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A 70 dB(A) limit proposal for façade exposure to urban noise, based on research

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ABSTRACT

Growing cities face increase of environmental noise in some areas, due to the expansion of transportation infrastructure and concentration of noisy activities. Authorities need guidance, based on research, to balance development needs with the capacity of the urban environment to accept noise effects. Prevention needs investment and both, government and construction companies, must share noise control costs in a reasonable base. It means that sources of noise can be controlled individually or in a certain array , but not in large multiplicity of an urban area. Consequently average noise levels can increase to some values that must be accepted as an environmental parameter to be considered in their projects. The government of the city of São Paulo has asked an evaluation of the maximum capacity of normal building façades to isolate external noise. IPT-Institute for Technological Research performed several field and laboratory measurements of the Weighted Sound Reduction Index of windows with simple monolithic 3mm glasses, easily found in local commerce. The best result was Rw=31 dB. In consequence, the external noise level shouldn't exceed 71 dB(A), for an average protection seeking an acoustic comfort of 40 dB(A) in rooms where people is susceptible to noise. The 71 dB(A) was chosen by law as a reference limit to noise impact over façades in the city, due to any new public work. This article reports details of the research, possibly useful for other cities with similar environmental profiles and proposes they round the limit to 70 dB(A).

INTRODUCTION

If someone buys an apartment or house in a satisfactory neighbourhood but, after a few years the situation worsen, with respect to noise, who can be considered responsible for the losses in quality of life and value of the property ?

Authorities argue that they can't refrain the development of the city and architects and civil engineers must pay attention to future trends of the areas where construction companies intend to build, including possibilities of noise increase. But which are the parameters for that attention ?

For a megacity like São Paulo, Brazil, it is quite difficult to deal with so many inputs to the subject, but researchers have succeeded in transforming some findings into guidances for standards and laws.

APPROACHES

Zoning has been the main approach for noise control. But most of the city territory is classified as multi-activity zones where noise sources are controlled individually, respecting a limit established by law. This limit couldn't be taken as a reference for projects because two or more sources together can increase noise levels several dBs above it.

Since the middle of 80's, authorities have been searching for means to share the responsibility of urban noise control with constructors, at least in rooms for rest, study, intellectual work and convalescence, involving residences, schools, office buildings and hospitals. A single reference for limitting noise levels in such rooms should be established.

A possible answer was found in a national standard [1], based on a table proposed by Beranek et al. [2] , rounding the recommended values, as shown in Table 1:

Table 1

Bedrooms in residences :	35 to 45 dB(A)
Classrooms in schools :	40 to 50 dB(A)
Offices :	35 to 45 dB(A)
Apartments in hospitals :	35 to 45 dB(A)

Source: (ABNT, 1987) [1]

There is an evident average value of 40 dB(A) as a reasonable adjustment of the background noise, for the rooms in the list. Its official adoption was criticized as a simplification of a standard that was too simple itself, based on recommendations, perhaps the only one of the kind in the world. But, despite its weaknesses, researchers had to admit the importance of the standard, in the 80's, in educating the population in matter of noise control, just because of its simplicity. People facing noisy neighbours, always complained to authorities, carrying along the easy-to-understand and short text of the standard.

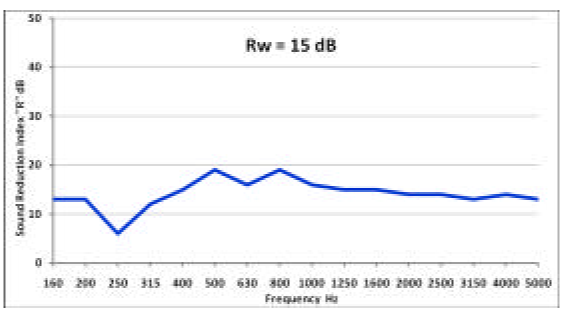
Government decided to ask for investigation about project and specification needs of façades resistant to external noise, in order to assure 40 dB(A) inside the roms, along the streets and avenues of São Paulo.

IPT-Institute for Technological Research performed the measurements and USP-University of São Paulo, analised results and interviewed investors, project managers, architects and civil engineers, working for building companies.

TRADITIONAL WINDOWS

Photo 1 shows the general characteristics of the most common window used in houses with one or two storeys in São Paulo, followed by Graph 1, with its sound isolation performance.

