PAPER #8.02

THE INFLUENCE OF ACOUSTIC STANDARDS IN CONSTRUCTION: A CASE STUDY OF SOCIAL HOUSING IN ARGENTINA

Vanesa Saez[a], Alberto Quintana-Gallardo[b], Beatriz Garzón[a], Ignacio Guillén-Guillamón[b]
[a]National University of Tucumán, Argentina
[b]Universitat Politècnica de València, Spain

How to cite
Saez, Vanesa, Alberto Quintana-Gallardo, Beatriz Garzón, and Ignacio Guillén-Guillamón. "The influence of acoustic standards in construction: a case study of social housing in Argentina." In *Proceedings of 3rd Valencia International Biennial of Research in Architecture. Changing priorities*. Valencia. 2022. https://doi.org/10.4995/VIBRArch2022.2022.15204

ABSTRACT

Exposure to high noise levels greatly impacts human health. For this reason, it is necessary to take into account the acoustic conditioning of built interior spaces, since human beings spend a large part of their time in them. To this end, each country must regulate and promote good construction practices that guarantee the mental and physical comfort of its occupants. In the case of Argentina, there is an insufficiency in the development of laws and regulations on acoustic architecture and even more so on acoustics in homes. In this sense, this study aims to evaluate the current acoustic comfort presented by public housing in Argentina, highlighting the existing legal gaps, and enabling recommendations in this regard, taking Spain as the country of reference. This country is taken since Argentine legislation has traditionally replicated European and Spanish standards instead of American ones. To this end, a systemic review and comparison are made between the laws and architectural acoustic regulations of Argentina and Spain. The observation of the noise protection standards in closed areas of these countries will be deepened. For a better understanding of these and to meet the objective, a prototype of public housing was needed in different parts of the country through the PRO.CRE.AR plan is taken as a case study and verified according to each standard. IRAM and UNE. As a relevant result, it is shown that the houses built by the State only partially verify the admissible minimums proposed by the regulations. The lack of laws and complementary documents focused on acoustic conditioning is concluded through the case study.

KEYWORDS

Noise pollution; acoustic comfort; architectural acoustics.

1. INTRODUCTION

From the industrial revolution to the present, there is evidence of an excess of sound from technological sources as opposed to sounds of human or natural origin. Currently, technological sounds represent 68% of the total, followed by human sounds with 26%, and finally natural sounds with 6% (Schafer, 2018). In other words, the population of cities is increasingly exposed to noise generated by

sources such as vehicular traffic, construction, rail, and air traffic, among others. One of the factors of environmental degradation is sound or acoustic pollution (Maristany, 2021). The term Noise Pollution refers to the excess of sound that alters the normal conditions of the environment in a certain area (Juárez and Garzón 2020). According to data from the World Health Organization (WHO), noise is the second environmental cause of health problems, just behind air pollution -suspended particles- (European Environment Agency, 2021). (Maristany et al. 2016) .

In such a case, the countries take precautions in this regard by implementing the necessary measures for the acoustic protection of the spaces. Many of these take as a reference the set of technical regulations provided by the International Organization for Standardization (ISO) and then adapt them to their local context, including them as binding recommendations or not. However, as Maria says Machiberrena (2022), there is a lack of research and concrete actions both at the regulatory level and in environmental certifications, on the importance of protection against noise in closed spaces, being these types of spaces where human being spends 80% of their time. weather. In the environmental certifications carried out by third parties, the acoustic requirements of the buildings for their classification only have an influence of 5.9% of the total, which indicates their low consideration concerning other parameters on hygrothermal comfort, lighting, and energy efficiency, among others. The acoustic conditioning of homes is essential to preserve the physical and mental health of its inhabitants and even more so in the face of a strong trend of remote work or online education, which adds more activities and more acoustic requirements to the domestic environment (Saez, et. al., 2021). In the case of Argentina, there is an insufficiency in the development of laws and regulations on acoustic architecture and even more so on acoustic conditioning in homes.

