5.4. Noise impact of highways: corrective devices

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1. Introduction

At the present time, noise is one of the main causes of annoyance in all countries, worldwide.

A lot of different european surveys, as this one made for the E.E.C. during the "Year of the Environment" - 1986, confirms that.

In such surveys, it is shown that the noise due to the road traffic is the worse perceived one, far beyond the other types of noises as these coming from, in descending order, the neighbourhood, railway traffic, airlines, ...

The road traffic contributes to 80% of the urban noise. Unfortunately, even if we now master a lot of means to reduce this type of noise, the traffic is growing so fast and the dimension of towns is going so wide, that the evolution stays bad. For instance, in Belgium, the traffic comes from 2 millions of vehicles in the 70's up to 4 millions today and Brussels, as the other european big cities, follows a continuous expansion which creates inextricable traffic problems. So, the number of people exposed to noise higher than the widely used criteria LAeq = 65 dBA is going up.

The need of efficient, affordable and realistic solutions to reduce this problem is essential. After some 20 years using different types of noise protection along highways, it is now possible to list these ones with their advantages and drawbacks.

2. Localisation of the problem

As for the other type of noise, we can separate the problem in three distinct parts: the emission, the propagation and the immission.

The way to reduce the noise will be different for each of these parts and, sometimes, it will be necessary to combine action on several of these.

The emission

This part concerns the source of noise.
The noise sources are the vehicles themselves and also the noise created by the contact between the tires of the vehicles and the road surface.

For the vehicle itself, the type of noise is mechanical (engine, gear box, transmission, brakes), aerodynamic and pneumatic... The noise depends on the type of vehicle (cars, buses, heavy trucks).The road/tire interface the noise depends on the road surface roughness, the quality of the tire and the speed at which the wheels are turning.

The propagation

The noise coming from the vehicles is propagating through the air up to the receiver. We will characterize the propagation domain up to the windows of buildings and note that a lot of things can be done to limit the propagation of noise.

The air is energy dissipative (air absorption) but in urban areas the distances are so short (often ? 100 m.) that its effect is neglectible. We just need to take this effect into account when multiple reflections occur and give long path of propagation nearby the highways.

To limit the propagation it is possible to put some obstacles between the highways and the houses, these obstacles can be trees or natural or artificial rigid obstacles (earthberms, noise barriers, buildings, ...).

One does not have to forget that each rigid surface can reflect the noise, sometimes once (single walls, sustaining walls, houses) sometimes a large amount of times (reflecting walls facing each other, ...) and can significantly increase the noise by the houses : one has to master these reflections too.

The immission

People who hears the noise coming from the road can be inside a house of which the soundproofing of the windows and walls can reduce significantly the perceived noise. Outside, as in parks or streets, the only thing we can do to reduce noise, is to limit its propagation.

3. Corrective devices nearby the sources

The legislation of different countries gives the limits of the noise immission for each category of vehicles. We can also act on the town planning for example, deviating the heaviest ways far away from residential zones, using ways which allow easy fluid traffic, right management of traffic lights, ...

Finally, speed control (e.g. by radars) can help to master the traffic flow concerning the road/tire interface, one has to know that a very large number of materials can be used on road surface, the noisiest ones are striped concrete and paving stone, asphalts are quieter and the new rubberized asphalt is one of the quietest ones. The range of noises emitted with these different types of surface is inside 10 dB, so the right choice of the coating is an important step to reduce noise.

4. Nearby the houses

The use of new reinforced windows which can give up to 40 dBA of transmission loss, instead of 24 for a traditionnal 3 mm single sheet of glass, is sometimes necessary to protect high floors, but one must take care to have the same performances for the window frames and the walls too. Some tricks at the design of the building can also be very useful (use of blind walls, place the quiet rooms at the back side of the building and so on, ...).

5. Acting on the propagation process

One of the simplest way to place an obstacle between roads and houses is naturally to use vegetation (trees). Unfortunately the weak noise reduction given by vegetation (+1.5 dB/10 m. thick pine trees) limits its application outside big cities.

