ACOUSTIC RETRAINING STARTING FROM WINDOWS REPLACEMENT.

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1 Introduction

The replacement of old windows, which is often acted for energy saving requirements, leads also to a reduction of the floor noise level (levels LAeq – defined “residual” by the D.P.C.M. 14/11/97) inside the buildings. In a previous article [1] the same authors analysed the levels of residual internal noise in many bedrooms in function of the type of the windows and the distance from a road. In this article the airborne and structural noise immission between different housing units, in function of the night residual noise level is investigated. Numerical evaluations of introduced annoyance, over the residual noise level, are performed in the frequency domain, analysing partitions with apparent sound reduction index near to the minimum values decided by the D.P.C.M. 5-12-97 (50 dB in residential buildings for horizontal-vertical partition between different housing units). This analysis is based upon the most common measurements methods in Italy.

2 Data Selection

2.1 Residual Noise Levels

Twenty-eight residual noise pressure level measurements in the night period (10 PM– 6 AM), measured in houses with closed windows, are used.

In particular, most of the measurements were taken in the night period, in which the people usually start sleeping, between 10 PM and 01 AM in the night. These measurements had a duration between 5 minutes and 8 hours (the whole night period) and were performed with different goals among them, but all in closed window rooms and in measurement conditions that respected the D.M. 16/3/1998 [4], excluding random events. These measurements were performed in Northern Italy in a five year period, between 2008 and 2013

2.2 Residual Noise Levels

15 measurements on field of the acoustic insulating power of vertical and horizontal partitions R'(f) were selected. All of these analysed vertical partitions that were built with masonry technologies, all the horizontal partitions were made of cement-brick. These are the most common buildings techniques in Italy.

All the measurements were performed following the technical standard UNI EN ISO 140-4 [5] with very low residual noise levels .

In Table 1 it is shown the distribution around the 50 dB value of these 15 measurements. It was decided to use R’w values between 49 and 51 dB to include also the measurement uncertainty, as indicated in a recent standard UNI 11367 [6].. This standard refers to the Dutch standard NPR 5092:1999 [7].

R'_w (dB) Value	%
49	53.3
50	20
51	26.7

Table 1: % of the occurrency of the R’w measured

These frequency measurements were plotted together to investigate if, in the various measurements, there were characteristic values that were often repeated at the same frequencies.

In fig. 1 it’s possible to note that similar phenomena are not shown in the average line because technologies were quite different.

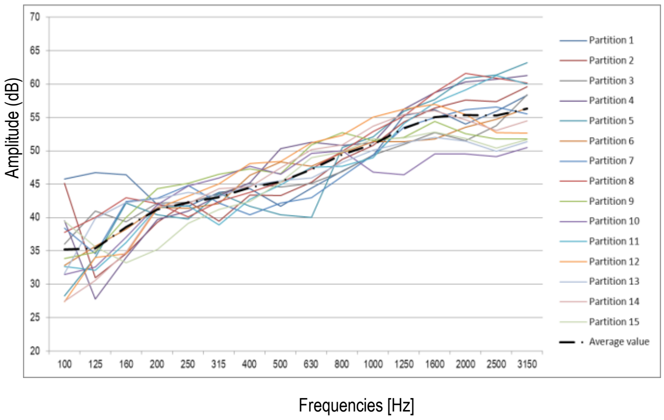

Figure 1: plots of the various R’(f) and average value.

In a recent article [8] 15 vertical and horizontal partitions were tested in Turin. The R’w values that are shown in the article (discarding a value much higher than others) reveal an average value equal to 49.6 dB and a standard deviation equal to 2.7 dB. These values are similar to the ones measured by the authors and presented in this paper.

In another article [9] 126 vertical partitions and 34 horizontal partitions, all in traditional masonry building technique, were tested. These measurements, performed in the province of Trento, gave an average value equal to 49.6 dB, similar to what was selected by the authors.

