A classification scheme for rehabilitated buildings. The Portuguese case

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ABSTRACT

Due to the effects of bailout of Portugal, the construction sector has been subjected to an unexpected adjustment process. The construction of new buildings has almost stopped and what is envisaged for the future is a moving from the new buildings construction to the rehabilitation of old ones, aiming to facilitate the renting market. In this context, and to assure some knowledge of buildings performance, a methodology to assess the overall acoustic quality of these rehabilitated buildings has been proposed. This methodology complements the one conceived for the new buildings, by extending the same concepts to the lower performance side of the buildings behavior, thus contributing for their classification in terms of acoustic comfort, and consequently for their acoustic sustainability. The proposed methodology has 5 classes (D+, D-, E, F, and G; the A, B and C are reserved for the new buildings or for those complying with the existing legal requirements), will allow users and renters to decide the best options based on the class of the apartment they want to rent. Whenever possible, this classification scheme was correlated with subjective data on the perception of noise inside the dwelling, obtained through socio-acoustic surveys.

Keywords: Classification, Comfort, Sustainability

1. FOREWORD

The concept of sustainability in housing buildings is continuously increasing, mainly due to energetic efficiency requirements set by buildings thermal legislation and energy reduction commitments. In European Union, through dedicated recommendations and the support given to various research programs, the needs to rationalize energy uses within member countries has been also envisaged in order to achieve a better global sustainable development.

However, the sustainability should not be strictly confined to energy balances. It must also include other components of individuals' well-being, for which the acoustical comfort inside buildings plays an important role.

So, in this context, acoustics (let's say building acoustics) is one of the most important aspects, as can be inferred from the COST Action TU0901 [1] main goals:

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i) harmonization of indicators used in its member states to describe buildings performances in terms of acoustics;
ii) Develop a common system for buildings classification (considering their acoustic insulation aspects).

There have been several proposals [2, 3, 4] dealing with classification schemes, *certifying* the global performance of buildings, using assessment procedures based on their acoustic insulation.

In Portugal, a similar methodology was developed, classifying not only the building, but the building and its environmental integration [5], taking into account the exterior noise environment, the sound insulation, the noise from service equipment, the reverberation time and the distribution of rooms inside the apartment and the building, attributing a number of "points" for each requirement. This methodology relies on the assessment of three physical realities, using appropriate indicators: i) one reality related to the vicinity; ii) other the building itself; and *iii*) another with the lodging characteristics (figure 1.), and it is part of an envelope system to classify the buildings, which incorporates the accessibility aspects, the lighting aspects, etc. that is currently under development and implementation.

Figure 1 – Physical realities considered for the global classification of buildings

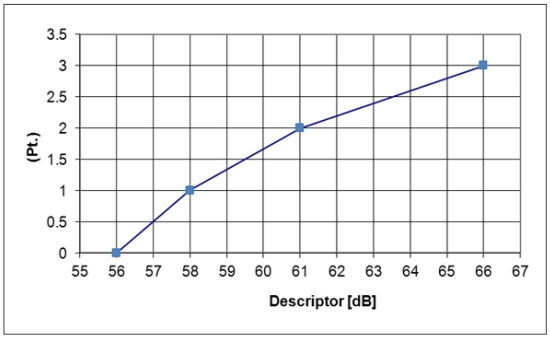
2. INTRODUCTION

Due to the effects of economic crisis that has been affected Portugal the construction sectors have been subjected to an unexpected adjustment process. The construction of new buildings has almost stopped and what is envisaged for the future is a moving from the new buildings construction to the rehabilitation of old ones, aiming to facilitate the renting market. In this context, and to assure some knowledge of buildings performance, a methodology to assess the overall acoustic quality of these rehabilitated buildings has been proposed. This methodology complements the one conceived for the new buildings - or to the ones that having been subjected to rehabilitation actions had to comply with legal requirements set up for new ones, respectively the Noise Pollution Act (Decree-Law 09/2007) [8] and the Building Acoustics Code (Decree-Law 96/2008) [9], by extending the same concepts to the lower performance side of the buildings behavior, thus contributing for their classification in terms of acoustic comfort, and consequently for their acoustic sustainability.

