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In situ acoustic performance of materials used in Brazilian building construction

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Abstract

The present study has the goal of showing the acoustic performance of materials routinely used in Brazilian building construction. In situ measurement procedures are presented for the determination of acoustic performance of the materials. Measurements were performed according to the standards ISO 140-4, ISO 140-5, and ISO 717-1. The results were compared with values for sound insulation prescribed by the German Standard DIN 4109. The performance of Brazilian building materials were shown to be below international standards of acoustical quality.

Keywords: Sound insulation; Acoustic comfort; Building construction; Urban noise; Apparent sound reduction index

1. Introduction

The increase in population and in number of vehicles have led to the appearance of a new component in urban life: noise. Noise pollution and its consequent influence over the environment and over human life quality have been the center point of several studies conducted worldwide. Noise has been causing increasing levels of annoyance and harm in the great urban centers around the globe. People are obviously especially sensitive to noise during leisure time. That is precisely the problem with urban noise. It upsets and annoys people also when they are not working, during the night.

Urban noises are emitted simultaneously by a wide variety of sources, such as industry, transportation and activities encountered in large cities. Several researchers have been trying to characterize urban noise, and to study how it affects city inhabitants. These studies show that traffic noise is followed by noise produced by neighbors as the main disturbing sources.

Considering that both traffic and neighbor noise upset people inside their homes, it is possible to conclude that these homes are not performing well in one of their purposes, which is the one of providing acoustic comfort to its inhabitants. This fact is critical in Brazilian homes, as opposed to countries such as France, Germany, England, and the USA, since these countries have specific rules for the acoustic insulation properties of materials used in building construction, and Brazil does not.

The present study has the goal of showing the acoustic performance of materials routinely used in Brazilian building construction. In situ measurement procedures are presented for the determination of acoustic performance of the materials.

2. Methodology

Laboratory measurements are used to determine specific properties of material or to make a complete investigation of it in order to establish acoustic data or a quality standard. They are also used to ensure that the quality of a

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material or a sample of building element meets international standards or local regulations. The test room suite of a laboratory is constructed very carefully to avoid any possible flanking transmission. Thus, when sound insulation tests are performed, practically all the energy in the receiving room is transmitted trough the partition under test. In actual building, there are so many possible transmission paths of sound in a building and so many factors influencing the acoustic quality of the construction that the only way of determining whether the building meets the legal requirements is to make measurements "in situ" in the actual building.

The airborne sound insulation between two rooms is calculated from the difference between sound pressure levels in the source and receiving rooms, plus a factor taking into account the absorption in the receiving room. In a laboratory, the correction factor involves the area of the test specimen, and the equivalent absorption area of the receiving room, which can be determined from the volume and the reverberation time of the receiving room. In actual buildings, the correction factor depends on the way the room insulation is defined. The two most usual definitions are: (1) the standardized level difference D_{nT}, involving the reverberation time of the receiving room referred to a standard reverberation time of 0.5 s and (2) the Apparent Sound Reduction Index R', involving the area of the common partition, the reverberation time and volume of the receiving room.

In this work the building elements have been evaluated in situ. Therefore, the apparent sound reduction index R' has been measured The in situ measurements were performed following the procedures specified by ISO 140-4 [1]; ISO 140-5 [2] and ISO 717-1 [3]. The investigated rooms were built with construction elements widely used in Brazilian building constructions.

For the in situ measurements, the following equipment and software were used: (1) Acoustic Analyzer Brüel & Kjaer model 2260 Investigator; (2) Software Building Acoustics BZ 7204; (3) Software Qualifier 7830 Brüel & Kjaer; (4) Power Amplifier Brüel & Kjaer model 2716; (5) Brüel & Kjaer omni directional noise source 4296; (6) set of microphones style free field 1/2″ Brüel & Kjaer model 4190; (7) set of cables and pre-amplifiers Brüel & Kjaer.

3. Results and discussion

When sound waves reach a wall, their energy is partially reflected and partially absorbed by it [4]. The paths of sound transmission are: (1) the direct transmission, through the elements of separation between rooms; and (2) indirect transmission, through the lateral walls, through the ceiling and floor. These two components sum up to yield the total sound energy transferred from one room to the other [4]. For walls made of homogeneous materials of constant width, the level of insulation is a function of the mass of the element and of the frequency of the sound that hits the wall.

One theory widely used to predict the coefficient of sound insulation in simple walls is the law of mass, which shows good performance according to several authors such as Beraneck [5], Heckl [6]. There are also other methods for the prediction of the insulation factor of simple walls, like those of Feshbach, Cremer, Josse, Brüel, Savioli, Meisser, and the Statistical Energy Analysis. These methods have been evaluated by Laranja [7], through the confrontation of measured and simulated results. As a result of these study he has concluded that, depending on the material studied and the frequency to be analyzed, different methods may yield different results.

When a high loss of transmission is desirable, without massive walls, the use of double or triple walls is the best option. Batista [8] states that the main factors that determine the quality of a double wall are: (1) the type of material, (2) the system of assembly of the walls, (3) the width of the air layer, and (4) the coefficient of absorption of the material placed in the air chamber to lower resonance. In order to assure the efficiency of this type of composition, several authors [1–5] suggest materials of different mass and rigidity, in order to guarantee that the walls will not display the same critical frequency. Sound transmission in this kind of structure is very difficult to be mathematically formulated through a simple expression, as it depends on different mechanisms of transmission. In order to evaluate the phenomenon of sound transmission, some simplified and limited models have been proposed, such as those of London, Goesele, Josse, Craik and Wilson, Sharp and Meisser. In order to estimate the insulation coefficients in this kind of structure, Lips [9] suggests the use of expression 1, which was obtained empirically

$$R'_{\mathrm{w}} = R^*_{\mathrm{w}} + (100.d.n.c) \tag{1}$$

where R'_{w} is the coefficient of sound insulation of the double wall; R^*_{w} is the coefficient of sound insulation of the simple wall; d is the distance between the 2 walls (m); n is the type of coupling between the walls ($n = 1$, if coupling is rigid; $n = 1.5$, if coupling is elastic; $n = 2$, if the walls are not connected); c is the type of material that fills the space between the walls ($c = 0.8$, if air chamber; $c = 1$, if the chamber is filled with absorptive material).

In Brazilian building construction, the material most often used for walls are bricks. The bricks are perforated ceramic blocks 15 cm-wide. Concrete blocks are also used, as well as dry wall. Silva [10] has evaluated the acoustic insulation by walls built with these materials. This evaluation has been carried out through laboratory measurements, according to ISO 140-3 [11]. The results have been obtained in frequency bands of 1/3 of octave, and afterwards, following the standard ISO 717-1 [3] converted to weighted apparent sound reduction index. The results of this evaluation are displayed in Table 1 [10].

In Ferreira [12] and in Ferreira et al. [13], the performance of Brazilian construction materials can be observed, when used for home building. In his work Ferreira has performed in situ measurements of the insulation between the