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A study for a new classification scheme for residential buildings in Brazil

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ABSTRACT

In Brazil, the national standard NBR 15575 has established acoustic performance criteria in buildings since 2013. This standard presents three levels of performance: minimum, intermediate and superior. This work aims to analyse the feasibility of a global acoustic system classification of residential buildings based on NBR 15575 and the work developed by European COST action TU 0901, which presents harmonized criteria for several acoustic requirements. It was studied a large database of field measurements performed in typical Brazilian constructions. Results are presented for airborne and impact sound insulation between dwellings, airborne sound insulation for facades and sound levels of service building equipment.

Keywords: Residential noise, Acoustical Classification Scheme, Annoyance
I-INCE Classification of Subject Number: 89, 81

1. INTRODUCTION

In July 2013 the ABNT NBR 15575 [1] entered into force. This standard was developed based on the international standard ISO 6241:1984 [2], aiming to translate technical requirements into human needs. The standard establishes minimum performance criteria for residential buildings that must be accomplished during each construction system lifespan. In an informative annex, intermediate and superior criteria are presented for those cases were higher performance is aimed to be achieved.

In its large scope, acoustics is just one requirement among many others in ABNT NBR 15575.The standard also establishes requirements for thermal insulation, luminous performance, fire safety, and others. Considering population awareness, it is positive to deal with a large scope standard, which has become well known around the country due to its relevance. On the other hand, the revision process of this standard that is undergoing, might become a hard task because of the number of different aspects and requirements that need to be taken into account.

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ABNT NBR 15575 is divided into six parts, including acoustic criteria in five of them. Parts 3,4 and 5, contain airborne, impact and façade sound insulation requirements. In parts 1 and 6, informative limits for sound levels due to service equipment are included.

The enforcement of technical standards in Brazil is not mandatory. However, due to a specific Brazilian consumer law [3], the use of ABNT NBR 15575 has become mandatory for all projects designed after July 19th, 2013, but with no criteria established for existing buildings or retrofit. As a consequence, any future change in the requirements affects construction costs. The revision of this standard is due to start in 2019, and an active participation of the construction market stakeholders is already being noticed.

The implementation of ABNT NBR 15575 has been a huge process in Brazil. Many workshops and seminars have been given, and a great number of professionals, such as architects and engineers, are still adapting their projects to the new requirements. Since 2013, ProAcústica (Brazilian Association for Acoustical Quality) is publishing a collection of guidelines [4-6] to make it easier for stakeholders to understand acoustical criteria and all implications of the new standard.

Meanwhile, a large social housing construction program was implemented by the national government. This program called "Minha Casa Minha Vida (My House, My Life)" itself, delivered more than a million houses after 2013 and it is still funding 1.7 million houses that are under construction.

The requirements adopted in ABNT NBR 15575 are too low if compared to the ones used in European countries due to economic and technical reasons. In Brazil, heavyweight materials, such as hollow concrete or ceramic blocks for wall systems and solid concrete slabs for floor systems, are typically found. Lightweight systems are not frequently adopted; however, they have been gradually included in the construction of new dwellings [7]. Workmanship is also a challenge, as the Brazilian construction market still lies down on low qualified professionals that are not aware of the dependence of high-quality level of construction and building performance. Some of the minimum requirements criteria and typical building materials used in Brazilian construction systems are shown in [8].

Despite all efforts to spread information about this new construction concept, most people in Brazil still ignore the new requirements and their relevance. In consonance with the improvement of Brazilian building standard performance ABNT NBR 15575, the development of a National Building Acoustics Classification Scheme might help Brazilian population to understand what they will receive in terms of acoustical quality in the new dwellings they are going to live in. Continuing the previous studies [7] and aiming to increase user's awareness about building acoustics performance, the main objective of this paper, is to develop an Acoustic Classification Scheme (ACS) proposal that can be used as a starting point for the discussion on the development of national guidelines or even a standard with building acoustics performance classes.