Photo 1. Window made of wood and 3mm monolithic glass



Graph 1. Sound isolation performance of the window showed in Fhoto 1

The test was performed in the the field, according to ISO standards in effect by that time [3] [4]. References [5] and [6] are respective new versions of the standards. All test data are presented in reference [7], including the small size of the room behind the window, that explains uncertainties in frequencies below 160 Hz, missing in the graph. The greater part of the façade was a solid block wall, 0,25m thick, with a Rw = 50 dB, tested in laboratory. So, it was possible to measure the composite sound isolation of both, wall and window, and to calculate the performance of the window, separately. The procedure was repeated with other windows tested in the field.

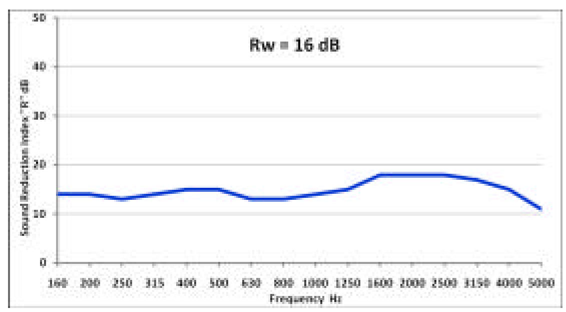
In IPT and USP documents, "insulation" means the whole acoustic protection against external noise, for someone inside the room, involving façade, roof or ceiling, walls with or without doors and floor. "Isolation" refers to a single component, as a window or a wall without openings.

Windows like the one in Photo 1, were competitive with industrialized options, made of metal or plastic. Situation has now inverted, mainly because timber market is much more restricted.

Graph 1 displays a poor performance of the window, consequence of gaps that can't be properly adjusted or sealed. Strong resonance also occurs and can transform the window into a secondary source of noise.

Photo 2 and Graph 2 refer to a type of sliding window, a local preference for bedrooms in multi-pavement buildings.

Photo 2. Window with an aluminum frame and three sliding parts, one with a 3mm monolithic glass and two blinds, made of plastic, for darkening and ventilation



Graph2. Sound isolation performance of the window showed in Fhoto 2

As in the case shown in Photo 1, measurements were performed in the field and calculation procedures were similar. The façade included a hollow concrete block wall, 0,19m thick, with a Rw = 46 dB. Again, the room was small, excluding data for the frequencies below 160 Hz.

Results showed a poor performance, due to the thin plastic panels and to deficient sealing.

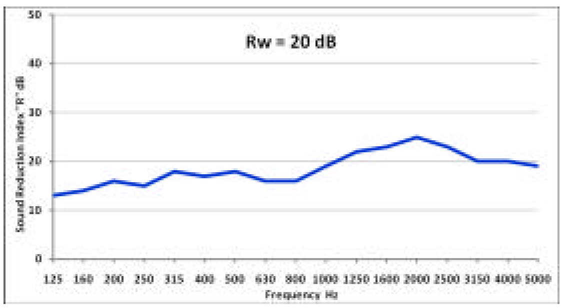
Photo 3 and Graph 3 are about a type of window that represents the general preference for living-rooms and sitting-rooms in multi-pavement buildings.

The windows showed in Photo 2 and 3 are in the same apartment. Now, as the living-room is larger than the bedroom, frequency of 125 Hz is included in the graph. The walls in both cases are extensions of each other. Measurements procedures and calculations were similar.

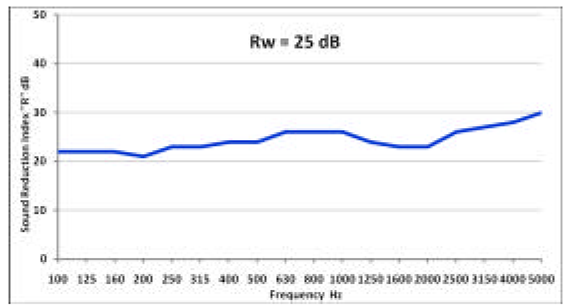
The performance improved, because the glass is the only material in the panes and joints are tight and better sealed.

Photo 3. Window with an aluminum frame, two fixed and two sliding panes with a 3mm monolithic glass

Photo 4. Window with an PVC frame and two sliding panes with a 3mm monolithic glass



Graph 3. Sound isolation performance of the window in Photo 3



Graph 4. Sound isolation performance of the window in Photo 4, tested in laboratory.

OPTIONAL WINDOWS

Variations of the traditional windows were tested, repeating the same performance patterns. Innovative solutions, when found in the field were provided with thicker laminated glasses. These wouldn't fit government request for new alternatives that could be popular also, as the traditional ones. So, it was necessary to select such options among the possibilities offered in the market, to be tested in the laboratory [8] [9], always with a 3mm monolithic glass.

