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Building acoustic requirements in Poland

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In European Country many different single-number quantities representing the acoustic properties of building elements are used to define the requirements in correlation with the applicable acoustic comfort in buildings. The concept of harmonization of these indicators will be analyzed in detail within a framework of the new action COST TU0901, which has been started recently.

The paper presents both the polish requirements being in force currently and the groundwork of their amendments. New in the polish legal regulations is the future enforcement of the requirement concerning the reverberation time in rooms. Furthermore, the comparison of the level of polish requirements with the another countries is described.

1 Introduction

The one of the basic requirements in the European Directive 89/106/EEC [1], concerning "Noise Protection" is formulated as follows:

"Construction objects have to be designed and executed in such a way that the noise which affects the residents or the people in the vicinity of such objects does not exceed the level of health hazard and that it allows them to sleep, rest and work in satisfactory conditions".

In order to be equal to these requirements, it is necessary to aim for the level of the standard requirements at a possibly maximum degree ensure the acoustic comfort of the buildings, recognized by most of its users. But the level of these requirements depends of economical possibility, so it must to be finding the compromise between the comfort and the building cost.

The polish standard PN-B-02151 [2] contains the requirements for the sound insulation between rooms, the sound insulation of the external walls and the impact sound insulation between rooms. It refers to a large scope of types of buildings like dwellings, offices, schools, hospitals etc.

The requirements concerning sound insulation have been established assuming that the equivalent sound level in rooms during the day time and night cannot exceed permitted value (for example, in the residential buildings $L_{Aeq,day}$ = 40 dB(A) and $L_{Aeq,night}$ = 30 dB(A)). A similar assumption was adopted in setting the requirements of external wall insulation. The adoption of these permitted values is now often considered as too high.

2 Evaluating parameters and criteria for the airborne sound insulation

The possible parameters recommended by the standard EN ISO 717-1[3] are the apparent sound reduction index R'_w or the corrected difference levels $D_{n,w}$ and $D_{nT,w}$, which can be eventually corrected with the spectrum adaptation terms C and C_{tr} and .

In Poland, the airborne sound insulation of internal partitions (between rooms) is expressed by

$R'_{A1} = R'_w + C_{100-3150}$

or, if the surface of partition is less then 10 m^2 or the rooms are shifted, by $D_{nT,w} + C_{100-3150}$.

According to EN ISO 717-1, in special situations, when the noise spectrum is differed from the pink noise spectrum, the spectrum adaptation term C_{tr} is taken into consideration.

The extract of the basic requirements for different type of buildings is presented in Table 1.

Type of building	Internal partition	R'_{A1} [dB]
Multifamily housing	wall between dwellings	50
	floor between dwellings	51
	wall between dwelling and technical and others "noisy" room	≥55 1)
	floor between dwelling and technical and others "noisy" room	≥55 1)
	internal walls between rooms or between room and hall	30
	internal walls between room and kitchen, bathroom or w.c.	35
Hotels (up to 2 stars)	wall between rooms	50
	floor between rooms	50
Schools	wall between school rooms	45
	floor between school rooms	50
Offices	wall between rooms	35-50 2)
	floor between rooms	45-50 2)
1) the demanded value is calculated in function of sound pressure level in "noisy" room 2) in depending on rooms function		

Table 1 : Requirements for the airborne sound insulation between rooms (the extract from PN-B-0251-3:1999)

The analysis of the suitable requirements relating to the multifamily buildings has shown, that the level of polish requirements, in many cases, is lower about 2 dB than in the another European country [4]. The comparison was difficult to do because the great diversity of the indices used for the evaluation of airborne sound insulation in different countries (these indicators cannot be compared directly). It was necessary to make some approximation and to take into account the differences between the two basic indicators like R'_w and $D_{nT,w}$ in function of the shape and the dimensions of rooms (figure 1).

