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TRAFFIC NOISE ABATEMENT BY MEANS OF ACOUSTICAL BARRIERS: AN EXAMPLE OF RELIABILITY OF PREDICTION MODELS WITH DIFFERENT KIND OF BARRIERS AND DIFFERENT CONTEXT

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Abstract

This paper synthesises a longer work written to verify the noise protection obtained with three different kinds of acoustical barriers (steel acoustic fencing, tile acoustic barrier integrated to the building, mass gravity gabion walls) in three different inhabited contexts.

The problem was due to the presence of a very busy road or railway in each context analyzed: the first one was in Reggio Emilia, with building less than 5 meters away from the road; the second one was a case of a new building so close to the railway that it was impossible to build up a traditional barrier so to integrate it to the new building itself; the third one was in a rural area with a few houses all around.

The research was based on an accurate experimental study of traffic noise both before and after the intervention: it required a large amount of human and instrumental resources, but it was possible to correctly establish the dimension and the materials of the barriers protecting people living close to the road.

A numerical model (ray tracing plus mirror image), based on the algorithm ISO 9613, was implemented and used both for the analysis of the initial situation and for the design of noise barrier.

The aim of the study was to design an acoustical barrier in order to guarantee compliance with the noise limit for that area type, according to Italian legislation, but the last step was the acoustical test of the barrier and it gave the same results as calculated with the model.

1. INTRODUCTION

The high increase of road traffic reaching citizens who live in big urban areas is going to became one of society’s important problems to deal with. It is therefore more and more frequent and necessary to perform sound level measurement along the streets, and simulation by acoustical models, in order to have reliable information to face the problem.

During the last years we could see many new laws and sets of acoustical rules (UNI) in Italy. Each of them was written with the aim to reduce and control noise pollution in urban areas. In many cases they follow the indications and advises suggested by European (EN) and International (ISO) Agencies.

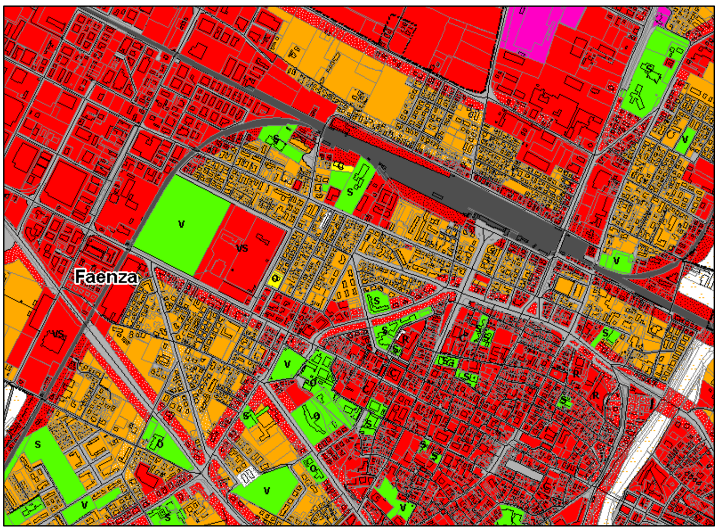
Particularly the National Board Law, L.447 (Oct, 26th 1995), gave many suggestions about noise problems and urban planning to Local Administrators, for example about:

1. Acoustical classification of urban territory, according to the prevalent urban destination of the districts (residential, industrial, scholastic, sporting and so on);
2. Definition of an "Improving Plan" for sites with great acoustical problems (both in urban areas and in industry).
3. Definition of priorities and control methods in order to minimise noise pollution or even more in order to prevent it.

