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NOISE CONTROL FOR A BETTER ENVIRONMENT

Effect on the acoustic comfort of vibrations produced in urban environment in housing

Morales Segura, Mónica[1]
Escuela Técnica Superior de Edificación – Universidad Politécnica de Madrid
Avda/ Juan de Herrara, nº 6 – 28040 Madrid (Spain)
ORCID ID: 0000-0002-4437-7606

Gil Carrillo, Francisco[2]
Escuela Técnica Superior de Edificación – Universidad Politécnica de Madrid
Avda/ Juan de Herrera, nº 6 – 28040 Madrid (Spain)

ABSTRACT

The problem of noise in buildings located in our cities not only comes from the transmission of it by air, which is known as airborne noise, but also by indirect transmission through the structure of the buildings and their enclosures, called structureborne noise or vibrations. For this second type, it is necessary to realize that is not only the building's installations that generate vibrations, but that the urban setting also produces them. The main objective of this work is to study the real influence that vibrations from the surrounding environment have on a building's acoustic comfort. In order to quantify this incidence, a series of tests of structureborne and airborne noise are being carried out in finished residential buildings that have not yet been occupied. Among the factors to consider when analyzing the obtained results are the different environments in which buildings are set: proximity to highways, railways, etc. From the study and processing of the data obtained and the different environments studied, the existence and real magnitude of the problem will be shown.

Keywords: Structureborne noise, soundscape, noise mapping
I-INCE Classification of Subject Number: 43

1. INTRODUCTION

Most of the vibrations that happen in buildings are motivated by the facilities of the building itself, by impacts, either induced by the users of the building or by its running machines [1]; and also, by the urban setting where the building is, like those produced by rail transit. These have been the subject of different studies due to the importance they have on the comfort of people [2]. However, there are other, which qualitatively and quantitatively are lesser, that have been less studied, that is why we have proposed this research. Although they pass in low frequency ranges and accelerations, and in most

[1] monica.morales@upm.es
[2] f.gil@upm.es

cases, they are below the thresholds that humans can perceive [3], this kind of structureborne noise exist and is part of the group of noises that we can find in a house.

Our research aims to go further the measurement of these vibrations. It also seeks to establish its relationship, if any, with the noise mapping of the city in which the buildings under study are located. Additionally, this research is important, since it is difficult to measure this type of structureborne noise once the building has been occupied, because they are covered by the vibrations produced by the building's facilities.

In summary, the importance of the research is that it focuses on a type of structureborne noise that has not been studied in depth and that have the difficulty that it is only measurable for a short period of time. This research also relates these vibrations to noise maps, which may lead to contribution to the improvement of them.

This paper has analyzed, in addition of the studies and recent experiences on vibrations residential buildings, the regulations that concern them, mostly collected in the UNE ISO rules. On the other hand, procedures related to evaluation, management of environmental noise, quality objectives and acoustic emissions collected in European Directives, decrees or municipal acts have been analyzed as well. In relation to noise mapping, the recent *Mapa Estratégico de Ruido de Madrid*, whose definitive approval was on June 28th, 2018, has been used. The specific bibliography on the elaboration of noise mapping has also been studied. The studies focused on the uncertainties and deviations that pass in the elaboration of noise maps are of special interest. [4]

This is a long-term research, so this study focuses on the process and mechanization of the working method to be applied, aiming at giving a solid foundation on which to develop the process and to reach accurate conclusions. The main target, therefore, is to propose a working method that will allow to quantify the structureborne noise in housing that does not come from the facilities, neither from rail traffic nor are produced by impacts. The purpose of that is to obtain a homogeneous information, with the same starting conditions, that we can interrelate with noise mapping. A secondary purpose of the study is to put into relation the noise mapping's information to the actual noise level of the setting.