2. OBJECTIVE

In this sense, this aims to evaluate the current acoustic comfort presented by public housing in Argentina, highlighting the legal gaps in acoustic matters, and enabling recommendations in this regard, and taking Spain as the country of reference. The choice of comparison with this country is that Argentine legislation has traditionally been taken as a model to follow and replicated the European and Spanish standards instead of the American ones.

3. METHODOLOGY

The methodology applied to achieve the objective is to make a systematic review and comparison between the laws and acoustic building regulations of Argentina and those of Spain. The observation of the noise protection standards in closed premises of each country will be deepened, being the IRAM 4044 standard in Argentina and the UNE 12354:2017 in Spain. For a better understanding of these for practical purposes, a prototype of publicly promoted housing was obtained in different parts of the country through the PRO.CRE.AR plan is taken as a case study. This presents the most traditional functional, aesthetic, and constructive typology of the country.

3.1. Bibliographic analysis of acoustic regulations

Currently, in Argentina, there is a national bill on the minimum budget for the environmental protection of acoustic quality. The main objective of this project is: To avoid or reduce the adverse effects of noise pollution on human health, other living beings, and the natural or cultural environment (Morandini, et al., 2018). In this sense, it proposes to implement an Acoustic Plan whose purpose is to design and implement measures aimed at reducing and maintaining sound and vibration levels below the guide levels of acoustic quality foreseen according to the

WHO. This acoustic plan requires the following: a) acoustic zoning based on the current or planned uses of the land, b) an evaluation of the existing acoustic situation according to the IRAM 4076 standard or its replacement. However, from the environmental and labor guidelines, the lack of technical specifications to carry out the acoustic conditioning of living spaces is evident. Within this specific field of acoustic architecture and directly related to the domestic habitat, since 2000 there has been a technical document proposed by the Ministry of the Interior called Minimum Quality Standards for social housing, last updated in 2019. This presents a section referring to acoustic comfort and refers to the corresponding regulation, IRAM series 4000, proposed by the Argentine Institute for Standardization and Certification (IRAM), a representative member of ISO and the Pan-American Commission for Technical Standards (COPANT) in Argentina. However, this document is not binding; it is simply a recommendation made by the aforementioned Minister.

At the provincial level, given the lack of sanction of the national law mentioned in previous paragraphs, the competent authorities carry out their legislation and ordinances on protection against noise, based on what is increased in article 41 of the national constitution and also in the civil code Article 2618. Where in the case of the constitution it refers to the fact that all inhabitants enjoy the right to a healthy, balanced environment, suitable for human development, and in the case of the civil code there are restrictions on the obligations as a citizen not to generate annoying noise. Only Buenos Aires, the capital of Argentina, has generated the greatest advances in acoustic matters with its provincial law no. 1,540/2004, which seeks to prevent and control noise pollution and identifies, among other things, its noise levels through noise maps, determining sensitive areas both in exterior and interior spaces and conflict areas (www.argentina.gor.ar, 2022). In the rest of the provinces, there are ordinances reformatory, annoying and excessive noise or sounds in the city (Hussl Bulgarelli 2017), however, we are sorry in these regulations it is an insignificant reference in terms of architectural acoustic conditioning. In this sense, it is up to the professional in charge and the client to apply the IRAM recommendations on protection against noise in interior spaces. In the case of low-income housing, they are subject to materializing in accordbynical specifications required by the provincial or national government, which must improve current laws and regulations. Under this scenario, the lack of binding laws at both the national and provincial levels on acoustic conditioning in interior spaces, both for new construction and for rehabilitation, is eve. It is expected that soon compliance with the IRAM Standards will be mandatory by law and it will indeed be important to analyze the recommendations they make on the subject.