The bibliography data reveal that the R’(f) sample curves that the authors selected is consistent for the following analysis.

These values are related to the traditional bricks building technique in Italy, specialized with light elements in the period after Second World War. This demonstrates that the traditional building methodology often permits to reach values not much higher than the 50 dB insulation R'w value.

We remind that the actual measurements nowadays in Italy are carried out mostly in case of legal problems.

2.3 Measurement Instrumentation

Measurements were taken using a Larson&Davis mod. 831 integrating sound level meter and a dodecahedral omnidirectional standard source to generate pink noise. All instruments were regularly calibrated.

3 The acoustical comfort inside a living unit: law and standards.

The concept of acoustical comfort inside a living unit in Italy it's not clearly defined by law.

The Italian administrative law defines it indirectly in the D.P.C.M 14/11/97, where are stated the differential criteria for the environmental noise: the environmental noise level can exceed the residual noise level by 5 dB during the day (6 AM – 10 PM) and by 3 dB during the night (10 PM – 6 AM). For these measurements the LAeq equivalent level is used. This criterion is not applied in rooms with closed windows if the environmental noise doesn't exceed 25 dB(A) in the night: so every effect of the noise is to be considered negligible and imposes the 25 dB(A) value as nocturnal minimum value.

As written in Secchi-Cellai [10], the Austrian standard Onorm B 8115-2 [11], gives different indications about the residual noise levels (nocturnal/daily) in living units situated in different residential areas.

Another reference could be the standard UNI 8199/98 for testing air conditioning systems: in this case the levels also includes the noise from the noise source and they represent some values that shall not be exceeded (absolute criteria)

Area type	Indicative Residual Noise Level (dB)
Quiet Area	20/15
Mostly Rural Area or Periferical	25/15
Urban Area , Mixed Rural Area - residential	30/20
Central Area (with shops, flats, offices) without specific noise sources	30/20

Table 2: different day/night residual level in different residential areas as in Onorm B 8115-2

Destination	Environmental noise level dB(A)
Bed Rooms	30
Living Rooms	40

Table 3: Maximum admitted noise level to assure acoustical comfort in houses UNI 8199/98

4 Results

4.1 Frequency Analysis.

An arithmetical average (this is a statistical analysis) was performed with the 28 residual noise measurements, obtaining the L(f) curve in dB(A). This curve, expressed with a single value, yelds an average value equal to 28.4 dB(A).

An arithmetical averaging were also performed with the 15 R'(f) values measured and described.

As reference was taken the LOUD speaking curve from protocol ANSI S3.4 – 1997, referred to male voice in free field, measured at 1 meter of distance (fig. 2). This curve was A weighted and can be considered as a TV showing a talk show at high volume or as children playing. This curve, expressed with a single value, yelds an average value equal to 73.7 dB(A).

The R'(f) curve was subtracted from the LOUD curve, obtaining the S(f) curve and L(f) was logarithmically added to S(f) to obtain a realistic estimation of the environmental value of the noise level to the receiver. This curve was plotted with L(f).

The S(f) curve shows the estimation of the intuding noise, in the room after being attenuated by the average partition R'(f): the results are shown in fig. 3.

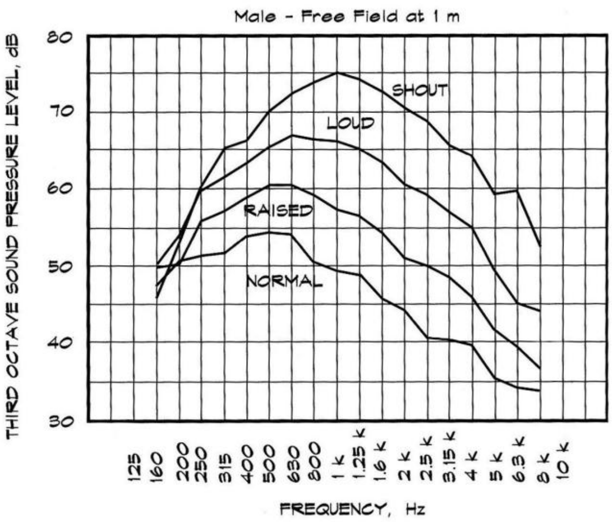

Figure 2: Average Peak Male Speech Spectra (ANSI S3.5, 1997)