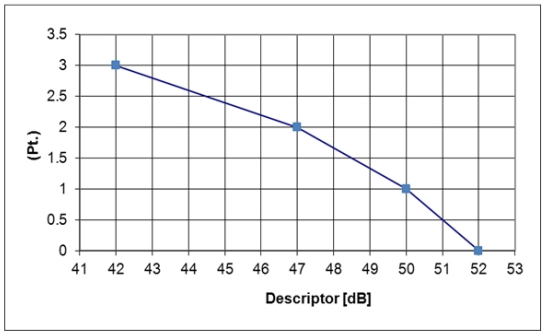
In the existing methodology the first legal document establishes the framework related to the exterior noise environment, and the second the acoustic comfort inside buildings, expressed by the sound insulation descriptors (airborne sound and impact sound), the maximum noise level due to service equipment, and whenever necessary the reverberation time. Nevertheless, the proposed evaluation is not only confined to physical indicators. The distribution of sensitive rooms in an apartment in relation to the exterior (specific façades facing traffic lines), the inter-relation between adjacent spaces inside building that could be act as potential noise sources (i.e. cafeterias or other shops *vs.* bedrooms), are also taken into account. The evaluation descriptor is named NAA (Level of Acoustic Assessment).

So, within this framework, the corresponding assessment is based on the quantification of legal indicators (when applicable), and on the proposition of special conditions whenever the existing legislation does not cover certain aspects that could be considered relevant for the purpose.

The criteria used to attribute "points" is based on a scale ranging from 0 to 3 points maximum, in accordance with the principles set in the Figure 2A (airborne) and B (impact and noise level)



(Trend type A)



(Trend Type B)

Figure 2 – Trend of curves to attribute "points"

The global classification/qualification index, for each domain of physical reality evaluation (environment, building, lodging, and all), will be calculated in average terms, and the final result will be compared as follows (note that NAA is expressed in "points"):

NAA < 1.0 ⇒ TYPE D - Low Quality: (LQ); Does not comply with the regulations and recommendations or does not assure a trustable acoustic comfort.

1,0 ≤ NAA < 1.5 ⇒ TYPE C - Basic Quality (BQ); It generally complies with the appropriate regulations and/or assures the minimum comfort conditions.

1,5 ≤ NAA < 2.5 ⇒ TIPO B - Recommended Quality (RQ); It implies an acoustic comfort higher than that set forth by national regulations.

NAA ≥ 2.5 ⇒ TYPE A – High Quality (HQ); It allows a pattern of acoustic comfort with high exigency.

3. REHABILITATION

Concerning the buildings rehabilitation, two options normally occur. The building is rehabilitated in total, and in this case normally the construction solutions adopted for new buildings are here implemented which turns this old building in a new one; or the building is partially rehabilitated, let's say an apartment, a set of apartments, etc., and the legal requirements have normally to be waived. The second option permits to alleviate the burden of administrative procedures that are necessary to follow for authorization purposes. However, in this situation, the buyer or the renter has no "instrument" to show whether the apartment he/she is acquiring has good acoustic quality, or better what degree of quality it has. This procedure is only relevant for the physical reality "Lodge" due to the fact that the environmental conditions, and all the others related to the evaluation of the new buildings, are not lie out of the respective licensing process.

The same consideration could be applied to those buildings that having been constructed at the times where there were no acoustic requirements to be considered (and which ones could be, at first, classified in class D, NAA less than 1.0), are needed to be subjected to an evaluation process in order

to be put into the market with an acoustic classification.

It must be stressed that we are actually living in a period of economic crises, and sometimes the political concerns addresses the recovery of countries economy, waiving or exempting the legal requirements actually in force.

For this case, a set of curves have been developed to help make this evaluation, detailing the classification D type previously mentioned, or just applying it to buildings or parts of them that have been rehabilitated, or even, to those that being not subjected to rehabilitation works an acoustic classification is envisaged by their owner specially for renting purposes.