In the case of Spain, the autonomous communities are obliged to comply with Law 37/2003 on Noise and determine the objectives of acoustic quality in the interior space of buildings intended for residential, hospital, educational or cultural use. Likewise, Royal Decree 1371/2007, of October 19, 2007, includes the Basic Document against Noise (DB-HR) in the Technical Building Code (Government of Spain, 2019). Its compliance guarantees the minimum requirements for protection against noise. In other words, it makes it possible to limit the risk of discomfort or illness that noise can cause to users due to the characteristics of its project, construction, and maintenance. This document takes as reference standards those provided by the Technical Standardization Committees of the Spanish Association for Standardization (UNE), a member of ISO, and the European Committee for Standardization (CEN). In 2016, the Basic Document with Comments (Dcc -DB-HR) was updated; In addition, the new Support Document DA DB HR 1 was published: "Guide for the use of magnitudes of acoustic insulation about the requirements", which expands the content of Annex H on the global assessment of the results of the insulation measures according to each type of noise. It should be noted that, in addition to the new DA DBD HR 1 Support

Document, there is a DB HR Application Guide Noise protection updated in September 2014 and also the Catalog of construction elements that allows decisions to be made in acoustic matters under the guarantee of the official values of sound insulation. Recently, the beta version of UNE 74201 (UNE, 2021) was presented, which proposes the acoustic classification of buildings; Although it is a fundamental step to improve the facilities in terms of the level of hearing they present, this standard is not yet binding.

3.2. Case study

For practical purposes, a prototype of public housing was obtained in different parts of the country through the PRO.CRE.AR plan between 2015 and 2000 is taken as a case study. As Figure 1 shows, this represents the duplex typology typical of the country, in many functional, aesthetic and, constructive aspects, being a house between dividing walls with 70 m 2 covered, resolved on 2 floors with a front and rear patio. Its location is generally in residential neighborhoods and its main source of noise is produced by the vehicular corridors that surround the neighborhood. That is, vehicular traffic noise of the aerial mobile type and vibrations in the following time slots from 7:00 a.m. to 8:00 a.m., 12:00 a.m. to 1:00 p.m. and 6:00 p.m. to 8:00 p.m. on days weekdays It should be noted that in the case of Argentina IRAM does not present noise maps; however, the acoustic quality bill mentioned in previous paragraphs characterizes residential areas as type III and recommends that sound levels do not exceed 65 dB during the day and 55 dB at night (https://www.hcdn .gob.ar/, 2022). In the case of considering the Spanish regulations, the DB HR establishes that, in the case of not knowing the external noise levels, consider between 60 and 70 dB for homes.

3.2.1. Technician report

Figure 2 shows the plan of the floors and Figure 3 shows a cross-section showing adjoining units. The envelope is materialized with different types of ceramic facings. The dividing walls of the house are double walled, hereinafter referred to as W1, formed by ceramic hollow brick (CB) 0.12 m thick, a layer of expanded polystyrene 0.025 m thick, 0.08 m thick CB, plastered on both sides, and painted. The north party wall, called W2, is resolved with a double BC wall 0.12 m thick on both sides and an EPS layer 0.025 m thick in the center and plastered on both sides. The southern dividing wall, called W3, is made up of CB 0.18 m thick, plastered on both sides. The floor, called S1, is made up of prestressed concrete beams and expanded polystyrene vaults. The windows and balcony doors open with aluminum profiles and 6 mm simple glazing without weather stripping. Its exterior doors are metallic, with 0.006 m fixed glazing. In the areas of the land where there is no building, there is a party wall of 3 m of solid ceramic brick masonry of 0.13 m plastered, called W4. The interior walls called W5 are made of CB of 0.12 m, plastered and painted on both sides. The interior doors are plywood plate doors and folded sheet metal frames.

