ACOUSTICAL DESIGN OF MULTI - FAMILY DWELLINGS WITH TAKING INTO ACCOUNT THE NEW POLISH STANDARD REQUIREMENTS

PACS REFERENCE: SS – RBA - 04

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ABSTRACT

In the years 1999 – 2000 the polish standard requirements concerning the sound insulation between the rooms have been changed [1]. The weighed index R'_w has been replaced by the new evaluation rates R'_{A1} and R'_{A2}, which make allowance for the noise spectrum and for the flanking transmission in the field situation.

The valuable assistance to the designers who wish to perform such evaluation is the computer system (working out by Acoustic Department of ITB). The calculation methods of flanking transmission in building, according to the standards EN 12354 –1: 2000 and 12354 – 2:2000 have been adopted (the EN standards were translated and assigned for establishment as PN EN [2,3]).

The computer system additionally incorporates the helpful tool - generalized database of the acoustic properties of the building elements and the procedure for the evaluating the traffic noise in the vicinity of building.

1. Introduction

Acoustic conditions performing in dwellings decide about their quality and therefore they shall be submitted for assessment during the design process as well as the stage of the realization of building.

Due to different evaluation criteria using in standards and possible necessity to undertake various actions to improve the acoustical properties, the following issues should be isolated:

1. noise from neighbourhood (resulting from partitions' sound insulation);

2. noise from technical equipments situated in the building, so-called installation noise (whose sound level in the room depends on the noise level of the source and on the sound insulation of the separating partitions);

3. external noise (whose occurrence depends on its sound level in front of the façade and on the sound insulation of the façade elements).

2. Standard requirements concerning the sound insulation in buildings

The changes in the polish requirements concerning the acoustic properties of partitions within the building consist in different evaluation rates with different quantities. It has been caused by the publication, in 1996, of the revised standards of series EN ISO 717, and, pursuant to this, the establishment in 1999 of the respective polish standards PN EN ISO 717:1999 [5,6]. In accordance with these tendencies two factors have been considered:

1. the effect of the shape of the noise spectrum transmitted by the partition on its sound insulation, stated by the spectrum adaptation terms C and C_{tr} , which represent two noise spectra considered as representative for the building, namely:

– the spectrum of pink noise (represented by the term C), which is characteristic for the neighbourly noise in residential buildings,

– the spectrum with a considerable content of acoustic power level in low and medium frequency ranges (represented by the term C_{tr}), characteristic for instance for a noise caused by road traffic in the city.

2. the effect of flanking sound transmission by the adjacent partitions in compartment, expressed as C_f.

As a result, in the requirements included in the new polish standard PN-B-02151-3:1999, the following changes have been introduced:

a) for the evaluation of airborne sound insulation of internal walls and floors, the so-called apparent evaluation rate of sound reduction R'_{A1} has been applied, where:

$$R'_{A1} = R'_w + C = (R_w - C_f) + C$$

b) for the evaluation of airborne sound insulation of external partitions, the so-called apparent evaluation rate of sound reduction R'_{A2} has been applied, where:

$$R'_{A2} = R'_w + C_{tr} = (R_w - C_f) + C_{tr}$$

R_w is the weighted sound reduction index of the partition specified in laboratory conditions, C_f – the correction that determines the value of flanking transmission for this partition within the building, C and C_{tr} are the spectrum adaptation terms.

In cases justified with other types of occurring noise, the suitable rates (R'_{A1} or R'_{A2}) applied for the acoustic evaluation of partition shall be choose according to the type of the noise spectrum transmitted by the partition. If the spectrum of noise is unknown, the rate R'_2 shall be taken into consideration as less favorable.

c) for the evaluation of impact sound insulation of floors the weighted normalized impact sound pressure level $L'_{n,w}$ has been applied, where:

$$L'_{n,w} = L_{n,w} + C_f$$

and $L_{n,w}$ is weighted normalized sound pressure level determined in laboratory conditions, C_f – the correction due to the flanking transmission.

The spectrum adaptation term C_l representing the characteristics of typical walking noise spectra (defined in ISO 717 –2 standard) is not used for the time being.

