Control Measures: Noise Reducing Devices in Cities

Ir. Jean-Pierre Clairbois;
Acoustic Technologies S.A./N.V. (A-Tech)
Av. Brugmann, 215
B- 1050 Brussels
Belgium
Phone: +32 .2.344.85.85
Fax: +32 .2.346.20.99
E-mail: mail@atech-acoustictechnologies.com

ABSTRACT

Acting on the propagation path, Noise Reducing Devices are noise barriers, acoustically absorptive claddings, and tunnels. Using these devices in cities is really challenging, and a great care has to be taken in order to master their actual efficiency in reducing noise.

Noise barriers can be efficient only if the houses to protect are situated in the "shadow zone". Barriers are better effective in wider spaces, and on elevated roads or viaducts. One can also find barriers of complex shapes or road covers, which can be very effective.

Sound reflections are a strongly negative factor in sound propagation inside cities, wherever it is possible to reduce these, one has to do it: acoustically absorptive claddings are the most appropriate.

Tunnels are the most effective (and expensive) solution. However, care has still to be taken in order to avoid the "tunnel effect" at their exits: once again, acoustically absorptive claddings are the most appropriate.

1. INTRODUCTION

In cities, Noise Reducing Devices should only be used in a global strategy, as specific tools, effective in specific situations. If used in the correct way, they can really help in reducing noise.

In order to better understand how to improve the use of Noise Reducing Devices in cities, it is worth to make a short recall. The acoustic pollution is a three parts process: starting from the **sound emission** from vehicles, following with the **sound propagation** through the environment, and finally reaching the receivers, mainly the houses (**sound reception**).

Applied to cities, one can separate this process:

	Sound emission	Sound propagation	Sound reception
Acting on	- every single vehicle - wheel/road, or wheel/rail interface - traffic management	- sound diffraction - sound reflection - sound transmission	- airborne sound insulation (sound transmission)
Efficient where?	everywhere around	Restricted to specific protected areas	restricted to specific protected rooms
Benefits	a few dB → 6 to 8 dB (more for multiple actions)	Strongly depends on geometry : a few dB → over 20 dB (tunnels)	global airborne sound insulation up to 35 – 45 dB
Effective for	the only concerned noise sources (air, road, train)	Reducing noise from rail and/or road traffic	Reducing all the outside noise (air, roads, trains,)

Noise Reducing Devices act on sound propagation, what is the most difficult part of the process, especially due to physics and geometry: in fact, we have to struggle against sound propagation in a full 3D environment. Nevertheless, these devices can be effective in urban situations if we remember on what physical phenomenons they really act, and master each of them: sound diffraction, sound reflection, and sound transmission.

We shall look now at different Noise Reducing Devices we can use in cities. Those Noise Reducing Devices could be used whatever the ground traffic is: road traffic or rail traffic. Everything presented hereafter is valid for both of them, except that railways are more often easier to protect due to fixed sources positions, closer locations of devices, and frequency spectra easier to protect.

2. OBSTACLES TO THE SOUND PROPAGATION

We directly forget here the use of **vegetation** to reduce noise in cities, as far as a noise reduction of 5 dB requires about 40 m of a dense pine forest.

Earthberms are also difficult to implement in cities, due to their effective width, and their reduced effectiveness in comparison to noise barriers.

"Classic noise barriers" are generally thin and better effective than eartberms, as they can be placed closer to the traffic, and then raise the resulting "shadow" line. However, noise barriers are ineffective above the shadow line, what can be challenging in narrow streets and/or with elevated buildings. In some cities, one uses noise barriers to protect pedestrians areas, otherwise the use of noise barriers is restricted to main roads, where geometry permits relatively efficient schemes.

Specific situations in cities are **viaducts and elevated roads:** not protected, these situations are strongly negative, but placing barriers on viaducts results in higher shadow lines and very effective devices. That means that even low noise barriers can be effective on viaducts, what is convenient because the barrier involves extra strains to the viaducts due to wind loads. However, low barriers are not efficient to protect far noise sources: if we want to keep low barriers on wider viaducts, for example a 2 x 2 lanes, or 2 x 3 lanes ones, a central noise barrier will be necessary (double face absorptive as presented hereafter).

If we still want to reach very high efficiencies while having high buildings, we have to consider more **complex barriers**: barriers with "hats", or even road covers. On the other hand, one also may think about complex shapes for aesthetic reasons: in all those cases, detailed acoustic studies are necessary in order to master the actual final efficiency of the resulting devices.

