ICSV13 - Vienna
The Thirteenth International Congress on Sound and Vibration
Vienna, Austria, July 2-6, 2006

PREDICTION OF THE ATTENUATION GIVEN BY A BAFFLED HIGHWAY USING A SCALE MODEL

Maud Serra[1]

[1]Peutz & Associates acoustical consultants
34 rue de Paradis, F75010 Paris, France
m.serra@peutz.fr

Abstract

When a road is built or modified, the resulting acoustical consequences have to be quantified in order to protect, if necessary, the buildings located in the neighbourhood of the road. In France, the laws in force define either a maximum noise level or a maximum sound level increase not to be exceeded in front of the facades of dwellings. To this end, different kinds of acoustical protections exist: the most common of these are tunnels and noise barriers but another kind of protection may consist in absorptive baffles hung over the highway. So far, studies dealing with that subject are very few, only two realizations exist in France and the usual environmental acoustics softwares are not able yet to simulate this kind of system. For these reasons this study was done using a scale model. This paper submits the different aspects of the study from the establishment of the metrological system to the production of results.

INTRODUCTION

The A86 is a highway near Paris. In order to ease the traffic on a specific congested part of this highway, the number of lanes has to be increased from 5 to 14 on a 340 meters long stretch. Consequently, the increase of the noise level in the area has to be evaluated and controlled in order to limit the sound exposure of the numerous dwellings nearby. Considering on the one hand the fact that a noise barrier solution was not possible within reasonable dimensions and on the other hand the fact that the client wanted to find a solution that did not need particularly strong ventilation restraints (a tunnel was not desired due to fire and safety purposes), it was decided to study the attenuation given by a baffled highway.

A classical computer modelling of the site was however performed in order to

Eds.: J. Eberhardsteiner, H.A. Mang, H. Waubke

estimate the noise levels generated by the highway prior to the insertion of the baffles, so as to be able to apply the attenuation given by the baffles to these results. The baffles' attenuation was measured on a 1:50 scale model consisting of an anechoic-like room including the highway and the closest buildings. This paper will specifically deal with this aspect.

Figure 1 – View of the site (unbuilt)

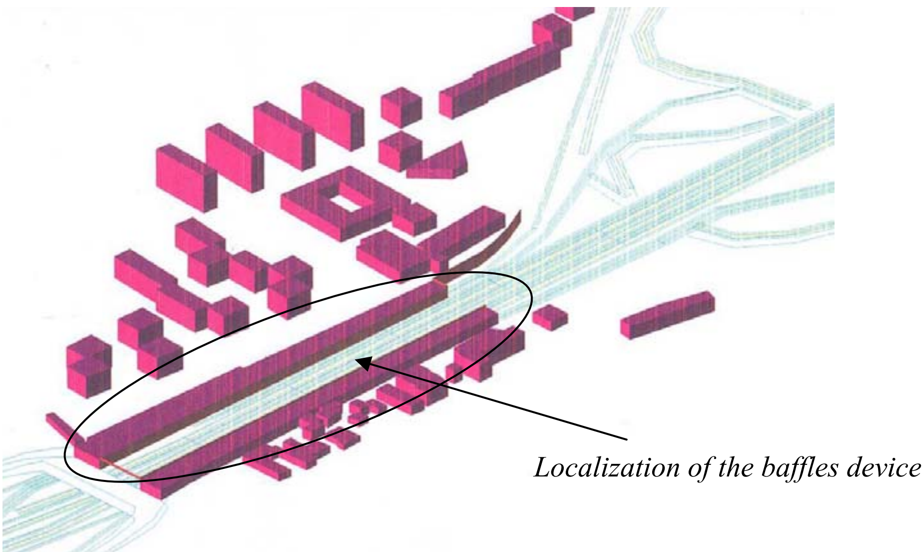


Figure 2 – View of the computer modelling of the site (future)

Figure 3 – Views of the 1:50 scale model

DEFINING THE PHYSICAL FEATURES OF THE SCALE MODEL

Scale modelling is a very useful tool to predict empirically the sound propagation in an environment that does not exist yet, or to model buildings with uncommon shapes. In our case, the atypical geometry of the architectural project was recreated in a more accurate way than it could have been using a computer model. In addition, the sound propagation in the scale model is very similar to reality; in particular, phenomena of diffusion and scattering are much better taken into account, while they are hardly controllable with acoustical prediction softwares.

