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Analysis and comparison of acoustic insulation in dwellings and buildings, recently build

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At this work is analyzed the acoustic quality of new dwellings from acoustic insulating measurements taken in both single-family dwellings and buildings.
Through this work is intended to conduct a case study in order to know the acoustic quality of dwellings built between the years 2001 and 2006, which fulfil the in force regulations in Spain at the time of construction called Norma Básica de la Edificación (NBE). Therefore, 49 acoustic insulation tests where realized in concordance to the international standard of measurements ISO 140-5 of acoustic insulation in-situ in sitting rooms and bedrooms of the selected dwellings.
This work is part of an acoustic quality investigation in dwellings in Spain, that will continue with the acoustic valuations and measurements in dwellings build under the new building regulation in Spain, that is to say, from the entry in force of document "Documento Básico HR" of the code "Código Técnico de la Edificación", so that in this way its going to be possible to compare the real benefits obtained by the implementation of this new regulation.

1 Introduction

In October 2007 the document "Documento Básico HR de Protección Frente al Ruido" from the code "Código Técnico de la Edificación" [1], came into force. This document is a new legal instrument which regulates the construction in Spain. Thus, each one of the projects authorized after that date will have to carry out new acoustic insulation requirements different to those that required the former standard "Norma Básica de la Edificación (NBE)", whose document CA-88 [2] established the minimum acoustic requirements to fulfil for dwellings, which currency dates back to 1982 with a modification made in 1988.

Due to the previously stated, this research is focus in quantifying the real difference of this increase in the demand, conducting an evaluation review in situ of the acoustic quality of the dwellings, in those which obtained the planning permission in the last years of the standard "Norma Básica de la Edificación" and those new dwellings built after October 2007 that carries out the new requirements.

The study that on presents in this paper shows the results obtained only in dwellings facades built between 2001 and 2006, of a selected sample having in consideration the information of representative constructive typologies of the Spanish building, obtained across statistical information, from where dwellings have been selected in accordance to what was described in paragraph 2.

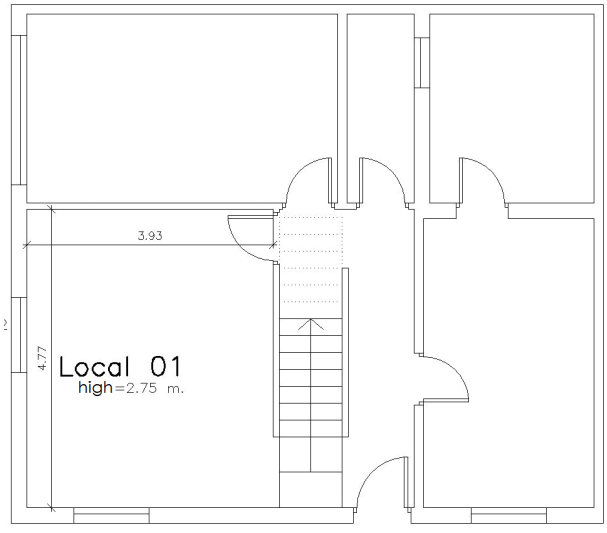
2 Selected Dwellings

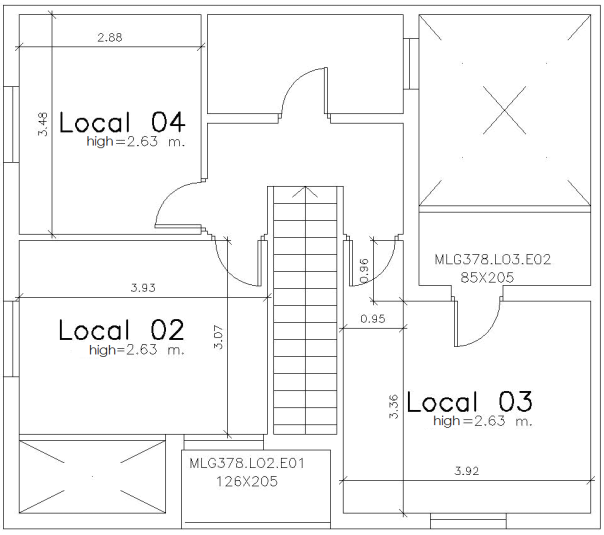
According to information gathered in the "Instituto Nacional de Estadísticas" (INE) regarding to Spanish building statistics in the last years, the following representative typologies in surface of dwelling, number of enclosures, materiality of walls and roof, percentage of glazed surfaces, type of window, material of structure, among other characteristics, were obtained.