The same Board Law defined new acoustical limits, and a following Decree Law (D.P.C.M. November, 14th 1997) gave them a specific value:

Acoustic class	**Description**	**AILV (day/night)**
Class 1st	"*Areas which need a particular acoustical protection*" :Areas where silence is a need to live or stay in: hospitals, schools, green areas, historical and cultural places, and so on.	***50/40***
Class 2nd	"*Residential areas*": Urban residential areas with only local road traffic, a few shops and no industry.	***55/45***
Class 3rd	"*Mix urban areas*": Urban residential areas with normal road traffic, commercial and business areas, but no industry. Rural areas with farms and breeding.	***60/50***
Class 4th	"*High activity areas*": Urban residential areas with high road traffic and trains, commercial and business areas, small industries.	***65/55***
Class 5th	"*Mix industrial areas*": Industrial districts with small residential areas included.	***70/60***
Class 6th	"*Industrial areas*"**:** Industrial districts where nobody lives in.	***70/70***

Where the indicated Absolute Immission Limit Value (AILV) is the highest noise value, in dBA, measured near a receiver point, but it doesn't depend on the kind and on how many sources are impacting it. We have other two laws (DPR 459/98 and DPR 142/2004) which gives specific limit values for roads and railways, higher than the one defined above, which refers to the kind of source you are working on and partly to the kind of receptor, too.



The example you are viewing here on the left is about the acoustical classification of a urban town. About the colours used on the map, you can refer to the colours used towrite on the table above.

Looking at the map and at the classes represented (and the situation is similar in any town) it become clear the meaning of an improving plan: as an example, when I've a green area near to a red one I need to have, inside the first one, the compliance of the first class limit, also if in the 4th area I can tolerate a higher noise.

2. NOISE ABATEMENT BY MEANS OF ACOUSTICAL BARRIERS

Acoustic barriers can be required in any situation in which noise pollution is a problem. This may be an interior scenario such as soundproofing a room in which excessive noise is created, i.e.; a recording studio, or it may be an exterior scenario such as a roadside.

Acoustic barriers can be either sound absorbent or sound isolating (reflective). Sound isolation involves generally stiff, heavy material which literally stops sound from passing through it, due to massed consistency. Sound absorption involves porous, open celled material, and stops sound by soaking it up. Sound isolation is the most effective of the two options when attempting to stifle noise pollution, however in some cases they can be employed together ensuring maximum protection.

Here I'll present a few intervention of noise reduction different not about the source, but about the kind of protection. About the first work you can read, step by step, about the complete study made to achieve the result which was aimed.

About the others, I'll show you the intervention and something about the results, but not the entire work of analysis.

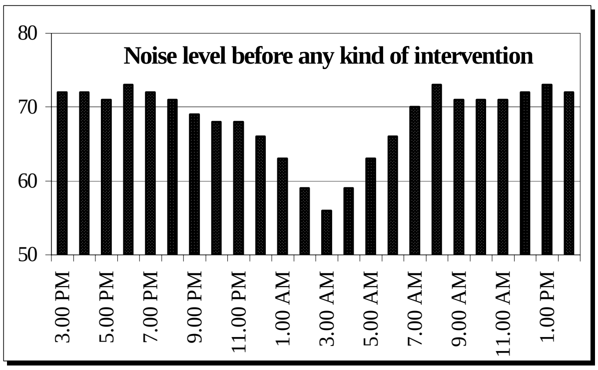
2.1 The first example, a classic acoustical barrier

This study was carried out on a very busy road which cross a urban area in Reggio Emilia (a town of about 150,000 inhabitants). That road goes through a built up area (residential area - 3rd class), running along a school and a green area (both belonging to 1st classe), too. In some cases buildings are less than 5 meters away from the road, and, on the whole, about 1,250 people are living there. The land was not altimetrically complex, but along the road there are 2 important intersections, and more, part of the road goes on viaduct, at the same height of the first floor of the flanking buildings.

The aim of the study was to find a solution in order to guarantee the compliance of noise limits for this area type, according to Italian Legislation.

The first step of the work consisted in a study of the actual traffic noise level along the road. At the same time, information on the traffic, including the speed of the vehicles, were gathered, in order to calculate the average hourly and daily traffic, and dividing data into day and night-time and light and heavy vehicles.