In aim of help to designers, the new polish standard also includes an informative annex describing the simplified methods of calculating the C_f correction for the flanking transmission in function of the mean mass per unit area of the adjacent partitions (at the time of its establishment, the EN 12354 - 1:2000 and EN 12354 – 2:2000 standards have not yet been established).

The set of requirements concerning the sound insulation of internal and external partitions is presented in the table 1 and 2, respectively.

Table 1. REQUIEREMENTS FOR SOUND INSULATION OF INTERNAL PARTITIONS IN MULTI - FAMILY DWELLINGS (acc. to PN-B-0251-3:1999)

Type of space in apartment		Floors		Walls
		R'_{A1} or $D_{nT,A1}$ minimum	$L'_{n,w}$ maximum	R'_{A1} or $D_{nT,A1}$ minimum
All spaces	All spaces of the another apartment	51	58	50
	Common corridor, stairways	individually	53	50
	Technical rooms	55[1)]	58	55[1)]
	Shop, service room etc. L_A < 70 dB	55[1)]	53	55[1)]
	Shop, service room etc. L_A = 70 – 75 dB	55-60[1)2)]	48-53	55-60[1)2)]
	Restaurants, bar	55-60[2)]	48-53	57-67[2)]
Room	Kitchen, bathroom, w.c in the same apartment	-	-	35
	Room, hall in the same apartment	45 - 51[3)]	58	35

1) In depending on the type of noise spectrum it should be taken into account the value of

$$R_{A1}' = R_w' + C \quad \text{or} \quad R_{A2}' = R_w' + C_{tr}$$

2) In depending on the sound level in a source room

3) Recommended

Table 2. REQUIEREMENTS FOR SOUND INSULATION OF EXTERNAL WALLS IN MULTI -FAMILY DWELLINGS (acc. to PN-B-0251-3:1999)

Type of space	Minimal values of R_{A2}' (or R_{A1}') in depending on the sound level L_{Aeq} outside the building					
	day	≤ 60	61 - 65	66 - 70	71 - 75	76 - 80
	night	≤ 50	51 - 55	56 - 60	61 - 65	66 - 70
room		23	28	33	38	43
kitchen		20	23	28	33	38

The evaluation for day and night is carried out separately. The maximum value of R_{A2}' (or R_{A1}') is taken into account.

3. Computer - aided system for the estimation of sound insulation between rooms in building

Designing a building with respect to the standard requirements consists in the selection of building elements after taking into account the characteristics of the spectrum of the noise penetrating through the partitions and the anticipated sound flanking transmission.

The prediction method for the evaluation of the sound insulation between the rooms on the base of the acoustic properties of building elements, with taking into account the type of noise spectrum and the flanking transmission in building, is incorporated into the computer program which has been elaborated in Acoustic Department of ITB for the last several years and has been permanently verified and improved.

The calculation method using in this system allows determining the scale of the occurrence, within the building, of the following types of noise: neighbours' noise (airborne and impact noise), noise caused by technical equipment in building and external traffic noise, in case the standard requirements are not met. The simplify prediction methods of flanking transmission in building, presented in the standards of series EN 12354 [2,3,4] have been adopted (the EN 12354 standard - part 1 and 2 were translated in the year 2000 and assigned for establishment as PN EN standards).

