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FACADE SOUND INSULATION OF BUILDINGS VS NOISE MAP IN PAMPLONA, SPAIN

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ABSTRACT

The Spanish Technical Building Code requires minimum insulation of facades according to the acoustic zone in which the building is located. Thus, the airborne sound insulation, $D_{2m,nT,Atr}$ between a protected enclosure (living room/bedroom) and the exterior varies from 30 to 47 dBA. The daytime noise index value, Ld, can be obtained by consulting the strategic noise maps. The urban agglomeration of the Pamplona Region (Spain) has carried out the strategic noise maps in its four phases (2007-2012-2017 and 2022) as well as their associated action plans against noise.

NASUVINSA is the public housing and urban planning company of the Government of Navarre in charge of the management of social housing in the region of Navarre. Over the last decade, numerous protected housing developments have been delivered in the agglomeration of the Pamplona region. Although not exhaustively, it has been possible to access to results of the acoustic insulation of facades since 2011. The overall results of the insulation obtained are presented in this work, as well as the correlation between such insulation and the daytime levels, Ld, obtained from the noise map in force at the date of the building project.

Keywords: *Facade sound insulation, regulations, noise maps, in situ measurements.*

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1. INTRODUCTION

The basic document 'DB-HR Noise Protection' [1] specifies the objective parameters and verification methods whose compliance ensures that basic requirements are fulfilled and that the minimum quality levels of the basic noise protection demands of the Spanish Technical Building Code [2] are exceeded. Internal partition walls, as well as facades, roofs, party walls and floors in contact with the outside air, which make up each part of a building, must have characteristics (in conjunction with the adjacent construction elements) which meet certain minimum requirements. Thus, for example, protection against noise generated in enclosures not belonging to the same property requires that the airborne sound insulation index, $D_{nT,A}$, shall not be less than 50 dBA.

The data over time of the acoustic insulation measured for the interior walls by newly constructed houses in our city (Pamplona, Spain) has already been the subject of previous studies [3-4]. This paper analyses the requirements of the regulations regarding facade sound insulation between a protected enclosure (bedrooms, living rooms, classrooms, offices) and the outside. Results of many measurements over the last decade will be shown.

2. INDEX FOR ASSESSING THE FACADE SOUND INSULATION FROM EXTERNAL NOISE

The acoustic index used in Spanish regulations to assess the sound insulation of facades, roofs and floors in contact with the outside air is the A-weighted standardized level difference, $D_{2m,nT,Atr}$. The final terminology ('tr') refers to the fact that the predominant noise is traffic noise, with a standardized characteristic spectrum. It is defined by the expression:

$D_{2m,nT,Atr} = -10 \cdot log \sum_{1=1}^{n} 10^{(L_{Atr,i} - D_{2m,nT,i})/10}$ [dBA] (1)

where:

$D_{2m,nT,i}$ is the standardized level difference, in frequency band i, in dB.

$L_{Atr,i}$ is the A-weighted standardized traffic noise spectrum figure in the frequency band i, in dBA

i cover all one-third octave frequency bands from 100 Hz to 5 kHz.

The normalized spectrum for traffic noise is identical (at least in the range of frequencies between 100 Hz and 3.15 kHz) with the one used in ISO 717-1:2020 [5] to calculate the adaptation term C_{tr}. If the dominant outdoor noise is aircraft noise, this index is also used for the overall assessment, but using the values of the standard aircraft noise spectrum, A-weighted, $L_{Aav,i}$. Such spectra are shown in Table 1. Of course, the overall power of each spectrum is 0 dB.

Table 1. Normalized spectrum values for traffic and aircraft noise

f_i	$L_{Atr,i}$	$L_{Aav,i}$	f_i	$L_{Atr,i}$	$L_{Aav,i}$
100	-20	-23,8	800	-9	-9,5
125	-20	-20,2	1000	-8	-10,5
160	-18	-15,4	1250	-9	-11
200	-16	-13,1	1600	-10	-12,5
250	-15	-12,6	2000	-11	-14,9
315	-14	-10,4	2500	-13	-15,9
400	-13	-9,8	3150	-15	-18,6
500	-12	-9,5	4000	-16	-23,3
630	-11	-8,7	5000	-18	-29,9

The $D_{2m,nT,Atr}$ index is not a common index in European countries. In the regulations of various countries (DIN 4109 in Germany, NF S 31-057 in France, Resistance to sound_Part E, Building regulation in England, UNI 11367 in Italy, for example) it is more common to use the indices $D_{ne,w}$ and $D_{2m,nT,w}$, together with the spectral adaptation term C_{tr}. It is not common to use the spectral adaptation term for aircraft noise.

3. REQUIREMENTS FOR FACADE SOUND INSULATION AGAINST EXTERNAL NOISE

The facade airborne sound insulation, $D_{2m,nT,Atr}$, between a protected rooms and the outside shall not be less than the values shown in Table 2, depending on the use of the building and the values of the daytime noise index, Ld, of the area where the facade building is located. The value of the Ld index is obtained from the last approved strategic noise map.