Figure 1. PROCREAR duplex floor typology dwellings

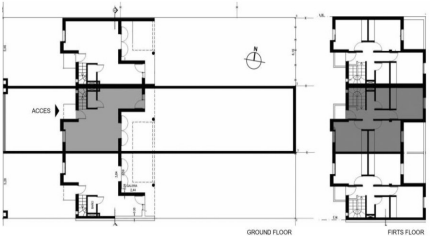

Figure 2. Plant. Own elaboration

Figure 3. Cross section of the analysis sector. Own elaboration

4. RESULTS

4.1. Review of current regulations for acoustic conditioning in Argentina and Spain

Table 1 below shows the requirements proposed by the IRAM and UNE standards for noise control in closed spaces, especially homes. For Argentina, IRAM 4044 (2015) presents the minimum permissible values of airborne and impact noise insulation to achieve acoustic conditioning in closed rooms, considering two possible scales. Scale I take the minimum values necessary to preserve people's health. Scale II establishes values that allow the occupants of different premises to achieve an adequate level for intellectual development, recreation or rest, and the protection of privacy. In the case of housing, it does not determine reverberation time, in terms of background noise values, it determines them according to

Case study :		Single-family house, duplex typology in dividing walls					
Country		Argentina			Spain		
Standard type :		IRAM 4044 standard			CTE - DB-HR		Observations
	wall type	Scale I	Scale II	Index	DB	Index	
Airborne noise	Among adjacent houses	55 dBA	56 dBA	R_w	50dB A _	$D_{mt,A}$	
	Between rooms in the same unit (no shared doors and windows)	42 dBA	48 dBA	R_w	33 dBA	AR _	They are different but comparable indices in normal reverberation conditions (0.5s)
	Between rooms in the same unit (with shared doors and windows)	35 dBA	41 dBA	R_w	33 dBA	AR _	
	facades	Scale I	Scale II				
	opaque wall	53 dBA	59 dBA	$D2\ n_{,nT,w}$	30-42dB A _	$D_{2\ m,nT,Atr}$	In Spain, these values are about external sources of 60 dBA
	Glaze wall (up to 20 %)	36 dBA	42 dBA	$D2\ n_{,nT,w}$			
Noise of Impact	between the same living place	53 dBA	46 dBA	$Ln_{,w}$	60-65 dBA	$Ln_{,w}$	
reverberation time	interiors of Accommodation	-	-	-	-	-	No recommended values are set
Noise Criteria	interiors of Accommodation	30 to 40 dBA		-	-	-	Argentina establishes a recommended value and DB HR does not

Table 1. Acoustic requirements according to IRAM and UNE standards. Own elaboration

the Noise curve Criteria. Spain requires through the CTE DB-HR similar requirements according to UNE 12354:2017, being the official version, in Spanish, of the ISO 12354:2017 Standard. It does not detect maximum levels of background noise, nor does it determine the reverberation time for single-family residences.

4.2. Verification according to regulations of each country

4.2.1 Airborne Noise

The simplified option obtained from the CTE catalog is used to determine the values of the airborne noise reduction indices of the construction elements. For the walls, the calculation of the global acoustic reduction index of the mixed construction elements of Annex G of the CTE-DB-HR (Spain 2010). In the case of the Rw of the slab, a value is taken from the simplified option of the catalog of construction elements of the CTE-DB-HR (Spain 2010) of the CTE-DB-HR. Table 2 shows the results obtained for each construction element and its verification according to IRAM and UNE standards through the CTE-DB-HR.

4.2.2. Impact noise

The concrete slab floor and its resistant structure are shared with the house that borders to the south, which means a more unfavorable context for impact noise. The impact noise value Ln is obtained using the simplified formula ISO 12354-2. Table 3 below shows the value obtained for Ln and compares it with the values established by the standards of each country. The low possibility of impact noise insulation is evident as it exceeds the acceptable pressure levels for both standards.