Of the extracted information, ten representative typologies of the Spanish building and dwellings were selected and dwellings matching this typologies and having access to be tested were looked for. Thus 8 one-family dwellings and two buildings of collective dwellings were selected.
Of the selected dwellings its characteristics are presented in the following table:

Dwelling	Nº storey	Surface (m2)	Nº Enclosures	Wall material	Glass type
01	2	70	5	Masonry	Double
02	1	80	7	R.C. + Mas.	Double
03	1	70	5	Mas.	Single
04	2	60	8	Mas.	Double
05	2	45	7	Mas.	Double
06	2	65	4	Mas.	Double
07	2	90	7	Mas.	Double
08	2	60	10	Mas.	Double
09	5	-	-	R.C. + Mas.	Double

Table 1 Characteristics of the selected dwellings





.Fig.1 Sketch typology 4

The perimeter walls of the dwelling consist of pillar structure and framed by one-way self-supported beams, 30 cm depth. The façade consist of cavity walls of 1 foot of thickness, double hollow brick masonry, air chamber and single hollow bricks, with interior coat of plaster and exterior cement mortar.

.Fig.1 Sketch typology 4

As it is observed in Figure N° 2, the windows carpentry is aluminium, they are sliding windows and its roller shutter box is prefabricated and located at the inside. It has PVC's blinds and the glass is of the double type of 4+6+4 mm.

In a similar way to the described one, there were characterized 10 dwellings selected according to the certain typology.

3 Performed Tests

The acoustic characterization was realized by means of exterior-interior sounding level variation tests using calibrated sonorous source by means of which pink noise was generated. There were registered levels of sonorous pressure in the interior and in the exterior of the dwelling where the difference of them corrected by the time of reverberation at the interior, corresponds to the difference of standardized sounding level $D_{ls,2m,nT}$ in one-third octave bands from 100 to 5.000 Hz according to the international Standard ISO 140 – 5 [1] which later became a unique value $D_{ls,2m,nT,w}$ in accordance to the standard ISO 717 – 1 [2]

4 Utilized Equipment

The acoustic measurement campaign was carried out with specific equipment for measurements in-situ. Brüel & Kjaer Sounding Source Type 4237, Sonometer Type 2260, Microphone Repolarised Type 4189, Amplifier Type 2716, Calliper Type 4231, DBX Equalizer 131, AKG Cordless Microphone Equipment WMS 4000 and Environmental Condition Measuring Device. The equipments were calibrated in authorized laboratories.

5 Tested Enclosures

All of the 10 selected dwellings were tested on acoustic insulation to airborne noise from sounds coming from the outside of living rooms and bedrooms. A total of 49 tests were realized in the dwellings distributed as it is shown in the following table:

Dwelling	Test Nº	Purpose
01	1	Bedroom
02	2	1 Living room y 1 bedroom
03	2	1 Living room y 1 bedroom
04	2	1 Living room y 1 bedroom
05	3	1 Living room y 2 bedrooms
06	4	1 Living room y 3 bedrooms
07	7	3 Living rooms y 4 bedrooms
08	5	2 Living rooms y 3 bedrooms
09	4	4 Living rooms
10	19	13 Living rooms y 6 bedrooms

Table 2 Realized Tests

6 Obtained Results

The global value of acoustic insulation, obtained by the Standard ISO 1717-1 [4] where the results obtained in the acoustic tests are pondered, are graphically shown in the following table:

$D_{ls,2m,nT,w}$	N
23	1
24	1
25	3
26	3
27	2
28	5
29	6
30	15
31	4
32	2
34	1
35	3
36	2
37	1

Table 3 Obtained Results

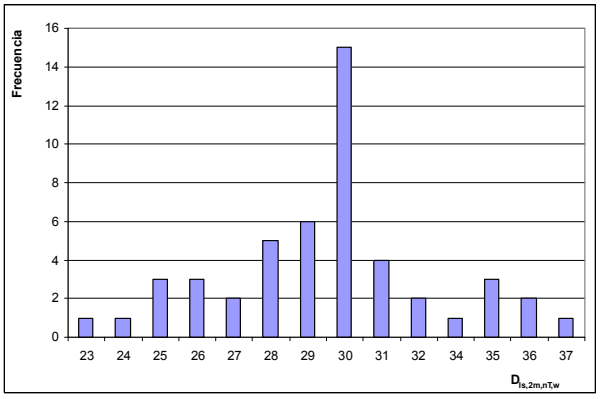


Fig.2 Obtained Results

7 Accomplishment of the standard called "Norma Básica de la Edificación NBE-CA-88".

The NBE-CA-88 [2] document from the Spanish Standard Norma Básica de la Edificación requires that for the dwellings facades of new constructions it must fulfil a global insulation "Aislamiento global mínimo ag = 30 dBA" in the case of resting areas and for the rest of the areas a carpentry class A-1 according to the classification established on the document Norma Básica de la Edificación NBE-CT-79, about thermal conditions in buildings.