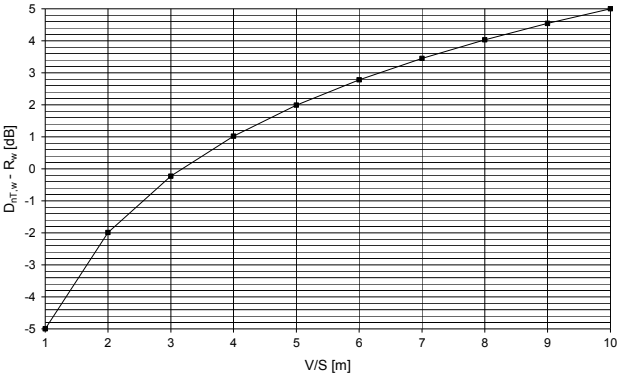

Figure 1: Difference between $D_{nT,w}$ and R'_w in function of V/S (V- volume, S – surface of the room; for walls V/S = depth, for floors V/S = high of room)

The airborne sound insulation of facades depends on the sound level of the external noise L_{Aeq}, evaluated at 2m in front of external wall, during the day (6h – 22h) and the night (22h – 6h).

The standard requirements are defined with using the apparent sound reduction index $R'_{A2} = R_w' + C_{tr\ 100-3150}$ (for road traffic noise) and $R_w' + C_{100-3150}$ (in another cases, like railway or air traffic noise).

The range of requirements for different kind of building, referring to the total sound insulation (wall and windows) is shown in Table 2.

L_{Aeq} [dB] outside		R'_{A2} (or R'_{A1}) for different types of buildings, dB		
Day	Night	Dwellings Hotels Offices	Schools	Hospitals
≥ 55	≥ 45	20 ÷23	23	23 ÷28
56 ÷60	46 ÷50	20 ÷23	23	23 ÷33
61 ÷65	51 ÷55	23 ÷28	28	28 ÷38
66 ÷70	56 ÷60	28 ÷33	33	33 ÷38
71 ÷75	61 ÷65	33 ÷38	≥ 38[1)]	≥ 38[1)]
[1)] to determine individually				

Table 2: Requirements for the total airborne sound insulation of the facade (the extract from PN-B-0251-3:1999)

3 Evaluating parameters and criteria for the impact sound insulation

The parameter used in Poland for the standard evaluation of impact sound insulation is the weighted normalized impact sound pressure level $L'_{n,w}$. The spectrum adaptation term C_I introduced in the standard EN ISO 717-2: 1996 [5] has not been taken into account due to the lack of a sufficiently clear relationship between the subjective evaluation of insulation between rooms and the technical evaluation of floors expressed with the index $L'_{n,w} + C_I$.

The current requirements concerning, for example, the impact sound insulation of dwellings in residential buildings, according to the polish standard PN-B-02151.03:1999 [1] are presented in Table 3. It is particularly worth focusing attention on the insulation between rooms neighbouring with one another not only in vertical, but also horizontal and diagonal direction.

Adherence to standard requirements for such directions of propagation is particularly important in buildings with lightweight walls and massive floors with floating floors. The incorrect building of these walls, without the appropriate break, leads to enlarging the flanking sound transmission, and as a consequence, to substantially lowering the insulation between rooms. An example of this is the result of a measurement carried out in one of the residential building in which the floors were made of 250mm concrete with floating floor and different floor surfaces. Most of the walls were made as lightweight gypsum board walls. The weighted normalized impact sound pressure level $L'_{n,w}$ measured in the horizontal direction, between the common corridor and living - room, was 79 dB, whereas the value permitted by the standard is 58 dB. The reason for such a dramatically bad result was the building of a lightweight wall directly on the floating floor placed on a common floor.