5. DISCUSSION

Regarding the legal instruments in force in Argentina concerning architectural acoustics, it is important to make visible that both at the national, provincial and municipal levels, this lacks laws that regulate and especially the interior space in homes. This explains that when materializing any type of housing, whether public or private, they do not verify even the minimum acceptable according to the

	Write	dBA	Index	IRAM 4044	CTE DB-HR
Walls	W1 (Enameled up to 20 %)	**21**	$D_{2m,nT,Atr}$	DOES NOT VERIFY	DOES NOT VERIFY
	W1 (Enameled up to 20 %)	**27**	$D_{2m,nT,Atr}$	DOES NOT VERIFY	DOES NOT VERIFY
	W2 – double wall	**52**	$DnT_{,A}$	CHECK Scale I	CHECK
	W3 – double wall	**52**	$DnT_{,A}$	CHECK Scale I	CHECK
	W5 - rooms in the same unit (no shared doors and windows)	**40**	AR _	DOES NOT VERIFY	**CHECK**
Slab	Beams and EPS	**45**	RW _	DOES NOT VERIFY	DOES NOT VERIFY

Table 2. Verification of Aerial Noise according to IRAM and UNE standards of the construction elements of the house. Own self elaboration

	Write	dBA	Index	IRAM 4044	CTE DB-HR
Slab	Beams and EPS	**88**	Ln	DOES NOT VERIFY	DOES NOT VERIFY

Table 3. Verification of Impact Noise according to IRAM and UNE standards of the construction elements of the house. Own elaboration

recommendations of the Standards. It should be noted that those built by the State guarantee the minimum acoustic requirements, however, according to the evaluation of the prototype, it does not meet the Minimum Quality Standards for social housing.

According to the comparison with the Spanish laws and regulations, in Argentina, it is necessary to advance and enact the environmental protection law for acoustic quality together with a series of legal instruments such as the Spanish Technical Building Code, which includes the Basic Noise Protection Document based on UNE standards and the Catalog of construction elements. The latter allows the professional in an architectural design position to choose constructive resolutions that guarantee compliance with the standard.

Regarding the recommendations based on IRAM by Argentina and UNE by Spain, there are some differences in the minimum admissible values recommended in both standards. At a general level, it is detected that the IRAM standard determines 2 possible admissible values to be reached, being those of Scale I less demanding than Scale II. Likewise, the UNE standard only starts from a reference value as the minimum acceptable. Regarding the measurement units in IRAM they use decibels (dB) and UNE uses decibels weighted to A (dBA), in addition, they take different terminology to define the unique value of the construction elements, however, the comparison is viable.

Based on this, it is observed that the values determined by the IRAM standard for airborne noise are more demanding, except for those proposed by UNE. The greatest differences are detected in the interior walls. In this sense, the IRAM standard grants different values to interior walls with windows and/or doors and interior walls without windows and/or doors. It should be noted that the values for walls without windows and doors are higher than those that do have. It is assumed that in walls with windows and doors it is more complex to achieve sealing for acoustic insulation and therefore the requirement is lower. On the other hand, the UNE standard takes the same value in both wall situations with or without openings and even presents values with differences between 2 to 15 dBA less depending on the type of wall and IRAM scale I or II. In the case of the façade wall, it is again observed that the demands are greater in Argentina, but it is necessary to carry out the following salvation. The admissible minimums considered for this type of wall in Argentina are recommended without distinguishing how many dB the external source presents. That is, it is understood that both a home near an airport or within a residential area must verify the same values.

Impact noises have more demanding requirements in the UNE standard that range from 60 – 65 dBA as opposed to 53 dBA scale I and 46 dBA scale II. Regarding the reverberation time, neither of the two standards expresses precise data for the dwelling, however, its consideration is necessary, since in many cases the dwellings have very polished wall and floor surfaces, which are counterproductive if what is wanted is Achieved is acoustic comfort in space.

The application of both regulations to the case study shows that the type of construction used to build a typical house in Argentina needs technological improvements to achieve an acoustic quality by the IRAM recommendations and the dBA values of the UNE standard for houses. urban single-family homes. In terms of airborne noise, the façade is the most unfavorable since the carpentry works due to its low performance, being made of simple glass and without adequate sealing of its joints. The impact and vibration noise pressure level in the mezzanine loss is also detected as high because it does not have any elastic insulation on both its upper and lower faces. Regarding the reverberation time, the original case presents many smooth and polished surfaces such as ceramics and slab bottoms with acrylic paint, and although none of the

standards establish admissible values for homes, it is considered important to improve it.