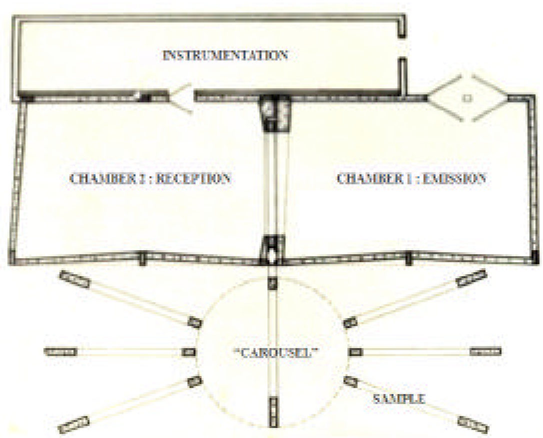
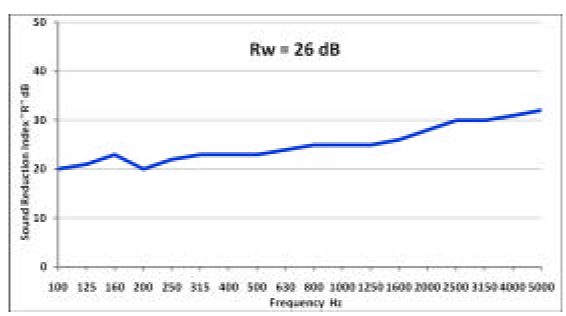


Figure 1. Floor plan of the Acoustics Laboratory at IPT

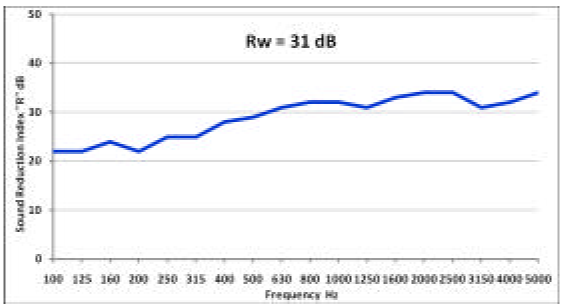
Frames in wood, iron and PVC were listed. At the end, 29 samples were tested, including those found in the field. PVC windows presented the best results, in function of the precise joints, good sealing and stability of the material. Subsequent graphs show some of the results.

Photo 5. Window with an PVC frame, a fixed pane and two projecting and sliding panes with a 3mm monolithic glass. Sample assembled outside the laboratory (See Figure 1)



Graph 5. Sound isolation performance of the window in Photo 5, tested in laboratory.

Photo 6. Window with an PVC frame and two projecting and sliding panes with a 3mm monolithic glass



Graph 6. Sound isolation perfomance of the window in Photo 6, tested in laboratory.

Inquire among architects and civil engineers revealed some dislike about the optional windows, with better acoustical performance, most because of their look. But good examples of their use were found, as the one in Photo 7.

Photo 7. Office building in a noisy avenue in São Paulo, provided an internal ventilation system, independent of façade. Season was summer when the photo was taken and practically all users keep the windows closed, for protection against external noise

THE LAW FOR BUILDING ACOUSTICS

São Paulo is located in the tropics and most of the year the windows are wide opened, for ventilation. There is no tradition in projecting ventilation systems, independent of windows.

But, if transport, commerce or other infrastructure make noisy areas interesting for new buildings, their design must be devised as they were made for places where winter is severe, windows are air-tight and an internal ventilation is necessary.

Figure 2 shows one of the possibilities for schools, as an example. Ventilated window sills, with noise attenuation, provide air-takes.

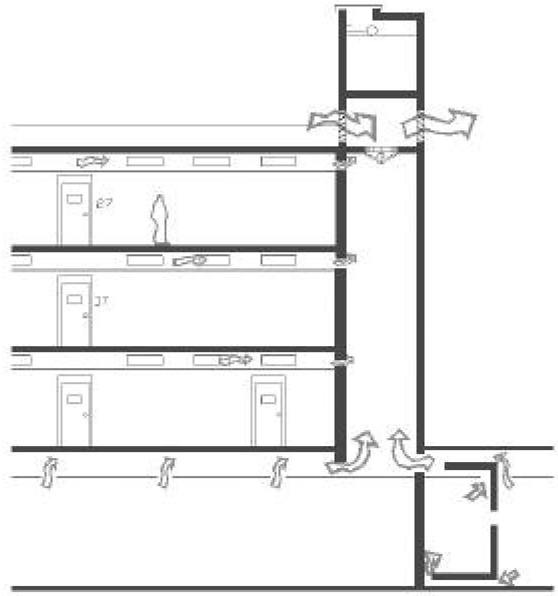


Figure 2 Schematic section of a possibility for ventilating a school independently of the windows. Ducts for air flow are not represented. The air is taken through mufflers adapted in the window sills.

