4	2
Number of dwellings	116	162
Number of respondents	72	87
Mean age of respondents [y]	51	45
Response rate [%]	62	54

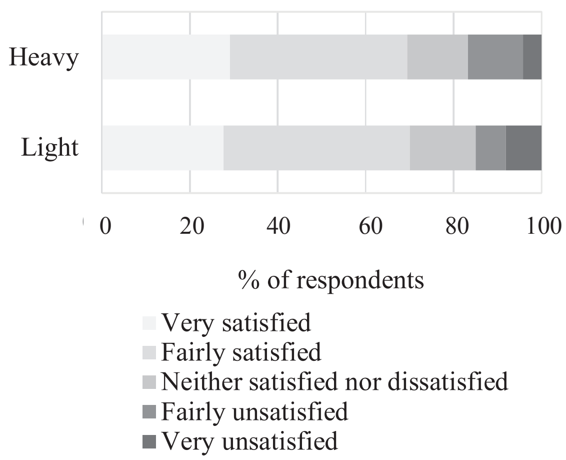

Figure 3. Satisfaction with sound insulation in the two *building types*. (How satisfied are you with the sound insulation as a whole?) The difference was not statistically significant (p=0.92, Z=-0.18).

4. Conclusions

Even though the airborne sound insulation was significantly smaller in *building type* Light, our quantitative study did not reveal significant differences in noise-related ratings between the two *building types*.

Describing the airborne sound insulation performance with a single-number quantity including the frequency band 50-80 Hz, such as $R'_w+C_{50\text{-}3150}$, seems to be unnecessary. Instead, describing the performance with a quantity including only the frequency band 100-3150 Hz, such as R'_w, seems to be sufficient. Our conclusions are in conformance with the suggestions of Rychtáriková et al. (2012), Hongisto et al. (2014) and Bailhache et al. (2014).

Acknowledgement

This study was part of a larger national research project (ÄKK 2012-2014) which was funded by Tekes, Ministry of Environment, and eight companies from the building sector.

References

[1] Bailhache S, Jagla J, Guigou-Carter C, Environnement et ambiances, Effet des basses fréquences sur le confort acoustique – Tests psychoacoustiques, Rapport USC-EA-D1_A2.1.4_2, Centre Scientifique et Technique du Batiment CSTB, France, Février 2014.

[2] Hongisto V, Mäkilä M, Haapakangas A, Hakala J, Hyönä J, Kylliäinen M, Acoustic satisfaction in multi-storey buildings built after 1950 – preliminary results of a field survey, paper 835, Internoise 2013, 15-18 September, Innsbrück, Austria.

[3] Hongisto V, Oliva D, Keränen J, Subjective and objective rating of airborne sound insulation – living sounds, Acta Acustica united with Acustica 100 2014 848-863.

[4] Hongisto V, Suokas M, Mäkilä M, Satisfaction with sound insulation in residential dwellings – the effect of wall construction, Building and Environment 85 2015 309-320.

[5] Rychtáriková M, Müllner H, Stani M, Chmelik V and Glorieux C (2012), Does the living noise spectrum adaptation of sound insulation match the subjective perception? Proceedings of Euronoise 2012, Prague, Czech Republik, 180-184, European Acoustics Association.