2. OBJECTIVES

- For the building acoustics performance descriptors indicated in ABNT NBR 15575, propose an ACS for dwellings, with a new range of classes.
- Based on this scheme, suggest new criteria for the future standard revision.
- Compare the current and the suggested criteria with the requirements presented on international documents.
- Considering a data base of field measurements performed after ABNT NBR 15575 implementation, evaluate the percentage of buildings that meets each proposed class.

3. METHODOLOGY

Measurement data was obtained from 478 field measurements of typical Brazilian dwellings carried out in compliance with ISO series 16283 [9-11], with the frequency range from 100Hz up to 3150Hz. Data of noise from building service equipment was obtained following ISO 16032:2004 procedures.

In order to organize the classes, it was decided to follow the framework proposed by "COST Action TU0901" [12], which presents a European classification scheme with a number of quality classes, based on harmonized criteria for several acoustic requirements [7,12]. The same "A-F" classes system was used to specify different levels of acoustics conditions in dwellings, as well as the 4dB steps between classes.

All descriptors presented in ABNT NBR 15575 consider the frequency range that starts on 100Hz up to 3150Hz, thus no extended frequency range with low frequencies is taken into account. To make it possible to compare the results, all descriptors and requirements presented on COST Action TU0901 proposal were converted to those adopted in Brazil using the procedure proposed by Monteiro et al. [13].

Finally, based on the 478 field measurements, it is presented a percentage of compliance in each class of the proposed Brazilian ACS .

4. PROPOSAL FOR A BRAZILIAN ACOUSTICAL CLASSIFICATION SCHEME (ACS)

Table 1: Airborne sound insulation

Airborne sound insulation between a dwelling and other dwellings - Living Rooms ans Kitchens

Scale: 63 62 61 60 59 58 57 56 55 54 53 52 51 50 49 48 47 46 45 44 43 42 41 40 39 38 37 36 35 34 33 32

NBR15575 $D_{nT,w}$	Superior ≥ 50dB	Interm. ≥ 45dB	Minimum ≥ 40dB				
Sugestion	Superior	Interm.	Minimum		Old buildings		
Proposed ACS $D_{nT,w}$	Class A ≥ 52dB	Class B ≥ 48dB	Class C ≥ 44dB	Class D ≥ 40dB	Class E ≥ 36dB	Class F ≥ 32dB	npd
Measured (%)	17%	24%	38%	20%	1%	0%	0%
ACS COST TU 0901 $D_{nT,w}$ [1]	Class A ≥ 63dB	Class B ≥59dB	Class C ≥ 55dB	Class D ≥ 50dB	Class E ≥ 46dB	Class F ≥ 42dB	n=82

Airborne sound insulation between a dwelling and other dwellings - At least one room is a bedroom

Scale: 63 62 61 60 59 58 57 56 55 54 53 52 51 50 49 48 47 46 45 44 43 42 41 40 39 38 37

NBR15575 $D_{nT,w}$	Superior ≥ 55dB	Interm. ≥ 50dB	Minimum ≥ 45dB				
Sugestion	Superior	Interm.	Minimum		Old buildings		
Proposed ACS $D_{nT,w}$	Class A ≥ 57dB	Class B ≥53dB	Class C ≥ 49dB	Class D ≥ 45dB	Class E ≥ 41dB	Class F ≥ 37dB	npd
Measured (%)	4%	13%	19%	44%	20%	1%	0%
ACS COST TU 0901 $D_{nT,w}$ [1]	Class A ≥ 63dB	Class B ≥59dB	Class C ≥ 55dB	Class D ≥ 50dB	Class E ≥ 46dB	Class F ≥ 42dB	n=124

Airborne sound insulation between a dwelling and premises with noisy activities

Scale: 69 68 67 66 65 64 63 62 61 60 59 58 57 56 55 54 53 52 51 50 49 48 47 46 45 44 43 42 41 40