As it is possible to see, reading the results of the monitoring campaign, the noise level measured before any kind of intervention was really high, especially if related to the noise limits in the area.



The average day level was 72.2dBA (corresponding to 2,765 equivalent vehicles in 1 hour with a speed of 67km/h) against the limit of 60dBA for the houses and 50dBA for the school. During the night the average value was 68.1dBA, 18 points more than the limit, with an hourly traffic of 418 vehicles at 76km/h.

The measured excess was really very high, so it became clear that, in many places, it was necessary to take measurements in order to solve the problem. The choice was to try two different solutions:

- Use of noise-absorbent asphalt: usually noise level reduction is not very high (3÷4dBA), but it is the same for each building, independently to the number of floors;
- Realization of insulating/sound-absorbing barriers: in this case noise reduction is higher (up to 10÷12dBA), but only for the lower floors of the nearest buildings.

First of all we needed to use an acoustic prediction model (software IMMI), to reproduce the geometry of the area of interest: the topographic characteristics of the area, particularly around the most affected buildings, were measured with a theodolite and an infrared distance meter.

Then, the model was accurately calibrated working on both geometrical and acoustical parameters. So, it was possible to make the computed noise level really very similar to the normalized experimental measurements.

The model was then used to obtain a single point calculation and a contour mapping of the "ante-operam" situation: it was necessary, in order to predict, in the second step of work, a result of the intervention, before to its realization. It was strictly necessary for the costs/benefit analysis of the entire problem.

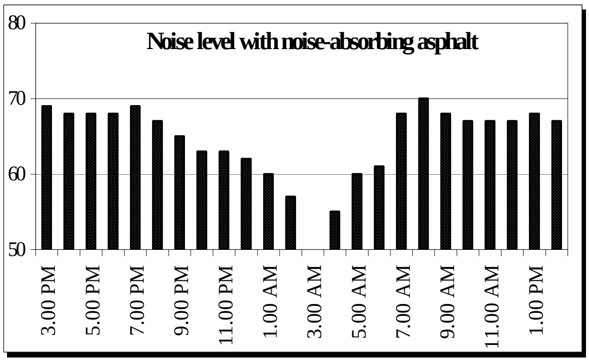
So the last decision was taken by the administration.

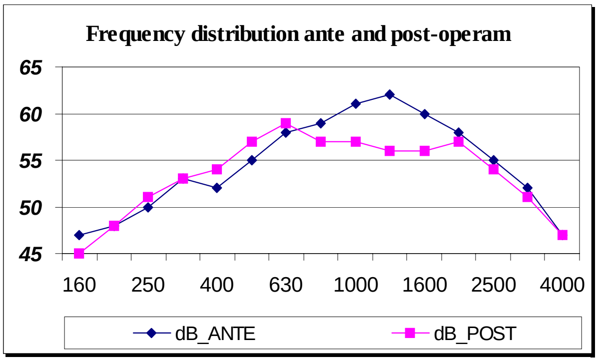
As soon as many people living there were complaining about the situation, Local Administrators decided for the first and quicker kind of intervention, laying down a noise absorbent asphalt, but working, at the same time, on the acoustical and structural project of a noise-absorbent/insulating barrier.

A noise-absorbent asphalt is, as a matter of fact, the same of a draining one: it is made with a particular mixture of calibrated gravel (at the sieve: 8-12-13-16mm), a small part of fine sand, and a particular bituminous binder. It is important the temperature, too. In such a way it is possible to obtain a porous texture (open cells) which allows, on one side, acoustical energy absorption, and on the other, the most important result, elimination of one of vehicle's noise sources: the contact of wheels and asphalt, the micro-explosion effects originated from the passing wheels which compress the air in the superficial cavities of a normal asphalt.

After that first intervention it was possible to see a real improvement of life's quality of the area, although the problem was not completely solved: after a new measurement campaign (5 months after the intervention) it was possible to see an average noise reduction of about 4dBA during day-time and 5,5dBA in night-time.