The most evident way to reduce the propagation of noise is to put rigid obstacles, that we usually call "noise barriers",due to the large wavelengths of the sound (traffic spectrum from 0.1 up to over 1 m.) the noise barriers do not protect against noise as they could do against light: inside the shadow zone of a noise barrier, the noise reduction is usually from 5 to 15 dBA.

To master this efficiency, care must be taken to avoid transmission through the material of the barrier (effective when the transmission loss is over 26 dBA).

A lot of experiments made by Professor Maekawa has conduct to a useful method to design efficient noise barriers.

The wedge angle at the top, as well as the angle of approach of the sound wave on the obstacle, affect its global efficiency.

One must know that, each other parameter staying equal, a thin noise barrier is better than, for instance, a 4/4 earthberm and that the vertical plane is better to reduce the noise propagation than an inclined surface, for an incident wave front.

Finally, the use of absorbent materials on the exposed side of the barrier can also contributes to better noise reductions by dissipation of the wave front, keeping all of this in mind, one must also design the geometrical parameters of the problem:

– the right height of the noise barrier to reach the noise reduction objectives (common height are from 3 to 5 m.), taking the relative position of the vehicles and these of the houses to protect into account;

– the length of the barrier: avoid the sound to come towarde surroundings by the ends of the obstacle, directly or by diffraction.

Rigid surfaces can reflect the sound. In the case of urban noise, the problem is the re-direction of the noise to the houses, an effect that increases the sound pressure levels where we just want to decrease it.

One can have single reflections, these ones can increase by up to 3 db the "initial" noise without any reflection. a trick can be to incline surfaces to put the reflection to the sky; unfortunately, the action of atmospheric phenomenon such as temperature gradients and for pressure gradiants can take this reflection an redirect it toward the houses. So, the best way to do is to dissipate the energy of the incident wave.

This case is the most annoying noise coming from highways: whith long, high heavy vehicles wich present a long reflecting surfaces that can interact with any other one as houses, or noise barrier. For instance, a reflecting noise barrier can be efficient when no interaction exists but unefficient when the heavy vehicle is passing i.e. when the noise is at ist maximum. An absorbent design ot the barrier can avoid this effect.

When we have two reflecting surfaces facing each other, we can have an infinite number of reflections (as a ping-pong game) betwen the walls. For example in an acces trench of a tunnel, the image sources wich can simulate the effect of the reflections of higher and higher orders, are going far away from the top of diffration due to the sustaining wall. The screening effect of the walls is lessened and the result is that, for a large amount of position in the surroundings ,we only hear the reflections instead of the direct fiedl coming from the trench. In comparison with a surface traffic, such a traffic inside a reflecting trench can give an increase of up 5 to 8 dba. Once again we can avoid reflections by use of absorbent materials on the walls.

A last case of multiple reflection is of great importance. It is easily understandable that, for interactions between reflecting surfaces, the closer the surfaces, the closer the image sources, the worst problem of noise.

Inside the tunnels, we have four reflective surfaces and the accustical energy can only go out at the ends. There, the problem of annyoyance for the surrounding is very high.

If we take the example of a single car going inside the tunnel : part when it was outside, the direct part of sound going to the surroundings was important. Successively, inside, the direct field emitted at the end is going down but a new sound field is growing up : the reverberated one.

The number of reflections is so high that the field become diffused and the sound is going in all the directions i.e. also back to the ends of the tunnel. The summation of a decreasing field and an increasing one give something as a "persistent" noise (in comparaison with free field conditions) for the surrounding. Reverberating tunnels can add up to 8/dBA to normal free-field traffic conditions.

As in each case of reflections, absorbent materials is once again the only solution.

We can also have more complex solutions to protect the acting on the propagation: noise barriers with "hat" partial or total road covering for wich it is also necessary to master the problem of reflections using absorbent materials to reach the objetive of maximal noise reduction.

6. Conclusions

If it is possible to conclude I would recall that, to protect against noise coming from highways, we can act on the emission, during the propagation and for on the immission.

Sometimes it is possible, or necessary to combine two or more different solutions to reach the objectives.

Sometimes it doesn't exist any (affordable or realistic) solution.