NBR15575 $D_{nT,w}$	Superior ≥ 55dB	Interm. ≥ 50dB	Minimum ≥ 45dB				
Sugestion	Superior	Interm.	Minimum		Old buildings		
Proposed ACS $D_{nT,w}$	Class A ≥ 60dB	Class B ≥56dB	Class C ≥ 52dB	Class D ≥ 48dB	Class E ≥ 44dB	Class F ≥ 40dB	npd
Measured (%)	19%	62%	12%	0%	8%	0%	0%
ACS COST TU 0901 $D_{nT,w}$ [1]	Class A ≥ 69dB	Class B ≥65dB	Class C ≥ 61dB	Class D ≥ 57dB	Class E ≥ 53dB	Class F ≥ 48dB	n=26

1- COST TU0901 ACS requirements were translated according to equations from [13]

Table 2 : Impact sound insulation

Impact sound pressure level in dwellings, from other dwellings

Scale (dB): 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

NBR15575 L'nT,w	Superior ≤ 55dB	Interm. ≤ 65dB	Minimum ≤ 80dB				
Sugestion	Superior		Interm.	Minimum		Old buildings	
Proposed ACS L'nT,w	Class A ≤ 54dB	Class B ≤ 58dB	Class C ≤ 62dB	Class D ≤ 66dB	Class E ≤ 70dB	Class F ≤ 80dB	npd
Measured (%)	2%	3%	11%	14%	7%	43%	20%
ACS COST TU 0901 L'nT,w	Class A ≤ 44dB	Class B ≤ 48dB	Class C ≤ 52dB	Class D ≤ 56dB	Class E ≤ 60dB	Class F ≤ 64dB	n=104

Impact sound pressure level in dwellings from premises with noisy activities

Scale (dB): 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62

NBR15575 L'nT,w	Superior ≤ 45dB	Interm. ≤ 50dB	Minimum ≤ 55dB				
Sugestion	Superior	Interm.	Minimum		Old buildings		
Proposed ACS L'nT,w	Class A ≤ 42dB	Class B ≤ 46dB	Class C ≤ 50dB	Class D ≤ 54dB	Class E ≤ 58dB	Class F ≤ 62dB	npd
Measured (%)	11%	11%	22%	11%	11%	11%	22%
ACS COST TU 0901 L'nT,w	Class A ≤ 38dB	Class B ≤ 42dB	Class C ≤ 46dB	Class D ≤ 50dB	Class E ≤ 54dB	Class F ≤ 58dB	n= 9

Table 3 : Façade sound insulation

Facade sound insulation in dwellings

NBR15575	Three classes - Subjective evaluation						
Sugestion	Superior		Interm.	Minimum	Old build. or retrofit		
Proposed ACS D2m,nT,w	Class A ≥ (Ldn-28)	Class B ≥ (Ldn-32)	Class C ≥ (Ldn-36)	Class D ≥ (Ldn-40)	Class E ≥ (Ldn-44)	Class F ≥ (Ldn-48)	npd
Measured (%) *	0%	6%	30%	33%	26%	5%	0%
ACS COST TU 0901 D2m,nT,w	Class A ≥ (Ldn-20)	Class B ≥ (Ldn-24)	Class C ≥ (Ldn-28)	Class D ≥ (Ldn-32)	Class E ≥ (Ldn-36)	Class F ≥ (Ldn-40)	n=66

* Considering Ldn=65dB as an average value due to each building has different values of Ldn for diferent dwellings