This comparison is only available if the ratios between the geometrical dimensions and the wavelength of the sound in reality and in the scale model is maintained; this requires multiplying the frequencies of the original signal by the scale factor, and consequently ultrasounds are generated. Then, the scale factor has to be chosen also considering the technological limits of the metrological systems.

In addition, in order to recreate the free field propagation of the sound, the scale model has been situated in an absorptive enclosure similar to an anechoic room.

Meanwhile, the materials used to simulate the baffles were tested in a small reverberant room to make as much a match as possible of their acoustical properties to the ones that really will be featured on site.

Figure 4 – View of the small reverberant room

MEASUREMENT ACQUISITION

The size and especially the frequency answer of the components of the metrological system have to be adapted to the scale of the model.

The most significant frequencies for traffic noise are in a range from 125 to 1000 Hz (essentially motor noise in low frequencies and pneumatic noise in medium-high frequencies). The study has been limited to this range - which already necessitates generating frequencies up to 50 000 Hz - to stay within the reliable domain of the measurements tools (notably the acquisition sound card).

In order to generate such high frequencies the sources were modelled with compressed air flowing through holed pipes whose diameter was selected after several experiments. The microphones were ¼ inch to fit the frequency band of the emitted signals; they were connected to a computer via a conditioning amplifier (type Nexus B&K). Then, measurements have been recorded by an acquisition software and filtered for each octave band from 125 up to 1000 Hz.

The measurement of the baffles' attenuation was made on the principle of insertion loss. It means that the noise levels were measured in a configuration of reference without baffles and compared to the noise levels measured with the different baffled devices (configurations 1 to 5) to obtain the corresponding attenuation. Furthermore, for each measurement session, two signals were recorded simultaneously, the first one just above the lanes (fixed point) and the second one in front of the facade in question, so as to set the resulting signals to a reference level and to make sure that measurements were repeatable.

One also has to remember that temperature and humidity are two parameters that can significantly influence measurement results; they have to be controlled at all times during the measurement process because the absorption of air is very important at very high frequencies.

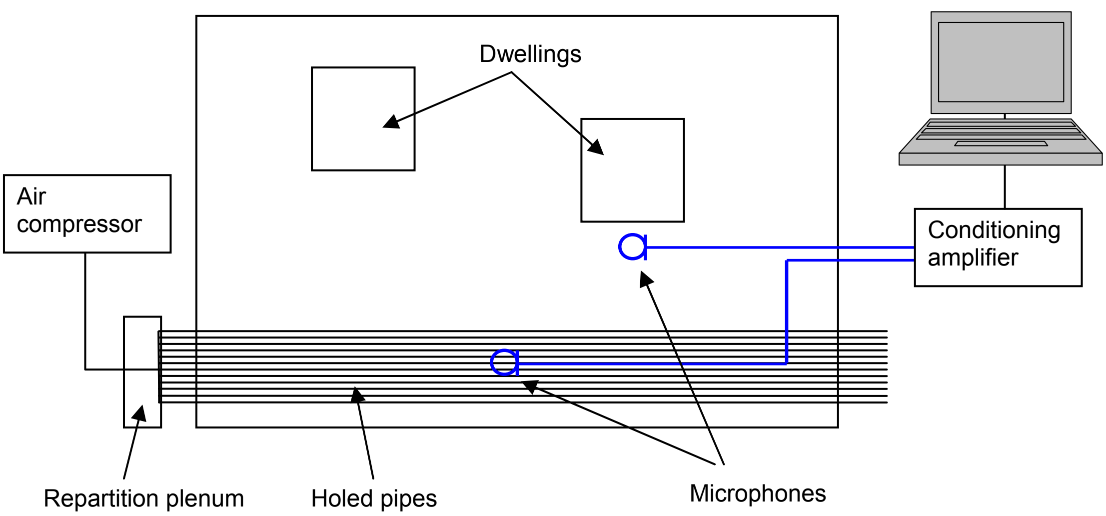


Figure 5 – Pattern of the measurement set-up

Microphone and conditioning amplifier *Air compressor*

Figure 6 – Views of the metrological equipment

PRESENTATION OF THE BAFFLED SYSTEMS

The baffled systems have two main effects on the sound waves:

- First, they behave like a parallel-baffle silencer such as the ones used to reduce the noise of fans between a technical room and the different rooms of a building. Each baffle is made with an absorptive material and sound waves are deadened thanks to the numerous reflections on this porous material. One has to note that this behaviour applies mainly to high frequencies.