We can observe that between 200 and 1250 Hz the S(f) curve values are higher than the L(f) curve values, also reaching 4 dB. This means that, also with masonry partitions with R'w values at the law limit (50 dB), at low and medium frequencies a component of intrusive noise is present that is very well heard by people who stay in the analysed rooms.

With a single number analisis we can obtain a differential level equal to: (Lintroduced – Lresidual) = (29.3 – 28.4) = 0.9 dB(A), negligible value and lower than the limit due to the differential criteria. A frequency analysis is necessary to obtain a better picture.

4.2 Window substitution effecting privacy.

It's very interesting to refine even more the analysis and to distinguish:

- the higher residual noise levels, related to rooms with old windows, installed before 1998, when the D.P.C.M. 5-12-97 become effective (in [2] were analysed 10 windows of this type that yelded a residual average noise level equal to 32.7 dB(A))

- the lower residual noise levels, related to new windows, with good thermal and acoustic characteristics. This noise levels were measured in houses where recently the windows were changed (in [2] were analysed around 3 windows of this type that yelded a residual average noise level equal to 21 dB(A))

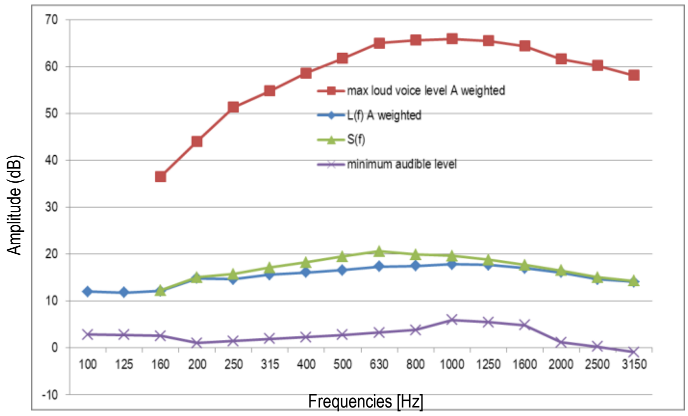

Figure 3: Plots of the various curves

Crossing the data we obtain:

The best case – related to the new windows

The worse case – related to the old windows.

4.2.1 Decreasing the residual noise level after replacing the old windows.

An averaging of the residual noise level measured in rooms with old windows and an averaging of the residual noise level measured in rooms with new windows were performed. In fig.4 these curves together with the Minimum Audible Level are shown.

We note a great reduction of noise level across the spectrum, at certain frequencies higher than 15 dB, which allows to reach the Minimum Audible Level (and the sound level meter measurement limits)

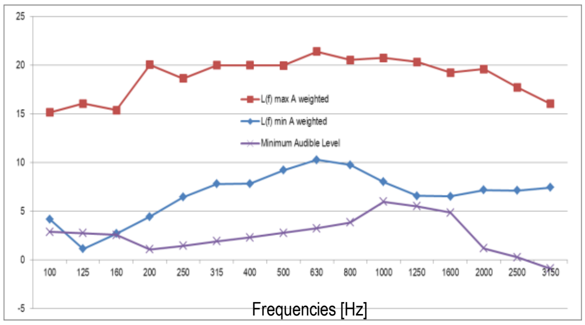

Figure 4: average residual level noise in rooms with bad windows and good windows

4.2.2 Best case: new windows

In fig. 5 the curves resulting from the best case were plotted: new windows with good thermal and acoustics devices gave a very low residual noise level.

As we can observe, differently from the previous fig 3, in this case the residual noise levels are lower and the S(f) curve is much higher than the L(f) curve in the whole frequency bandwidth, also exceeding L(f) by 6 dB at certain frequencies.