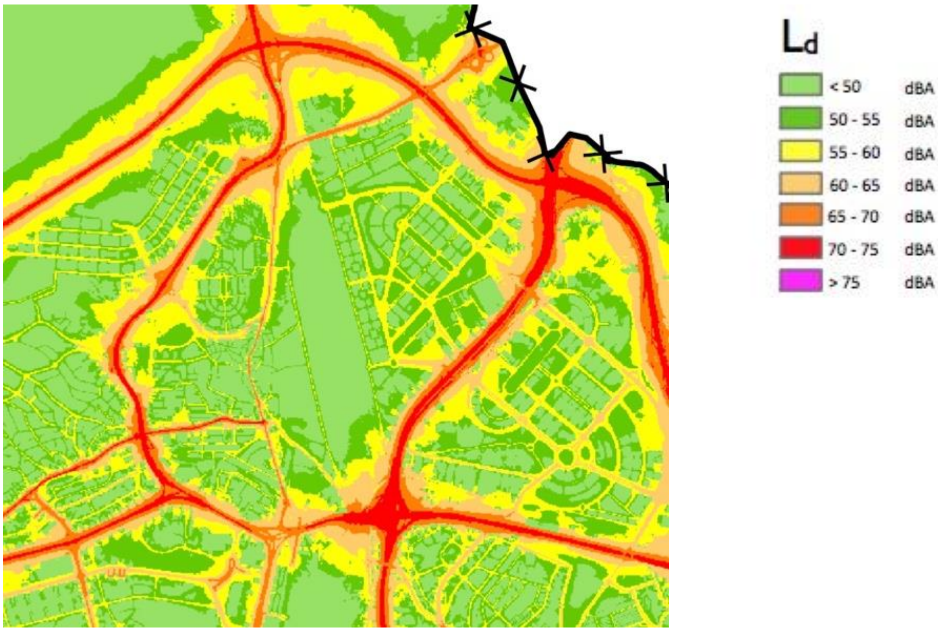

Figure 1:Detail of the noise mapping from Mapa de Estratégico de Ruido de Madrid. Ayuntamiento de Madrid (2016)

2. STARTING CONDITIONS

The investigation began with a number of tests on apartments in buildings where a series of specific conditions:

- Location of the building
- Plant and location of the apartments in the building
- Construction system of the building and execution time.

2.1 The location of the building

The location of the building in towns with updated noise mapping was the first of the conditions, since we needed to know the noise level of the place where it is located. Buildings also needed to be away from railway tracks or if close they should not have too traffic around, in order to allow our essay. [5]

Preferably the chosen buildings had to have facades to different ranges of noise levels indicated in the *Mapa Estratégico de Ruido de Madrid*. Noises are ranked in seven different ranges (<50, 50-55, 55-60, 60-65, 65-70, 70-75 y >75 dB A, as stated in figure 1) so, as buildings usually have four facades, the research tries to cover four intermediate ranges.

Inside the building, some apartments have been chosen located in different areas of the noise mapping. In the main facade noise level is known, since it corresponds to the lot as it was. On the side facades the noise level is also known, although it is appropriate to contrast with nearby buildings with the same orientation and similar level of noise in the main façade. In the case of the back facade similar buildings have been searched or an estimate has been made by measurements. The estimate will be very probable because the ranges are five to five decibels A. In all cases, airborne noise has been measured on all facades, the measure has been always taken in a day situation (L_d) since it has been considered that equivalent sound level (L_{eq}) is less precise.

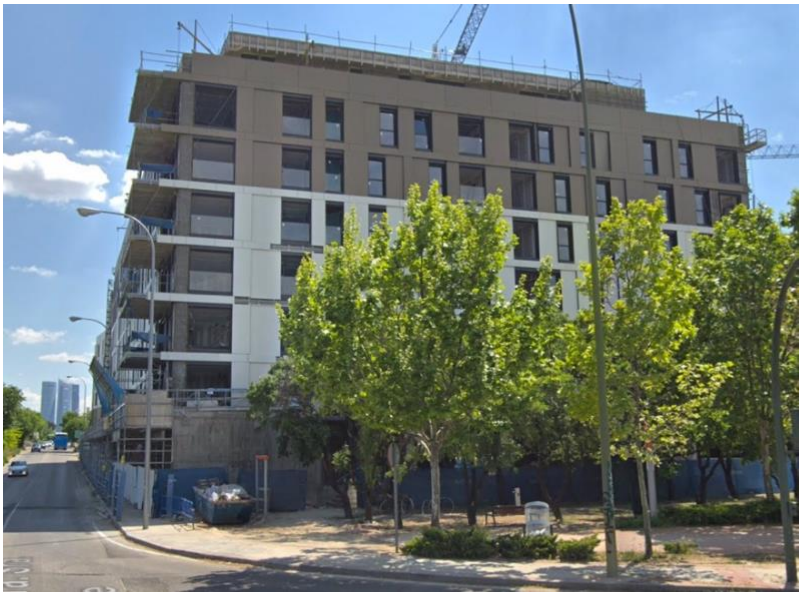

Figure 2: Example of a building to be tested. Front façade oriented to a heavy traffic road and other facades to low traffic roads.

2.2 Plant and location of the apartments within the building

In each of the existing facades in the building, as just exposed, two apartments have been chosen. This in order to be able to compare in the ranges of noise levels that the noise mapping indicates. One of them on the lowest floor, usually first floor, and the other on the top of the building. The criterion has been to have one very close to the foundations and another as far away as possible. [6]

In total, for a conventional rectangular building, measurements have been taken in eight apartments, two for each of the daily noise level ranges.

2.3 Construction system of the building and construction phase

The buildings under study have been chosen with similar characteristics in terms of their construction. They are five or six floors buildings (5+penthouse), whose structure is formed by pillars and beams (mostly flat beam) of reinforced concrete. They supported one-way slabs of concrete joists with ceramic pieces between them. In general, they are structures without distances bigger than six meters.