The requirements considered in this process, are the following:

1. *Airborne sound insulation, $D_{2m,nT,w}$, (living rooms and bedrooms)*

2. *Airborne sound insulation, $D_{nT,,w}$ (between rooms of emission apartment and living rooms and bedrooms of reception apartment)*

3. *Airborne sound insulation, $D_{nT,,w}$ between common accesses as emission places and living rooms and bedrooms of reception apartment*

4. *Airborne sound insulation, $D_{nT,w}$, between bedrooms or living rooms (as reception spaces), and adjacent spaces used for commercial, industry, services or entertainment (as emission places)*

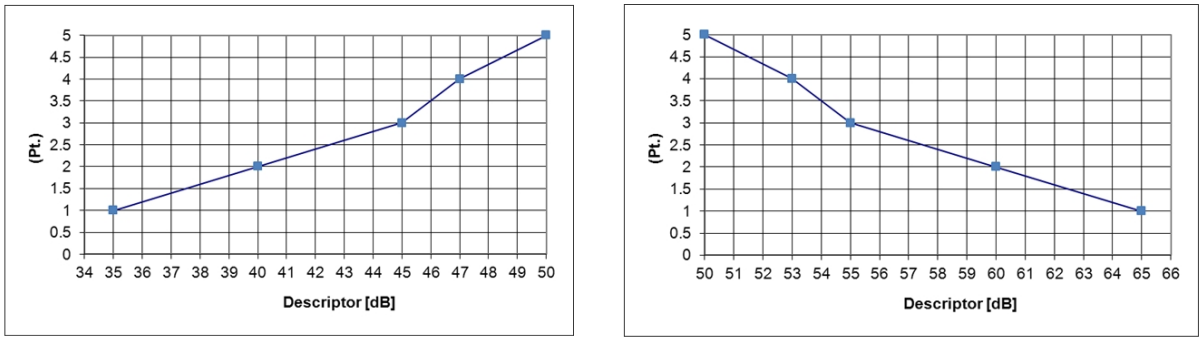
5. *Impact sound insulation, $L'_{nT,w}$, in bedrooms or living rooms (as reception spaces), due to impact sound exerted on other apartment floors or on common accesses (as emission places)*

6. *Impact sound insulation, $L'_{nT,w}$, in bedrooms or living rooms (as reception spaces), due to impact sound exerted on floors of adjacent spaces used for commercial, industry, services or entertainment (as emission places)*

7. *Noise level from equipment service, $L_{Ar,nT}$, such as lifts, water supply systems, garage doors, ventilation, rubbish, waste water, pumps, cooling etc., within bedrooms or living rooms*

8. *Airborne sound insulation, $D_{nT,w}$, between living rooms and bedrooms of the same apartment or unit*

To all of these requirements, curves with trends similar to those used for new buildings are adopted, (however with a different range of points), as follows:



(Trend type A) (Trend Type B)

Figure 3 – Trend of curves to attribute “points” rehabilitated buildings or those with class D

This leads to the flowing 4 type classes, respectively: D+, D-, E, F e G, where the first one corresponds to a reduction of 3 dB in relation to the legal requirements, the second 5 dB (3 + 2 dB),

let's say 2 dB relatively to the previous one, and E and F to reductions of 5 dB each, in relation to the previous limit. Class G corresponds to the worst one, being the set of classes and respective types expressed as follows:

$4.5 \leq NAA < 5.0 \Rightarrow$ Type D+
$3.5 \leq NAA < 4.5 \Rightarrow$ Type D–
$2.5 \leq NAA < 3.5 \Rightarrow$ Type E
$1.5 \leq NAA < 2.5 \Rightarrow$ Type F
$NAA \leq 1.5 \Rightarrow$ Type G

The assessment of the physical reality "Lodge" is made using the following equation:

$$Dwelling = \frac{\sum_1^N \alpha_i Pt_i}{\sum_i \alpha_i} \qquad 1)$$

Where N is the maximum number of items considered for the assessment, Pt_i the average points attributed to each item, and α_i the corresponding weighting coefficient as set in the Table 1.