Table 4 :Noise from building service equipment

Equivalent sound levels in dwellings due to building service equipment L

Scale (dB): 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45

NBR15575 LAeq,nT	Superior ≤ 30dB	Interm. ≤ 34dB	Min. ≤ 37dB				
Sugestion	Superior		Interm.	Minimum	Old Buildings		
Proposed ACS LAeq,nT	Class A ≥ 25dB	Class B ≥ 29dB	Class C ≤ 33dB	Class D ≤ 37dB	Class E ≤41dB	Class F ≤ 45dB	npd
Measured (%)	5%	13%	15%	40%	10%	8%	10%
ACS COST TU 0901 LAeq,nT	Class A ≤ 20dB	Class B ≤ 24dB	Class C ≤ 28dB	Class D ≤ 32dB	Class E ≤ 36dB	Class F ≤ 40dB	n=40

Maximum Sound levels in dwellings due to building service equipment L

Scale (dB): 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

NBR15575 LASmax,nT	Sup. ≤ 36dB	Interm. ≤ 39dB	Min. ≤ 42dB				
Sugestion	Superior		Interm.	Minimum	Old Buildings		
Proposed ACS LASmax,nT	Class A ≥ 30dB	Class B ≥ 34dB	Class C ≤ 38dB	Class D ≤ 42dB	Class E ≤46dB	Class F ≤ 50dB	npd
Measured (%)	15%	11%	33%	11%	26%	0%	4%
ACS COST TU 0901 LAFmax,nT [2]	Class A ≤ 25dB	Class B ≤ 29dB	Class C ≤ 33dB	Class D ≤ 37dB	Class E ≤ 41dB	Class F ≤ 45dB	n=27

2 – Due to the inexistence of a demonstrated method, COST TU0901 ACS requirements were not translated into $L_{ASmax,\,nT}$

The previous tables (1 to 4) were organized as described:

- 1st line presents a scale, in dB, to guide the comparison;
- 2nd line presents the classification presented by ABNT NBR 15575;
- 3rd line presents a suggestion for future revision of ABNT NBR 15575;
- 5th line presents the proposed Brazilians ACS;
- 6th line presents the percentage and classification of measured data from Brazilian buildings;
- 7th line presents adapted COST TU0901 ACS requirements. The adaptation was carried out to make it possible to easily compare the requirements.

5. DISCUSSION AND FUTURE WORK

As it can be easily noticed, in general, each class from the proposed Brazilian Acoustic Classification Scheme would be around two classes behind COST TU 0901 proposal. Due to the lack of strictness of acoustics requirements, this might be considered as a satisfactory starting point, until a stronger culture of building acoustics awareness is established and incorporated to the standards and construction market. The proposed ACS suggests slightly improved requirements for ABNT NBR 15575, assuming that in the midterm future it will be possible to adopt stricter values as normative.

The proposed lowest two classes, E and F were addressed to existing buildings that were designed with no commitment with acoustics performance, before the publication of ABNT NBR 15575. Despite not being usual in Brazil, the idea is to stimulate improvements in possible retrofits.

One of most challenging aspects in Brazilian building acoustic performance is impact sound level between dwellings [7] and also airborne sound insulation between dwellings when none of the rooms is a bedroom. The assumption of providing a higher acoustic performance for bedrooms, assuming a higher noise tolerance for living rooms and kitchens needs to be contrasted with subjective studies with Brazilian population.

In fact, as a future work, the authors highly recommend the development of user's satisfaction research with the current and proposed requirements. Similar approaches have been applied in many countries [14,15] to evaluate the expected satisfaction in order to define a more adequate criteria based on the results: i.e., Figure 1.