Function of separated spaces		max $L'_{n,w}$ [dB]
All paces in apartment	All spaces of the another apartment (horizontal and diagonal directions)	58
	Common corridor, stairways (horizontal and diagonal directions)	53
	Technical room	58 [1)]
	Shop, service room etc. L_A < 70 dB	53 [1)]
	Shop, service room etc. L_A = 70 ÷ 75 dB	48-53 [1)]
Room	All spaces of the same apartment	58
[1)] It concerns the transmission from the floor of the noisy room to the space in apartment regardless of its position		

Table 3: Requirements for the impact sound insulation in residential buildings (the extract from PN-B-0251-3:1999)

The insufficient, in the feeling of the people, impact sound insulation between dwellings, has been made evident in the results of survey, conducted in Poland in the 1980s and 1990s [6]. It was shown at the time that the audibility of impact sound, despite fulfilling standard requirements, is at ca. 60%, and even a slight deficiency of the impact sound insulation (by 1-2 dB) causes audibility in practically 100% of the examined cases.

Many measurements of impact sound insulation in new residential buildings have been carried out in the last three years [7]. It was found that impact noise from neighbours is very often evaluated as a nuisance even in situations when the standard requirements are fulfilled in excess.

This may be explained by increased social expectations concerning the acoustic comfort of dwellings, but also by the fact that in practically all of the examined dwellings the level of acoustic background was very low, reaching as little as 23-25 dB (A) during the day.

Figure 2 presents the results of measurements of normalized impact sound pressure level L'_n for floor between dwellings of the following structure: reinforced concrete 250mm + floating floor (with 20mm mineral wool and 20mm set board) + wooden floors on backing. All of the internal walls were made of C-100 steel profiles, filled with 50mm mineral wool and lined with gypsum boards 12,5mm. The weighted index for this case was $L'_{n,w}$ = 50 dB, therefore the polish standard requirements were fulfilled in excess of 8 dB. Despite such a good result, the great nuisance of impact sound from neighbours (particularly footsteps) had been recorded.

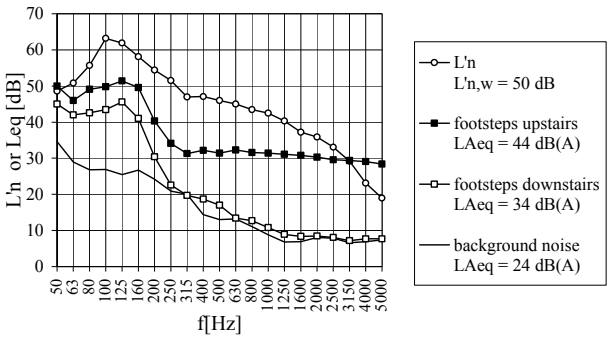

Figure 2: The measurement results of the normalized impact sound pressure level L'_n in comparison with the equivalent sound pressure level of the footsteps and background noise

A comparison of the results of the measurements of the sounds of footsteps "above", reaching the dwellings being examined and the background noise level normally found in these dwellings may explain this situation. It is clearly seen that in the frequency range between 50 Hz and 250 Hz the sound pressure level of footsteps noise is often up to 10-20 dB higher than the sound pressure level of the background. This is also reflected in the values of the A-weighted sound levels of impact and background noise. The level of footsteps noise exceeds the background level by 10 dB(A).

This example shows that it would be necessary to give more consideration to the influence of the low frequencies on single number evaluation (take the spectrum adaptation term for the range starting at 50Hz), having a source that would better reflect the character of the footsteps noise than the normalized tapping machine used up to now.

The level of Polish standard requirements on the background of regulations of other European countries is relatively low. In many countries it is required (or recommended) that the weighted normalized impact sound pressure level $L'_{n,w}$ should not exceed 53 dB, whereas the basic requirement in Poland is set at the level of $L'_{n,w} \leq 58$ dB.

Another single number indicator $L_{nT,w}$, used for example in France, Belgium or Austria, differs from $L'_{n,w}$ by the term of $\Delta_i = 15 - 10\log(V)$ (Figure 3).