6. CONCLUSIONS

After completing this study, the following conclusions can be drawn:

- The minimum insulation values of the Spanish (CTE) and Argentine (IRAM) regulations are similar. The CTE requirements are comparable to scale I of the IRAM regulation
- While the CTE is mandatory in Spain, the IRAM regulations limit themselves to indicating that they will be the appropriate values. That results in non-compliant buildings and houses, especially in social housing and publicly funded construction projects as is the case in the case study.
- The house chosen as a case study does not comply with Spanish and Argentine regulations. This is due to the non-mandatory nature of the IRAM standard. In the hypothetical case that the regulations become mandatory due to the transition to the Spanish and European model, the house would have to be rehabilitated to comply with the code.
- The CTE incorporates the Catalog of Building Elements, which allows decision-making in acoustic matters under the guarantee of the official values of acoustic insulation.
- In the Spanish territory, the air insulation of the building envelope depends on noise mapping, in that direction, incorporating this into the IRAM regulations would be an added value.
- The houses built by the State do not meet the minimum standards of acoustic quality and consequently exacerbate the problems related to affordability, their sustainability, and the user's human health.

REFERENCES

Blasco, Lucia. 2021. "Psychology of Space: How Interior Architecture Alters Our Health and Influences Our Behaviors," April 17, 2021.

Hussl Bulgarelli, Agustina; Garzón Beatriz and Soldati María Eliza. 2017. "Acoustic Regulations In Argentina: Comparative Case Study," 1–14.

IRAM 4043, (2003). "Acoustics. Evaluation of Acoustic Insulation in Buildings and Construction Elements. Part 1: Airborne Noise Insulation."

IRAM 4044, (2015). "Acoustics, Protection Against Noise in Buildings. Argentina: Argentine Institute for Standardization and Certification."

Juarez, Isabel ; Garzon Beatriz. 2020. "Assessment of the Acoustic Quality of an Urban Area of San Miguel de Tucumán" 24: 62–76.

Machimbarrena, Maria. 2022. "Technical Conference. New Acoustic Classification UNE 74201 - YouTube." June 2, 2022. https://www.youtube.com/watch?v=iIaIEuVR8J8.

Maristany, Arturo Raúl, Leandra Abadía, Miriam Agosto, and Lorena Carrizo. 2016. "Noise Control in Facades as a Contribution to Acoustic Sustainability." *In: Congreso Arquisur (20.:2016 Sept. 28-30: Concepción)* , 163–75. https://rdu.unc.edu.ar/handle/11086/18853.

Morandini, Norma and Medina Abal. 2018. *LAW OF MINIMUM BUDGETS FOR ENVIRONMENTAL PROTECTION OF ACOUSTIC QUALITY CHAPTER I General Provisions*. Buenos Aires: Chamber of Deputies.

Peris, Eulalia. 2020. "Noise Pollution Is A Major Problem, For Both Human Health And The Environment — European Environment Agency." May 11, 2020. https://www.eea.europa.eu/es/articles/la-contaminacion-acustica-es-un.

Saez, Vanessa Celina; Juarez Isabel; Garzon Beatriz. 2021. "CONSTRUCTION FOR ACOUSTIC ADAPTATION IN PANDEMIC AND POST-PANDEMIC."

Spain, Government. 2010. *Catalog of Construction Elements of the CTE. Technical Building Code CTE* . vol. 3. https://www.codigotecnico.org/index.html.

Spain, Government. 2019. *DB-HR Noise Protection - Technical Building Code.* https://www.codigotecnico.org/DocumentosCTE/ProteccionNoise.html.

UNE 74201. 2021. Spanish Acoustic Standard Acoustic Cla*ssification Scheme for Buildings.*