And most of all was important to see the average modification of spectrum: it was a really useful information for implementation of calculation model and for the following acoustical project of the absorbing/insulating barrier.





The project of the absorbing/insulating barrier was carried on with the help of the model: after the first calibration step and the simulation of the actual situation, it was used to calculate the contribute of noise-absorbing asphalt to sound abatement to receptors. After that second calibration, the model was used to reproduce the real situation in standard traffic conditions.

Barriers were designed working on vertical and horizontal sections, and their length and height were calculated in order to bring noise level at top floors of the nearest and affected buildings, as more as possible within the limits. And obviously the same has been made for the school and the green area.

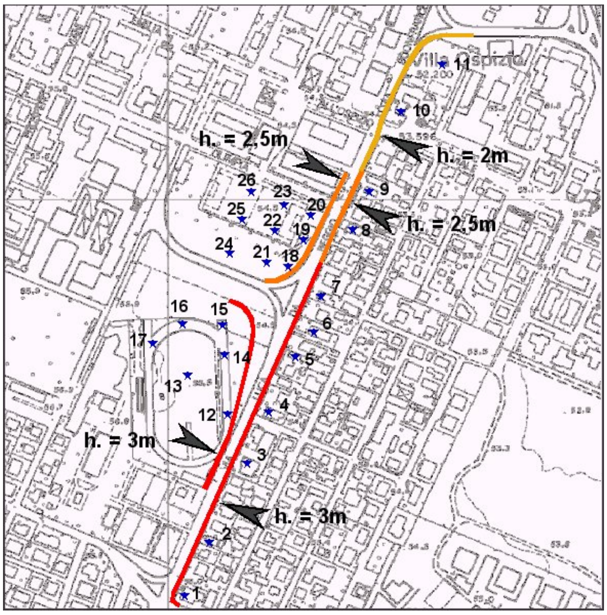
It soon became clear that the worst situation, and therefore the one to be considered in the design of the barriers, regarded night-time: during the night the noise level decreases about 4dBA (from 72.2 to 68.1dBA) due to traffic reduction, but the limit set by the law is 10 dBA lower for night-time than during the day. Luckily this limit applies only to residential buildings and not, for example, to the school or the green areas, where the limit is only used during the day.

The model calculation gives, for each section, the "standard additional length", too. It is the length the barrier should have, on each side of the section, to ensure that the noise coming from the end of the barrier does not affect the calculated abatement.

Due to the varied altimetry of the road and of the receptors, the high of the barriers changed according to the position of the affected buildings.

The barrier used was partially a “sound absorbing” type (steel panels with mineral wool inside), in order to avoid the increase of level due to reflections on the opposite side.

Furthermore, in order to reduce impact on the landscape, glass panels were used whenever possible.