It means, that in rooms of height H = 2.6 ÷ 3.0 m the value of $L_{nT,w}$ is greater then $L'_{n,w}$ (so, the evaluation is worse) in the case when the room's surface $S \leq 10$ m^2. On the contrary, in the biggest rooms, for example with surface about 30m^2, $L_{nT,w}$ = 53 dB corresponds to $L'_{n,w}$ = 58 dB (Figure 4).

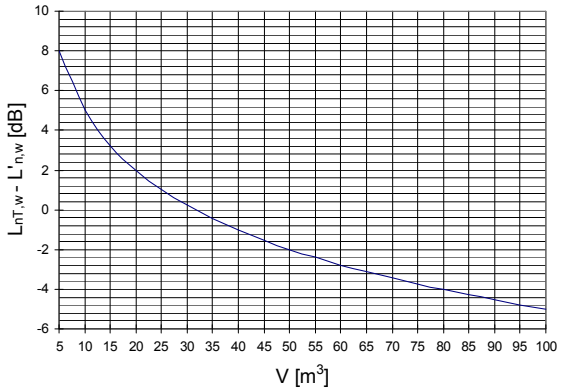

Figure 3: Relationship between the differences ($L_{nT,w} - L'_{nT,w}$) and the volume of a room

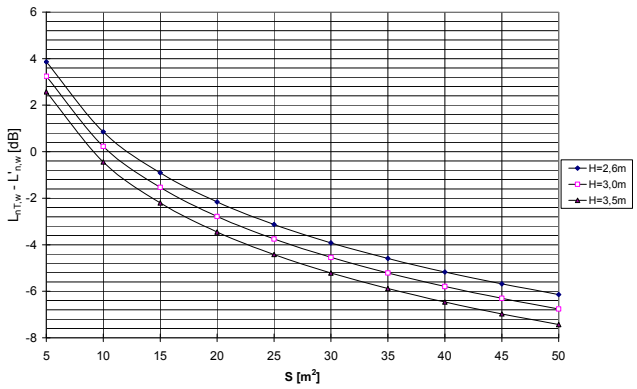

Figure 4: Difference between $L_{nT,w}$ and $L'_{n,w}$ in function of the room's surface for the typical heights of the rooms

4 Criteria for the excessive reverberant noise in rooms

Reverberation time is one of the assessment criteria for the acoustic performance of a room. In the case of typical residential and public buildings legal regulations for reverberation time are associated with the protection against noise problem, also with the reverberant noise control. In many rooms the reverberation time should be controlled in order to ensure good acoustic conditions for speech and music reception. In Poland, there are no legal regulations or standard for reverberation time in a building. The standard PN-B-02151 "Noise control in buildings" is expected to be supplemented with requirements concerning reverberation time in rooms from the point of view the control of reverberant noise and the speech intelligibility. The analysis of relative requirements applied in different European countries has served for the preparation a draft document, which will is still under discussion and will probably be finished by the end of 2010.

5 Conclusion

Survey studies carried out in Poland show that the noise coming from adjacent rooms in multifamily buildings is too often audible even if the standard requirements are fulfilled. This means that the level of standard requirements is inadequate to social feeling and they have to be changed in taking into account the economic possibility of building users.

There is also urgent need to standardize the reverberant noise in rooms, especially in schools, sport halls and so on but also in common circulation spaces in multifamily dwellings.

The changes being prepared in Polish standard requirements refer to two issues:

1. adopting, following the example of some European countries, insulation classes of 5 dB ensuring different acoustic comfort of dwellings,
2. introducing the requirements for the reverberation time and weighted equivalent absorption surface.

It also seems reasonable making requirements concerning sound insulation between dwellings dependent on the level of the acoustic background in the building. This problem is discussed against the new Polish requirements and their modification planned in the near future.

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[6] Izewska A, "Prognozowanie klimatu akustycznego mieszkań na etapie projektowania" *(Prediction of the acoustic climate of dwellings on the phase of designing)*, project of KBN No 7 T07E 016 17, Warsaw, 2001 (in Polish)

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