The walls that formed the enclosure are composed by several layers, this meet the requirements of the *Código Técnico de la Edificación* (CTE: main Spanish regulation acts in construction), in our case in particular, the CTE's chapters pertaining to the composition of the walls are the energy saving and noise isolation (CTE DB HE y DB HR).

The main requirement for the performance of the tests has been the execution step in which the building should be. We needed buildings finished in their entirety but still not occupied; the works should have been finished to avoid possible structureborne noise due construction, machinery, movement of workers, etc. [7] At the moment in which any of the facilities: elevators, pressure equipment, etc. would started to run we would could not get the measure of the vibration object of the investigation in isolation.

3. TEST PROCESS

As mentioned in the introduction, before beginning the vibration measurements, the meteorological conditions of the day have been considered in order, if applicable, to establish the variations that this could produce in the measurements. We have also taken external airborne noise level data to make a quick comparison with the range that the noise mapping indicates, first in order to verify that it is within the range that we figured out and, second, to test that this is not a particularly noisy day. In addition, it has been necessary to take into account that there are not impulsive or tonal components that could hide the results.

The measures data were taken in the apartment's main room on five positions, four in the corners, one meter away from the walls, and one in the center of the room. Normally, there are two of them close to the façade walls and there are two of them which where next to the interior partitions, with which we get measurements at different distances from the building structure. The perimeter points are closer to walls, while the center of the room is away.

The equipment to take the measurements is composed of a triaxial accelerometer, designed with a piezometric crystal in cut mode, to eliminate the base tensions and other effects that may appear at low frequencies. The frequency range is ($f_{(10\%)}$) 0,13 .. 4800 Hz, the sensitivity is 500 +-5% mV/g and the acceleration dynamic range is +-12 g. To assure an accurate data collection to the excitations has been placed on preheated wax discs to improve contact and therefore homogenize the surface. Data captured in the different tests have been treated with the appropriate software. The time of the gathering data has been stipulated in two minutes, [9] enough to record a stationary vibration.

Figure 3: The red mark indicates one of the positions of the accelerometer about one meter from the walls.

A specific computer program recorded the accelerations, in m/s^2, that were taking place in the three directions throughout the performance of the test. At the same time the software generates the frequency weighing (W_m) to articulate the magnitude of the structureborne noise [7], all this is represented in a graph time / acceleration (s - m/s^2). The computer program also allows us to transform the accelerations to decibels.

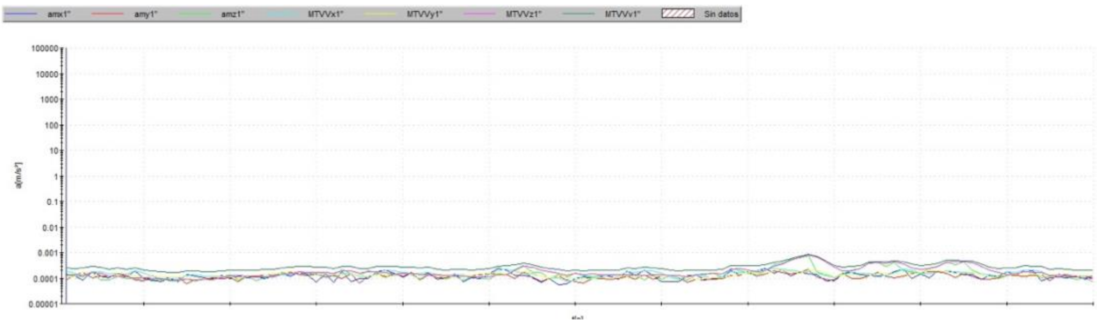

Figure 4: Example of one of the graphs obtained in one of the measurements

Once the sufficient number of tests have been carried out, the data obtained will be analyzed and processed in order to find the relationship between the noise mapping of the place where the building is located.

4. CONCLUSIONS

This document has presented the method and the conditions for carrying out vibration's tests in buildings. The vibrations studied are not due to the facilities, nor to the impacts, and the purpose is its study and put into relationship to the noise mapping. Therefore, it has been exposed the bases and premises that have been drawn up for an accurate analysis of the data. So far we only have the conclusions regarding the research approach, which are summarized in the following:

- There is great difficulty in measuring the structureborne noise that affect buildings and that are not included within those generated by the facilities of the building, resulting from impacts or rail traffic. Being within imperceptible ranges (they are smaller than 0,001 m/s^2 weighted in frequency W_m) once the building in use they would be hidden by others of greater influence.

-Data must be taken in the first and last floors to have information from areas closer to or far from the foundations. As well, measurements must be taken next to the building structure, such as the points on the perimeter of the room, to contrast them with measurements far from the building structure, such as data gathered in the center of the room. This will allow us to analyze the progression of the structureborne noise through the different constructive elements

- Finally, and related to noise mapping, it is important to perform the test in the different noise level ranges of noise mapping in order to evaluate whether the incidence is higher or lower in the noisiest than in the less noisy areas.

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