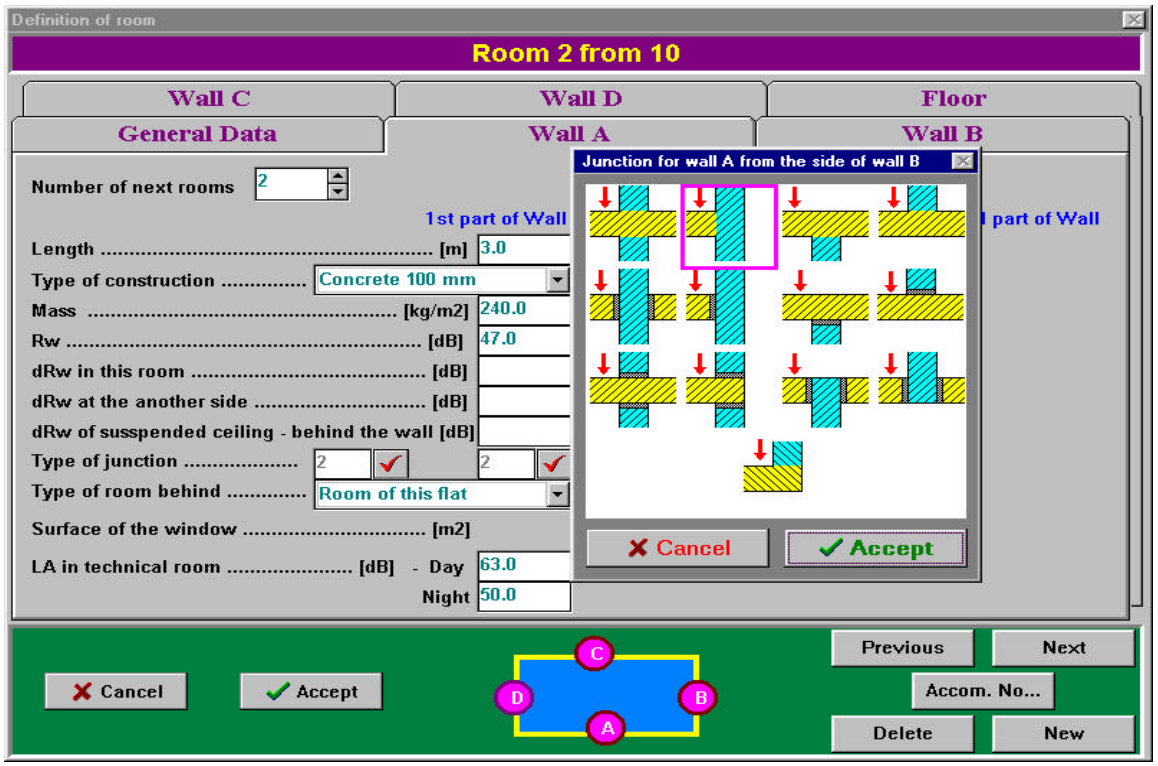
Improving the calculation methods relied on appending the program with two tools helpful for the user, namely: 1) database containing data on the acoustic properties of building elements, 2) procedure for the calculation of the A - weighted sound level value for the traffic noise present in the vicinity of communication routes on the basis of data concerning movement, geometry of the way and the urban development situation.

The generalized database contains the previously applied and the new acoustic indices of typical construction elements (R_w, R_{A1}, R_{A2}, $L_{n,w}$, $\Delta L_{n,w}$) categorized into groups of similar construction properties. Five categories of data have been selected, with respect to: 1) external walls, 2) ceilings, 3) floors, 4) external walls and 5) windows. The categories of internal walls, external walls and floors have been divided into sub-categories of massive and light constructions. The database for the ceilings contains the data, which describe the acoustic properties of massive ceilings only (this is due to the limitation in applying the calculation method). The acoustic parameters, specified for various types of constructions (not for the

specific products of defined manufacturers), have been determined pursuant to theoretic analyses and generalizations of the results of laboratory tests performed at the Acoustic Department of the ITB.

The procedure for the evaluation of the A - weighted sound level value for the traffic noise is useful for determining its occurrence in the compartments if the sound level in the building's vicinity has not been measured. The calculation method has been formulated on the basis of the French method (elaborated by SETRA and CETUR) and on the basis of the own research results. This method has been verified through measurements for many real-life urban situations. The comparison of the calculation and the test results has shown that the difference between them is no greater than 2 dB.

Including this database into the computer program shall provide valuable assistance to the designers who shall wish to perform the acoustic evaluation of a building's design.



4. Conclusions

To cater for the needs of the designers, the Acoustic Department of the Building Research Institute prepared a computer programme which serves the prediction of the acoustic quality of multi-family dwellings.

This is a particularly important issue at the moment of active introduction of the requirements included in the new polish standard [1], in which principles of acoustic evaluation of compartments differ from the ones used before. The formulated method of prognosing the acoustic climate of the apartments [7,8] takes account of this new approach, thus allowing for the provision of the appropriate acoustic quality of the buildings – the basic utility feature of a construction object. This is in accordance with the building regulations binding in European

Union – Council Directive No. 89/106/EEC on „Noise Protection”. In this Directive, the basic requirement has been stated in the following way:
"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”.

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