Sound insulation between dwellings Main class criteria A-D in DS 490:2007 Draft class criteria E-F from proposed revision			Characteristics of DS 490 sound classes for dwellings and occupants' expected evaluation Information from DS 490 and proposed revision		
Class	Airborne	Impact	Sound class descriptions	Good or very good	Poor
A	$R'_w + C_{50\text{-}3150} \geq 63$ dB	$L'_{n,w} \leq 43$ dB and $L'_{n,w} + C_{I,50\text{-}2500} \leq 43$ dB	Excellent acoustic conditions. Occupants will be disturbed only occasionally by sound or noise.	> 90 %	
B	$R'_w + C_{50\text{-}3150} \geq 58$ dB	$L'_{n,w} \leq 48$ dB and $L'_{n,w} + C_{I,50\text{-}2500} \leq 48$ dB	Significant improvement compared to minimum in class C. Occupants may be disturbed sometimes.	70 to 85 %	< 10 %
C	$R'_w \geq 55$ dB	$L'_{n,w} \leq 53$ dB	Sound class intended as the minimum for new buildings.	50 to 65 %	< 20 %
D	$R'_w \geq 50$ dB	$L'_{n,w} \leq 58$ dB	Sound class intended for older buildings with less satisfactory acoustic conditions, e.g. for renovated dwellings.	30 to 45 %	25 to 40 %
Draft E	Draft $R'_w \geq 45$ dB	Draft $L'_{n,w} \leq 63$ dB	Sound class intended for older buildings with unsatisfactory acoustic conditions.	10 to 25 %	45 to 60 %
Draft F	Draft $R'_w \geq 40$ dB	Draft $L'_{n,w} \leq 68$ dB	Sound class intended for older buildings with clearly unsatisfactory acoustic conditions.	< 5 %	65 to 80 %
References: "Lydklassifikation af boliger" (Sound classification of dwellings), versions DS 490:2007 and proposed revision			**Note:** Within each sound class the percentage of satisfied or dissatisfied occupants may depend on the type of criterion. The grouping is mainly based on the subjective assessments of airborne and impact sound from adjacent dwellings.		

Figure 1: Example of expected satisfaction according to DS 490, with the result of the research and a proposal for new values [14]

The proposed ACS will help people without technical knowledge to understand better the acoustical performance using the intuitive A-F scale, that could be presented in a label with a colored scale or even a datasheet with more complete information: Acoustics labels are already used in Brazil for windows, building energy efficiency and can be be a useful tool to increase awareness of building acoustics performance and to be adopted in a mandatory standard in the future. Examples of Brazilian and recent international labeling is shown in Figure 2.

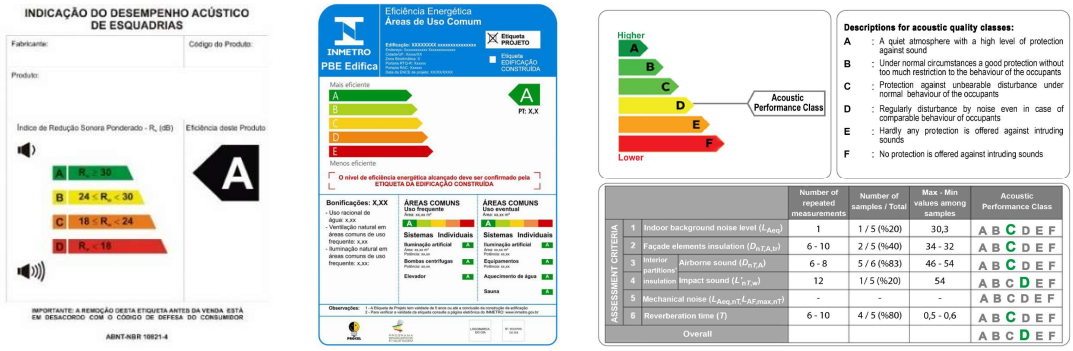

Figure 2: Brazilian labels for windows [16], for energy performance of buildings [17] and part of a Turkish datasheet explaining the class and subjective expected response [15]

This preliminary ACS can be used as a framework for the future development of a national acoustic classification of dwellings standard and can be a relevant topic to be discussed in the future revision process of ABNT NBR 15575 when considering the adoption of stricter requirements.

It is expected that the implementation of an Acoustic Classification Scheme for buildings in Brazil will stimulate the Brazilian construction market to improve its construction systems performance, and to pay more attention to users' satisfaction. This will, in the long run, foster cooperation and understanding between manufacturers, promotors, legislators and end users.

6. REFERENCES

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