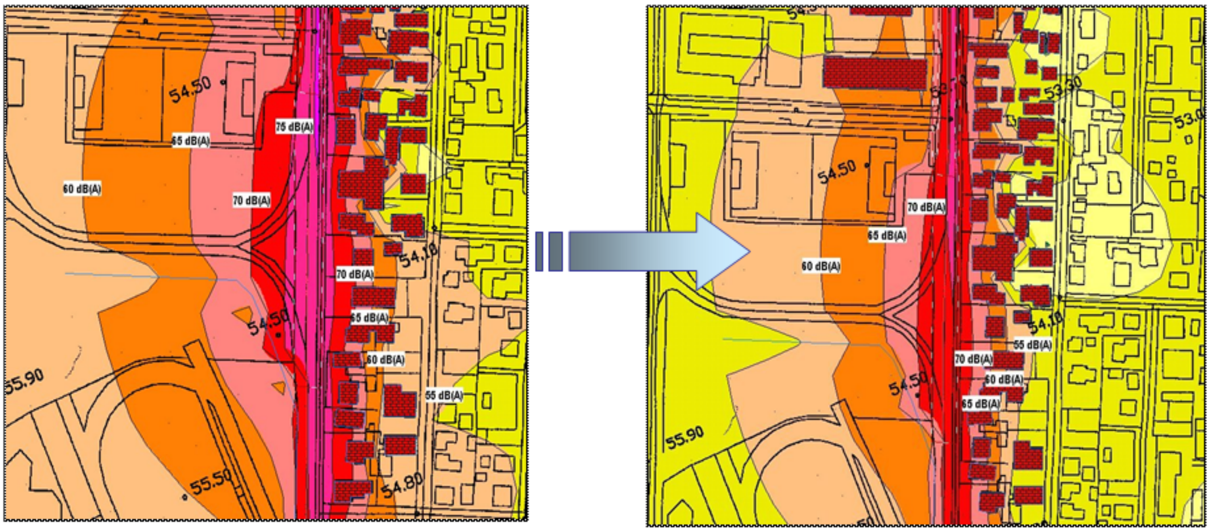


The model was used to define the geometry of the barrier, and to evaluate its efficiency, too. To make that, the model was used to calculate the new noise levels, after both interventions, in the same points of the first measurement campaign. So it was possible to make a comparison between the two situations: the first, related to the “ante-operam” scenario, and the second, to the “post-operam” one.

According to the model’s results, noise abatement was interesting: the average attenuation at the second floor of the buildings was about 8dBA, about 6 at the third one, and more than 10dBA at the ground floors and in the open areas nearest to the barrier.

Moreover, after the barriers were built and installed along the road, measurements were taken again in the same locations used the first time. Also in this case a simultaneous measurement of the traffic flow was made, showing that the average traffic had not changed, and enabling the normalization of the measured levels.
The noise levels measured confirmed the results of the model, with a maximum deviation of

about 2 or 3dBA and however, larger deviations have been found far from the principal road, probably due to effects connected with other noise sources (not included in the model), such as other minor roads.



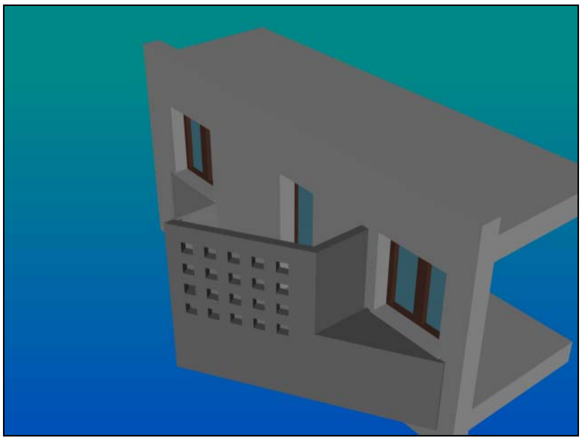
2.2 The second example, a barrier integrated to the façade of the building

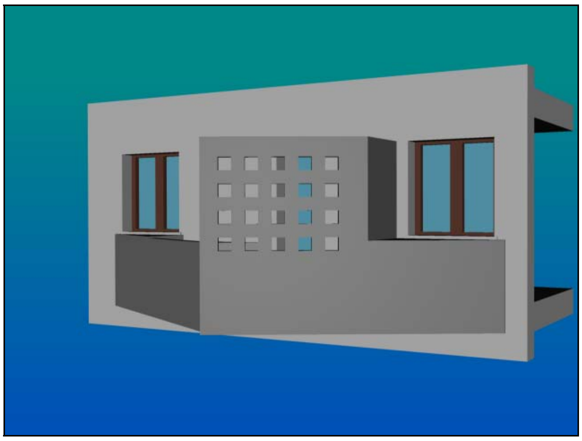
In this case the problem was a railway, passing near to an area where there was the project to build up many new residential buildings (the project class was again the 3rd).

The acoustical measurements campaign over the free area pointed out a very critical situation: during daytime the acoustical level over the area, at the height the ground floor, varied between 57 and 65dBA (the limit value was 60); during night-time it was 52-60dBA (limit 50). Obviously, at the higher levels the acoustical impact would it be higher, but it was predictable only with the help of the prediction model.