Table 2. Minimum values for the $D_{2m,nT,Atr}$ index in Spanish regulation

Ld , dBA	living room, bedroom classroom, office	kitchen, corridor waiting room
Ld≤60	30	30
60<Ld ≤60	32	30
65<Ld ≤70	37	32
70<Ld ≤75	42	37
Ld > 75	47	42

When official data of the daytime noise index value, Ld, are not available, the value of 60 dBA will be applied for the type of acoustic area with predominantly residential land use. Although the indices for assessing outdoor noise insulation could be different, the required facade sound insulation in other countries also depends on the use of the building and the ambient noise levels in the environment where the building is located. For example, in Germany, insulation requirements for facades (R'_w + C_{tr}) range from 30 dB (for Ld up to 55 dBA) to 45 dB (for Ld up to 70 dBA). In England, in areas with outdoor noise levels of 70 dB, a minimum insulation of 40 dB is required for the $D_{ne,w}$ index. In the case of Italy, the regulation UNI 11367 classifies buildings into four classes, depending on the acoustic performance achieved. The minimum facade sound insulation requirements, index $D_{2m,nT,w}$, are 32 (Class IV), 37 (Class III), 40 (Class II) and 43 dB (Class I).

Considering the main single-number quantity descriptors (R'_w , $D_{n,w}$ and $D_{nT,w}$) and their combinations with the spectral adaptation terms, 27 descriptors are obtained for the facade sound insulation index [6]. It will show here results for the descriptor of the Spanish Standard, $D_{2m,nT,Atr}$ and the most used in many European countries, $D_{2m,nT,w}$ (measured with one speaker) together with the adaptation terms C and C_{tr}. In fact, $D_{2m,nT,\ Atr} = D_{1s,2m,nT,w} + C_{tr}$.

4. DATA

Results of acoustic insulation measurements on facades carried out in the period from 2011 to 2022 by 4 accredited laboratories for this type of measurements were provided. The location of the housing developments where these dwellings are found (location described in Table 2) are shown in Figure 1. This figure shows the noise map (Phase IV) of the Agglomeration of Pamplona. All the strategic noise maps carried out in Spain are available in the Noise Pollution Information System (SICA) on the website of the Ministry for Ecological Transition and Demographic Challenge of the Government of Spain [7].

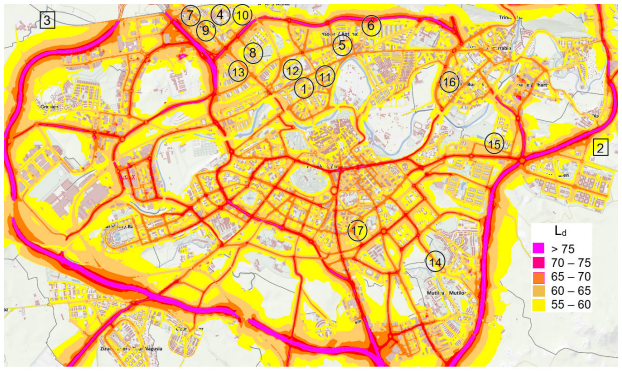

Figure 1. Location of the measurements. Points plotted on the acoustic map (phase IV) of the Agglomeration of Pamplona.

Figure 2. Example of measurement point (in black) and acoustic mapping of the area.

Figure 2 gives an idea of the available data. Location of the house (in black) where the measurements are taken and daytime levels, Ld, obtained from the current acoustic map.

5. RESULTS

Table 3 shows the results obtained for facade sound insulation against exterior noise in the measurements for which results were available.

Table 3. Facade sound insulation

Loc	Meas	Lab	(l-b), m^2	D_{2m}	D_{ls}	Ld
5	2011	1	(b) 6,6	33	36 (-1;-3)	
15	2011	2	(b)	34	37 (-1;-3)	
2	2011	1	(b) 4,1	28	31 (-1;-3)	
2	2011	1	(b) 4,8	32	35 (-1;-3)	
3	2011	1	(b) 6,5	32	35 (0;-3)	
4	2011	1	(b) 6,6	32	36 (-2;-4)	
10	2011	1	(l) 9,12	31	34 (-1;-3)	
5	2011	1	(l) 8,96	32	35 (-1;-3)	
5	2011	1	(l) 9,12	30	35 (-2;-5)	
6	2011	1	(b) 5,6	43	47 (-1,-4)	
6	2011	1	(l) 6,9	43	50 (-2,-7)	
7	2011	1	(l) 7,4	36	38 (0,-2)	
7	2011	1	(b) 7,4	37	39 (0,-2)	
8	2011	1	(l) 22,7	31	35 (-1,-4)	
8	2011	1	(b) 22,7	33	37 (-1,-4)	
9	2011	1	(l) 7,4	37	40 (-1,-3)	
9	2011	1	(b) 7,4	37	41 (-1,-4)	
10	2011	1	(l) 10,8	31	34 (-1,-3)	
10	2011	1	(l) 11,1	34	36 (-1,-2)	
10	2011	1	(l) 19,0	31	34 (-1,-3)	
10	2011	1	(l) 11,1	33	35 (0,-2)	
12	2011	1	(l) 9,4	34	37 (-1,-3)	
12	2011	1	(l) 9,1	35	39 (-1,-4)	
13	2011	1	(l) 7,8	34	38 (-2,-4)	
13	2011	1	(b) 7,9	37	40 (0,-3)	
11	2011	1	(b) 5,9	29	33 (-1;-4)	
11	2011	1	(l) 8.30	29	33 (-1;-4)	
1	2011	1	(b) 5,70	26	31 (-1;-4)	