We can now find on the Noise Reducing Devices market some **"added devices"** to place at the top of barriers in order to improve the diffraction effect. Extreme care has to be taken about the actual benefit of these devices on the global noise in the environment, as far as they even can sometimes increase the noise instead of reducing it!

With highly efficient Noise Reducing Devices, or even with "classical noise barriers", one can reach theoretical values of noise reduction due to diffraction of over than 15 dB, or even more (e.g. a 3 mH noise barrier, with a car 3 m distant in front of, and a pedestrian 3 m behind it, has a virtual efficiency of 20 dB if only diffraction occurs). At those values, one has to remember that the sound also propagates through the barrier: that **sound transmission** could be significant. Such noise barriers need airborne sound insulation performances of 30 dB(A) or more.

We also will see hereafter that **sound absorptive** noise barriers are better choice in order to reduce sound reflections on these.

The use of noise barriers in cities thus needs extra care in comparison with "country" situations.

3. REDUCING SOUND REFLECTIONS

Sound reflections are very important in the sound propagation process in cities: every time sounds reflect on a surface, a part of the sound energy can be (negatively) redirected toward the houses.

The simplest case is **single reflections**: one can find single reflections on sustaining walls or even on noise barriers. The effect of these single reflections is an increase of noise from 0 to 3 dB. Absorptive materials have to be used on barriers in order to avoid those reflections and, for sustaining walls, absorptive claddings are appropriate.

We more often face **multiple reflections** instead of single ones: that case is worse when reflective walls are facing each other. This is moreover the major cause of the "canyon effects" due to reverberation inside narrow "U" streets. It can lead to an increase of noise from 3 to 8 dB.

Of course, we cannot place absorptive materials on façades, though the architecture of façades could improve things. However, multiple reflections can be, and should be avoided in cuttings: access trenches to tunnels, or open ceiling tunnels have parallel sustaining walls that could advantageously be covered with **sound absorptive claddings**.

Lowering roads into reverberating trenches is definitively not a good method to reduce noise, but that has been done a lot of times in the seventies (Paris, Brussels). However, it is really easy to change that negative solution to a positive one with acoustically absorptive claddings. That becomes a rule in several cities (e.g. in Brussels, almost all those walls are now protected). Final efficiency obtained with acoustically absorptive claddings depends, as well as for barriers, on geometry: staying general, efficiencies can vary from 3 to 8 dB(A).

4. SOUNDPROOFING THE WHOLE ROAD (TUNNELS)

Acting on the sound propagation path, we have seen that it is rather difficult to reach high performances with classic noise barriers, and that the shape of those barriers becomes more and more complex while the target efficiency increases. Tunnels are drastic solutions to definitively solve the problem of noise in cities if we do not forget elementary care about "collateral" effects as: the tunnel effects at the exits, the sound transmission through the tunnel envelope, and the ventilation exits.

One has seen that multiple reflections are the worst while occurring between parallel reflecting walls: in tunnels, “close field” sound propagation is even worse, due to twice two parallel walls (ground and ceiling, and lateral walls). That effect is so serious, that sound propagates inside tunnels nearly as plane waves: i.e. that sound pressure level does not reduce while the distance to the vehicle is increasing.

Inside tunnels, that creates a safety problem: it is not possible to guess from where the sound is coming, because all the sounds inside the tunnel are merging into a confused hubbub. However, this is no problem for the environment if the tunnel envelope is sufficiently insulating and if silencers are placed at the ventilation openings.

The major problem of tunnels is located at their exits: the reverberation is such that every single noise emitted inside the tunnels is found back at the exits. Two corresponding problems are generated:

- For a single car moving inside the tunnel, we have **persistence of the noise level** at the exits, wherever the car is : that persistence makes the noise duration longer, what can be very negative in sleep disturbance;
- For a complete traffic, the consequent noise emitted at the exits corresponds to the **summation of the noise of every single vehicle inside**, what locally increase noise at the exits.

Again here, the use of acoustically absorptive claddings on the tunnel walls, but also the tunnel ceiling is the solution, and even acoustically absorptive road surface can help. As far as the covered part is actually acting as a **silencer** for the noise emitted further inside the tunnel, it is not necessary to cover the whole length of the tunnel. Generally, 50 to 70 m of acoustically absorptive claddings at the exits are enough to completely solve the tunnel effect.

Finally, some countries are using what we call **"false tunnels"**: those tunnels are not usual ones but may be considered as total road covers. In that case, light materials are very often used and special care has to be taken in order to master the sound transmission through the tunnel envelope.

5. REFERENCES

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