Table 1 - Weighting coefficients for the component dwelling

Number of requirement	Coefficient α_i
1	3
2	5
3	3
4	8
5	8
6	10
7	2
8	1

Finally, taking into account that for similar construction solutions (partitions) their acoustic performance depends from the geometric characteristics, supporting conditions, etc. it is possible to obtain, for those similar solutions, acoustic indices exhibiting different values from each other, but complying with the legal requirements, at the same time. Thus, in order to be reliable and instead of considering the worst behaviors (situations which could be too much penalizing for a fair assessment), an average process of these values must be done, as follows:

$$Insulation: I_{final} = -10 \log\left[\frac{1}{k}\sum_i 10^{-D_i/10}\right] \quad dB \qquad 2)$$

$$Sound\ field: I_{final} = 10 \log\left[\frac{1}{k}\sum_i 10^{L_i/10}\right] \quad dB \qquad 3)$$

Where: I_{final} is the average value; D_i the airborne sound insulation of partition i; L_i the noise field within space i; and K the number of considered situations.

4. EXAMPLES

In Table 2 three examples of implementation of this procedure are presented. The buildings (apartments) selected for these assessments are old (dated before 1990), located in the Lisbon, and were tested according to the requirements set forth by Portuguese Regulations in order to be put on the market. They all correspond to housing buildings.

The data presented for each building include the averaged value of the respective descriptor (whenever needed), the attributed points, and the obtained classification.

Also, for performance items: i) whenever the item does not exist in the building, there will be no value to be attributed; ii) whenever the item exists but was not measured due to non-explicit reasons the attributed value expressed in points is 5, which corresponds to the basic value, let's say meaning there is conformity with legal framework.

Table 2 – Examples of assessment

	Requirement	Chiado	Assessment	Av. Berna	Assessment	B. Alto	Assessment
Dwelling	1	(40); 3	1.9	(35); 1.7	2.0	(33); 1	0.1
	2	(52); 1.6		(53); 2		(46); 0	
	3	(56); 3		(45); 2.4		(25); 0	
	4	-		(57); 0		(46); 0	
	5	(60); 1		(52); 3		(71); 0	
	6	-		(41); 3		(55); 0	
	7	(27); 3		(29); 2		(38); 0	
	8	1*		(40); 1.4		(20); 0	
Global			Type B		Type B		Type D

* - this score means there were no measurements performed, but the assessment must be considered.

Table 3 – Extension of example 3

Requirement	Bairro Alto	Assessment
1	(33); 5.0	2.5
2	(46); 3.5	
3	(25); 1.5	
4	(46); 1.6	
5	(71); 1.8	
6	(55); 3.0	
7	(38); 2.7	
8	(20); 1.0	
Classification		Type F

5. CONCLUSIONS

The presented procedure is very simple and easy to use, giving suitable and comprehensible outputs, which are really understandable for the community. It can be applied to new or old buildings, or even to ones which could be under rehabilitation process, revitalizing the cities and giving them appropriate reasons to live in.

It is based on measurements related to all legal descripts set by the Portuguese regulations, in accordance with a specific system of sampling [6].

This methodology is to be proposed within the Portuguese context for sustainability assessment of acoustic comfort in buildings and of buildings, envisaging its integration in a future multi-criteria analysis of building's performance.

As enhanced, the proposed methodology allows the promoters, authorities and end users, to classify the existing buildings that not comply with the legal requirements set force by Portuguese law, and to those that can only be subjected to rehabilitation purposes. In this context, it also allows the calculation of economic investment in the rehabilitation process according to changes in classification classes.

The assessments done and presented in Table 2 are coherent with the global analysis the buildings are normally subjected to by potential buyers.

The methodology is actually under development namely in terms of weighting factors and inclusion of possible additional indicators, in order to produce a multi-criteria evaluation method.

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ACKNOWLEDGEMENTS

The authors would like to thank all those who have contributed for the development of this methodology, mainly the residents of the buildings included as examples, for having kindly authorized the use of performance data of their apartments.