11	2011	1	(l) 8,65	31	36 (-2;-5)	
1	2011	1	(b) 5,85	29	33 (-1;-4)	
12	2011	1	(b) 6.00	28	32 (-2;-4)	
8	2011	1	(l) 10,8	34	35 (0,-1)	
8	2011	1	(l) 11,1	35	39 (-1,-4)	
12	2011	1	(b) 5,9	34	37 (-1,-3)	

Table 3. Facade sound insulation (cont.)

Loc	Meas	Lab	(l-b),m^2	D_{2m}	D_{ls}	Ld
14	2012	2	(b)	34	37 (-1;-3)	60-65
14	2012	2	(b)	35	39 (-1;-4)	60-65
14	2012	2	(b)	34	35 (1;-1)	60-65
15	2013	2	(b)	31	33 (-1;-2)	55-60
14	2013	2	(b)	35	39 (-2;-4)	65-70
14	2013	2	(b)	34	37 (-1;-3)	65-70
14	2013	2	(b)	33	36 (-1;-3)	65-70
17	2013	2	(b)	32	37 (-2;-5)	65-70
17	2014	2	(b)	29	33 (-1;-4)	65-70
14	2014	2	(b)	28	32 (-2;-4)	65-70
14	2014	2	(b)	30	34 (-1;-4)	65-70
16	2019	2	(b)	35	40 (-1;-5)	65-70
14	2019	3	(b) 6,1	36	42 (-2,-6)	65-70
14	2019	3	(b) 6,1	36	42 (-2,-6)	65-70
15	2020	3	(b)	33	39 (-3;-7)	60-65
16	2021	1	(b) 6,67	46	50 (-1;-4)	65-70
16	2021	1	(b) 4,8	32	35 (-1;-3)	65-70
17	2021	1	(b)	33	39 (-2;-6)	60-65
3	2022	4	(l)	30	36 (-2;-6)	

Legend:
Loc: Location of new housing (see Fig. 1)
Meas: Year of measurements
Lab: Laboratory (accredited) that performed the measurements. There were 4.
(l-b), m^2: Receiving room (**l**iving room/**b**edroom) and wall surface in contact with the outside.
D_{2m}: $D_{2m,nT,Atr}$ (dBA); Standardized level difference, A-weighted, on facades and roofs, when the dominant exterior noise is due to traffic [1].
D_{ls}: $D_{ls,2m,nT,w}$ (C;C_{tr}): Weighted standardized level difference; single-number quantity derived from one third octave band values, measured with one loudspeaker (**1s**) [5]. **C** and **C_{tr}** are the spectral adaptation terms for, respectively, pink noise and traffic noise. It can be assumed that $D_{2m,nT,Atr} = D_{ls,2m,nT,w} + C_{tr}$
Ld: A-weighted long-term average sound levels, determined over all the diurnal period (7 – 19 hours) obtained from the noise map in force at the date of the building design.

6. ANALYSIS

Although the basic document 'DB-HR Noise Protection' was approved in 2007, an adaptation period was granted, and it became mandatory in April 2009. Until this date, the previous regulation on acoustic conditions of buildings, NBE-CA-81 [8], continued to be applied. For this reason, it cannot be concluded whether current facade sound insulation requirements in force were fulfilled for measurements prior to 2012. Although the old evaluation index (R) was not the current index ($D_{2m,nT,Atr}$), the value required at that time (30 dBA) will be assumed to be equivalent (for purposes of compliance with the requirements) to the minimum value required today. It is possible to carry out such an assessment for measurements after 2012, because the sound insulation requirements were already in force and the strategic noise maps were published.

Cells whose results do not strictly comply with the requirements of the sound insulation standard are highlighted with grey background in Table 3. However, in some cases, the non-compliance is only 1-2 dBA, which is within the margin of the error of measurement. In six of the cases, the non-compliance is more than 4 dBA.

7. CONCLUSIONS

After the entry into force of the new building acoustic insulation requirements in Spain (CTE and dB-HR), a notable increase in the acoustic performance of the interior partitions of buildings has become evident. Although an increase has also been noted, it has been much lower in the case of facade insulation against external noise. The facade sound insulation obtained is lower than required in a significant percentage of measurements. In six of the cases, the non-compliance is more than 4 dBA.

More data are required to draw further conclusions. For example, it had not been possible to access to the architectural designs where acoustic insulation of facades was justified, in the light of the dB-HR requirements. This would allow confirming whether strategic noise maps are useful as well as its impact on the required sound insulation. It is the author's opinion that the great uncertainty associated with the results obtained in the elaboration of acoustic maps significantly limits the subsequent decisions that, in theory, they entail.

8. ACKNOWLEDGMENTS

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