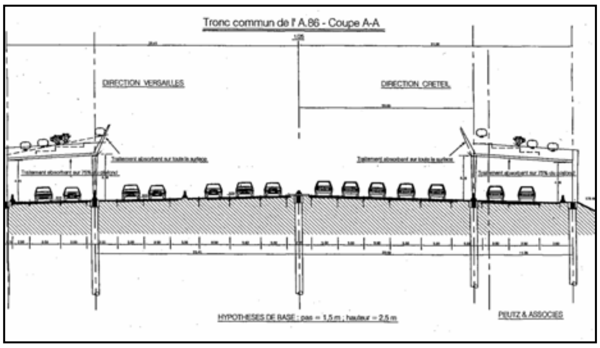
- The second effect of the baffled devices is that they create a cumulated noise barrier effect each time a sound wave hits a baffle. This last effect can be extended to all the traffic noise spectrum frequencies.

The defining geometrical parameters of the efficiency of such devices are the baffle's thickness and height, and the space between baffles.

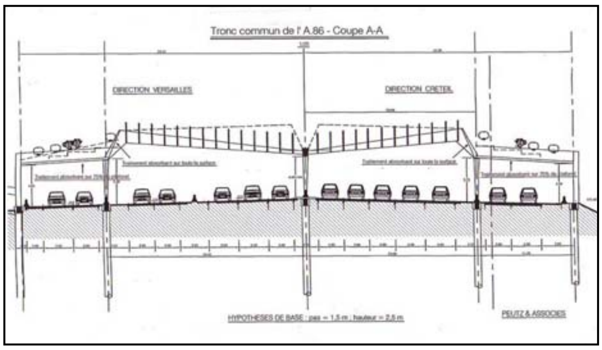
The baffles thickness has been fixed at 10 cm with the following composition: 10 cm of mineral wool (density 90 kg/m^3) between two perforated steel panels (75/100^e thick and perforation rate ≥ 20%).

In the model, these baffles have been depicted with a resilient underlayer generally used under floor coating.

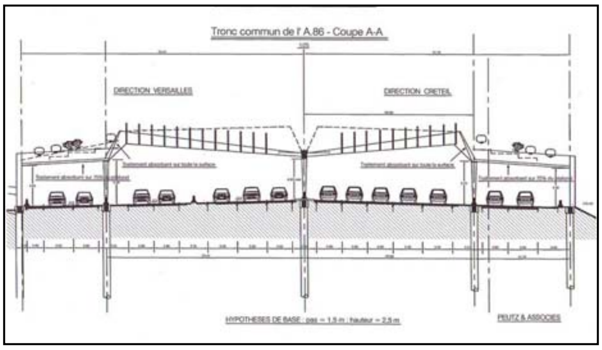
Different shapes were tested, featuring the following variations: fixed height and pitch but uncovering either two or four central lanes, variable height and fixed pitch, variable height and pitch.