This means that the good technical performances that we can obtain upgrading the acoustical insulation façade power are not balanced with the partions between housing units, which still allows high intruding noise levels even if they respect the legal insulation standards.

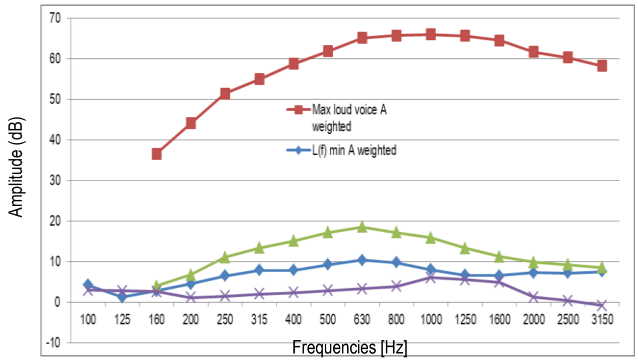

Figure 5: plots of the better combination

4.3.3 Worse case: old windows

In fig. 6 the curves that come from the study of the worse case were plotted: old windows with bad thermal and acoustics devices that gave higher residual noise levels.

In this case the S(f) curve results almost identical to the L(f) curve apart a small deviation between 400 and 1000 Hz that arrives to 1.5 dB max. The intrusive noise level in this case will not be perceptible in the majority of cases.

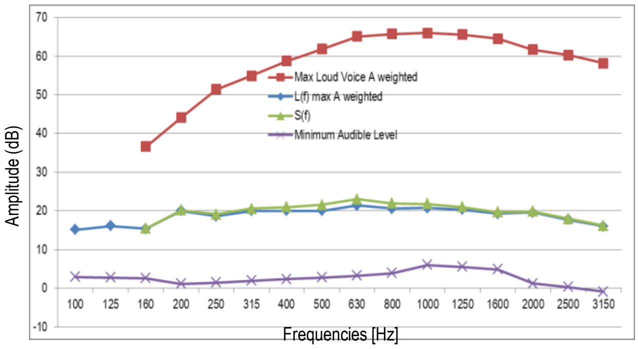

Figure 6: plots of the worse combination.

This demonstrates what occurs in many living units after the replacement of windows: the perception of the noise generated inside the building, from the other housing units, increases greatly and the Italian low R'w requirement , given by D.P.C.M. 5-12-97, are not enough to guarantee an acoustical comfort.

5 Conclusions

The authors collected and selected apparent noise reduction index R'w measurements of vertical and horizontal partitions and residual noise levels related to rooms with new and old windows.

It was demonstrated that at the moment of the windows replacement, nowadays very frequent due to the fiscal detractions for thermal improvement, the internal residual noise level greatly decreases and the noises generated in the other housing units become annoying. This is true with windows with good acoustical properties and in presence of partitions with R'w values close to 50 dB, which is the minimum law values today in Italy.

This also demonstrates that the D.P.C.M. 5-12-97 values, , are not enough to guarantee an acoustic comfort inside the housing units. It's necessary a change in the dominant building technology of the partitions between the different living unities to obtain an acoustical comfort inside the houses.

A recent study demonstrates that the noise is the cause of quarrels between neighbours in Italy in one third of the cases [12]. The recent standard UNI for the acoustical classification calls "basic" the third class, that presents, with reason, airborne sound insulation of the facade lower than the actual D.P.C.M (D2m,nT,w = 37 dB instead of 40 dB).

It's certainly necessary a larger study to define the requalification methods of existent buildings: this research demonstrates that exists a delicate equilibrium between the various acoustical requirements, the modifications introduced by the increasing of the energetic performances of buildings and the cohabitation in the housing units in condominiums.

6 Aknowledgments

Thanks to ing. Andrea Rosati, ing. Gabriele Ghelfi and arch. Emanuele Mesiano for their contribution in our research

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