So it become necessary to evaluate an acoustical abatement intervention over the entire area and it was made following a double action line: first it was inserted a small acoustic barrier all along the railway, in order to protect all the area, at the pedestrian level; moreover it was projected a self-screening building, with architectural wings integrated to the façade, in order to protect, directly, the more sensitive parts of the apartments, the living and bed rooms.

Also in this case the help of the model was fundamental: it helped in the project of the dimension and the position of the wings and also in this case the noise levels measured after the realisation of the project confirmed the results of the model, with a maximum deviation of about 1,5-2dBA (and I think it was a really good result, taking in account the anomalous kind of intervention analysed.





2.3 The third example, a mass gravity gabion walls

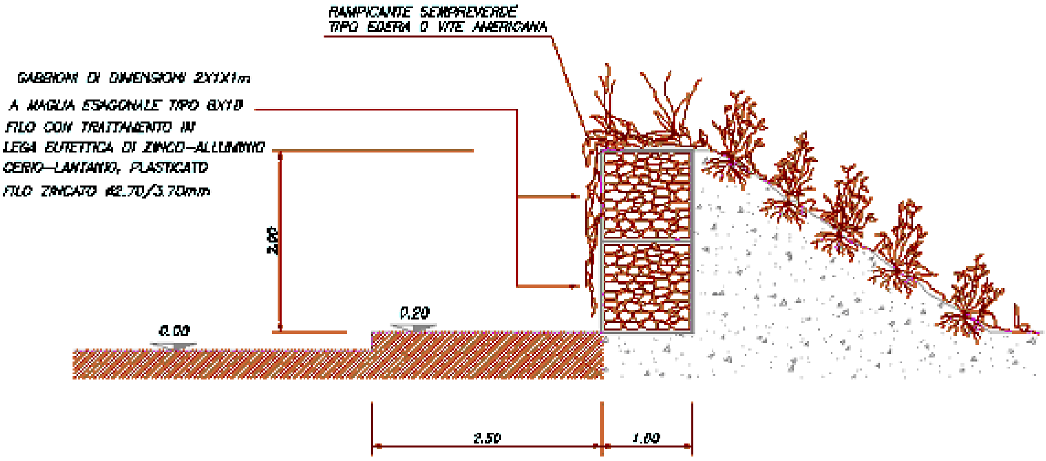
The third context we are writing about concerns again a new residential area, but in this case we had a new project road, too. So, again it was extremely useful the aid of the prediction model: its application was necessary to model both the new source and the new receivers.

So, working step by step, first of all we needed to work to the model of traffic: the construction of an O/D matrix was necessary to know how many and what kind of vehicles would have travelled on that way. Then it was necessary to define the geometry of the project situation, with the correct 3D design of the new road and of the new buildings.

Then the last step was the one of the acoustical model. It was quite difficult, because of the total absence of information about the acoustical context, in the project scenario. So we needed to make many hypothesis, about the speed, the traffic composition, the ground absorption, and so on.

Anyway, also with many uncertainty about it (the final error in the model would depend both on traffic evaluation and acoustic evaluation), the model gave a secure response about the final result: the necessity of a mitigation.

As there were much space to work on (the distance of buildings from the road was about 50meters) the decision was about a mass gravity gabion wall: it was the best choice in order to get a nice environmental impact of the barrier, that would have been covered by vegetation in a few years, as you can see, from another intervention, in the next photos.



3. CONCLUSIONS

As a conclusion for this paper I would underline two aspects of environmental acoustics:

- first of all the great help that a prediction model can give to the projectors, but only at one condition: a great help is strictly linked to the accuracy of the input information and the good result of the model is strictly linked both to that condition but also to the know-how of who is working at the model;
- as a second consideration I think it is possible to tell that a good protection from noise can be achieved both with traditional barriers, but also with unusual systems with the same efficiency.