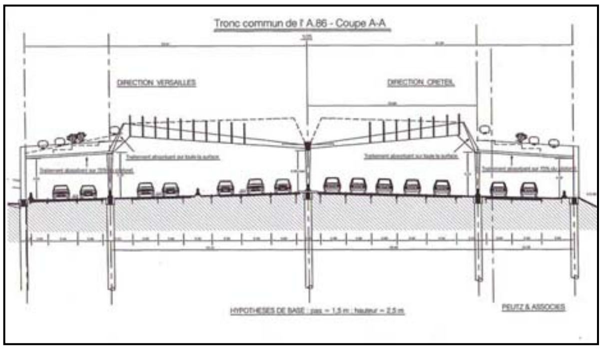
Configuration 0 –reference



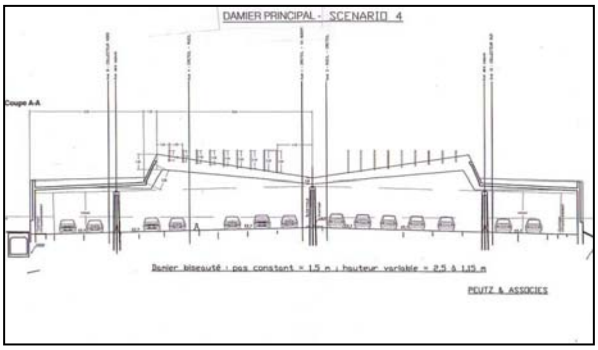
Configuration 1



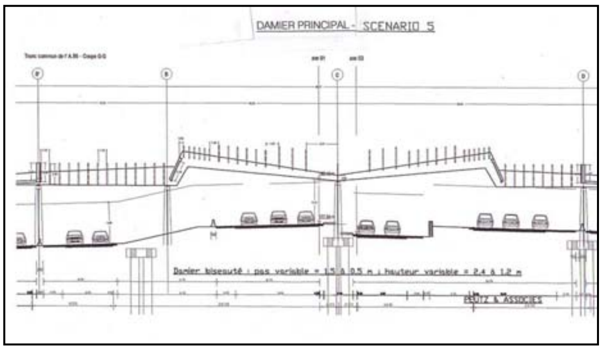
Configuration 2



Configuration 3



Configuration 4



Configuration 5

Figure 7 – Views of the different tested configurations of baffled devices

RESULTS

According to the results of the computer model, the baffled system had to feature a minimum attenuation between 6 and 9 dB(A) in order to fit the maximum noise level target required in front of the most critical facade, i.e. at the 4th floor of the most exposed dwelling.

The results of the different tested configurations fit the theoretical objective.

However, due to the uncertainties of measurement and modelling, the configurations featuring an attenuation under 7 dB(A) have been ruled out (configurations 3 and 4). The configuration 5, which is a bevelled baffled device with a variable pitch, involves a satisfactory global attenuation in dB(A), but also a reduction of the attenuation in low frequencies of approximately 2 dB. This reduction is mainly due to the fact that some baffles are too short in relation to the wavelength; it was not acceptable when considering a traffic noise spectrum. Configurations 1 and 2 both give acceptable results. That way, configuration 2 shows that the uncovering of the two central lanes involves a reduction smaller than 1 dB(A) due to both the wave guide and noise barrier effects of the first baffles.

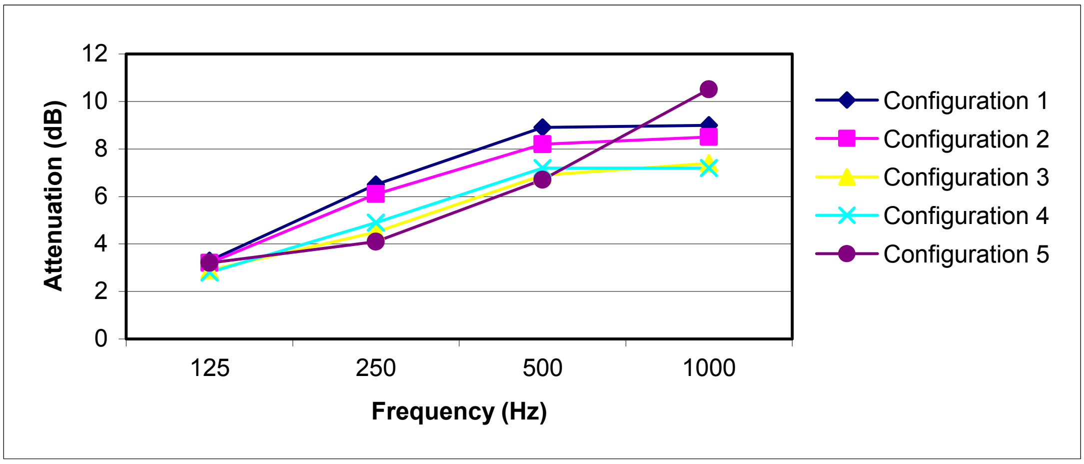


Figure 8 –Results in terms of attenuation at the 4th floor for the different kinds of tested baffles devices

SUMMARY

The study described in this paper has been very useful to help the architect and the client to choose an optimized solution compatible with the acoustical protection of the residents bordering the highway. From a scientific point of view, scale model measurements have permitted an alternative solution to bypass the limits of the present environmental prediction softwares, which turned out to be particularly restrictive for this specific unusual project.

In order to finalise the project and to improve the methodology and the results of this kind of scale model study, real-scale measurements on site are planned at the achievement of the work, in 2009. The comparison between both measurements will be the topic of a future paper.

REFERENCES

J.-G. Migneron, “Acoustique urbaine” (Masson / Les presses de l’université Laval,-Quebec, 1980)

M. E. Delany, A. J. Rennie and K. M. Collins, “Scale model investigations of traffic noise propagation”, National Physical Laboratory Acoustics report Ac58, 1972

H. C. Pinfold, “Traffic noise in miniature”, New scientist, 1967

T. S. Korn, “Measurements of street noise on models”, New scientist, 1967

L. Nijs, “The prediction of traffic noise levels with the aid of a scale model”, Delft University of technology, 1977

R. Josse (under the direction of), “Acoustique, reef”, CSTB, 1982

F. P. Mechel, “Numerical results to the theory of baffle-type silencers”, Acustica, 1990