In order to fulfil the standard required by the NBE-CA-88 [2] the work must be done pondering the acoustic insulation of the compounding elements of the facade by its surface and from this hand over a supporting datasheet about the fulfilment of the acoustic insulation required. Even though the tested dwellings fulfil the handing over of the supporting datasheet in order to prove its construction, it can be observed that in the realized test, the obtained value of standardized Level Difference ($D_{ls,2m,nT,w}$), only the 57% of the tests presents results over 30 dB. In regard to tested dwellings, in 6 of them some of the tests obtained values below 30 dB.

8 Acoustic quality of selected dwellings facades analysis

Based on the realized tests, the technical specifications of products and the materials used in the facades, and the visits made to the dwellings, it can be concluded that the acoustic quality of the dwelling's facades depends basically on the glass type and the carpentry used, besides the presence and condition of the roller shutter boxes. In the tested buildings it could be observed that the utilization of double glass (thermo panels) remarkably increases the acoustic insulation, especially if it's combined with a hermetic closing contributed by side hanging windows

9 Prognostic about the entry in force of the new Código Técnico de la Edificación

With the entry in force of the Código Técnico de la edificación, the way of demanding an acoustic minimal insulation of dwellings facades of new construction changes. Now minimal values are established for facades and lounges in a different way depending on the level of existing noise in the exterior.

Hereby, the exigency makes better sense, since it is not necessary to provide from an unnecessary acoustic insulation to those facades of dwellings that are not in a zone where high acoustic level exists in the exterior, and on the contrary, in those noisy zones the new constructions must provide this major acoustic insulation.

In order to do a projection of the studied dwellings in this investigation, the fulfilment of the new Código Técnico de la Edificación was studied, supposing that they were located in zones of a level of average noise, that is to say with a value of day Noise Rate Ld of between 65 and 70 dB.
The obtained results appear in the table Nº4:

Ld	Established Requirements		Fulfilment Percentage (%)	
	Bedrooms	Living rooms	Bedrooms	Living rooms
Ld < 60	30	30	50	63
60 <L_d < 65	32	30	18	63
65 < Ld < 70	37	32	0	19
70 < Ld < 75	42	37	0	0

Ld > 75	47	42	0	0

Table 4 Fulfilment of the Código Técnico de la Edificación

10 Conclusions

Since it is possible to observe in both presented analyses, the acoustic quality of the construction in Spain must rise to fulfil the new demanded standards. Though the results from tests shows an important fulfilment of the legislation under which they were constructed, if we project the results to a scene under the new in force legislation is observed that they would hardly fulfil, and therefore it is necessary take important actions, in the elements, in the materials, and especially in the constructive processes to reach a sufficient level of acoustic insulation.

Since it was mentioned before, in the dwellings facades which windows have double glasses they presented better results so much globally like in the band of complete frequencies. Those sides hanging windows type also presented better results that in case of windows with closing sliding panel.

Finally, it is necessary to emphasize the importance of the entry in force of the Documento Básico HR from the Código Técnico de la Edificación, since as it's demonstrated in this investigation of dwellings facades it is a legal tool that will allow raising considerably the acoustic quality of the new buildings in Spain.
Equations should be centered and identified by a number, as following:

References

[1] Boletín Oficial del Estado, 254 October 23, 2007. Real Decreto 1371/2007, October 19, por el que se aprueba el documento básico «DB-HR Protección frente al ruido» del Código Técnico de la Edificación y se modifica el Real Decreto 314/2006, de 17 de marzo, por el que se aprueba el Código Técnico de la Edificación.

[2] Boletín Oficial del Estado, 242 October 8, 1988. Order from September 29, 1988 por la que se aclaran y corrigen diversos aspectos de los anexos a la norma básica de la edificación NBE-CA-82 sobre "condiciones acústicas de los edificios".

[3] ISO 140-5:1999 Acoustics - Measurement of sound insulation in buildings and of building elements Part 5: Field measurements of airborne sound insulation of façade elements and façades.

[4] ISO 717-1:1996 Acoustics -- Rating of sound insulation in buildings and of building elements -- Part 1: Airborne sound insulation.