For offices, apartments in residential buildings and hospitals the solutions can be similar to the one presented in Figure 2. Mufflers can be conceived with easy-to-remove kits for sound absorption and air-filtering, in order to facilitate maintenance.

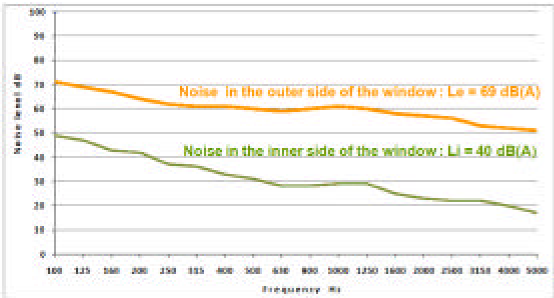
Notified with test results, inquire analysis and ventilation studies, authorities decided to enforce the spplicaion of the findings to new projects. Architects and civil engineers should start to 'think acoustics" as industrial engineers had done two decades before, in consequence of the so called "Silence law" [10] and popular demand for control of noise emitted by factories. Reasons are discussed in [11].

The new law for building acoustics should state a maximum level in dB(A) for the outside noise that façades should isolate, in order to assure that the resultant intrusive noise would remain under or equal 40 dB(A), assumed that components could be easily found in commerce, with normal glasses.

Part of the answer was the Rw = 31 dB, as the best performance for acoustic isolation of the windows tested, with 3mm monolithic glass.

A typical traffic noise curve was adjusted to a value, in dB(A), that could produce in the immediate inner side of that window, with Rw = 31 dB, a noise curve with the required maximum level of 40 dB(A). Graph 7 shows the adjustment. A 69 dB(A) external traffic noise would meet the requirement.

But, depending on the sound absorption of the room, users could have lower levels than 40 dB(A). All field test data were reviwed to figure out the amount of reverberant sound level reduction provided mainly by furniture, carpets and curtains. No room had any acoustic ceiling. Table 2 shows the results.



Graph 7. Adjustment of a typical traffic noise curve to the value of 69 dB(A) in order to be reduced to 40 dB(A) by the window of Photo 6, the best in sound isolation, among those tested.

Table 2

TEST											
A	B	C	D	E	F	G	H	I	J	K	L
REDUCTION IN SOUND LEVELS DUE TO ROOM ABSORPTION											
2	2	2	2	6	6	4	3	6	6	6	6

In rooms with high sound absorption,the average level of the intrusive noise in positions far from the windows showed a consistent reduction of 6 dB, compared with levels close to them. But it was decided to take into consideration only the 2 dB reduction found in rooms with few itens of sound absorption.

The external noise of 69 dB(A) mentioned in Graph 7, could be a little higher, giving the the limit of 71 dB(A) for the law [12] that would guide their projects, whenever implying in noise pollution increases, during day-time. For the night-time, it was addopted the same well-succeded 59 dB(A) limit of the former law [10].

CONCLUSION

"To think Acoustics" may be a challenge for architects and civil engineers where they are not used to it. In São Paulo, the bylaw attempt is now being reinforced by two new Brazilian standards.

One deals with performance of residential buildings with no more than five stories [13], including acoustic requirements for façades, walls and floors, also valid for taller buildings. The scope states the validity.

The other new standard, actually isn't properly so, but a revision of reference [1], quite different, much more complete and objective. When reviewing limits for ambient noise in several rooms, the commission got to numbers very close to those of an also recently revised ASTM standard [14] and decided simply adopt them. When published, it will be an important complement for the old "building acoustics law" of São Paulo [12] and either for the new "building performance standard" of reference [13].

The ASTM recommends limits to correspondent rooms of Table 1 are showed in Table 3. Now, the medium term for the noise level drops below 40 dB(A). Consequently the 71 dB(A) reference limit for façade exposure to urban noise in São Paulo, can be rounded to 70 dB(A), as a suggestion for orther cities concerned with increasing noise pollution.

Table 3

Bedrooms in residences :	35 to 39 dB(A)
Classroms in schools :	40 dB(A)
Offices :	35 to 44 dB(A)
Apartments in hospitals :	35 to 39 dB(A)

Source: (ASTM, 2008) [14]

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