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DEVELOPMENTS IN ROAD TRANSPORT NOISE AND APPROPRIATE MEANS OF PROTECTION

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1. THE CONTEXT

A consequence of economic growth is that people and goods have needed to be increasingly mobile over the last ten years, a factor which has led to a significant and continuous increase in road traffic. This increase has resulted in the expansion of towns and cities (urban development) and connections (large transport infrastructures), as well as a longer exposure time-frame (shorter nocturnal periods). Under these conditions, it has been proven that sound levels at building frontages, expressed in Leq, have not decreased in the last thirty years, despite a relatively limited reduction in black-spot areas in periurban districts. An increase in “grey spots” is also apparent, due in particular to the increase of traffic geographically through time. Besides these aspects, one of the main objectives has been to maintain calm areas.

Moreover, people’s sensitivi ty to the environment is becoming increasingly apparent day by day, thus noise annoyance due to road traffic is causing growing concern. This article examines the progression of knowledge and thus performance related to noise control devices over the last ten years.

2. THE STAKES IN PLAY

Perception of road transport noise is traditionally analysed on the basis of dose-effect and/or dose-response curves, resulting from measuring the dissatisfaction of frontage residents by carrying out in situ surveys and laboratory studies.

Sound levels are generally expressed in A-weighted equivalent energy levels for a given period of observation. For example: LAeq, 6 am to 10 pm, for land transport.

Levels reached under the severest conditions are from 70 to 78 dB(A), which has consequences not only in terms of comfort, but also on the health of people subjected to these situations: inability to communicate, various physical disorders, difficulties in sleeping, stress, etc. Therefore noise is perceived as a nuisance, often described as an annoying and even the most annoying nuisance, despite the fact that it is not the only explanatory factor.

Consequently, the stakes in play related to public health are unquestionable, though they are difficult to quantify and, as a result, remain unquantified. It should be noted that the most sensitive persons are children, the elderly, persons with flexible working hours and those in hospital.

Lastly, it should also be remembered that the European Union has chosen noise abatement as one of six essential requirements in its area of action.

3. DEVELOPMENTS IN REGULATIONS

Taking account of noise caused by transport is a recent phenomenon. The first French statutory texts appeared in 1978. In fact, it was the "noise" law of December 31st 1992 (Articles 12,13 and 15) together with its enactments in 1995, and later, that made the definition of present requirements possible. Within this short period of twenty years, stipulations based on the Leq indicator have been made considerably more severe, following an initial period at a statistical level of 130. We have progressed from a limit of 70 dB(A) using a single Leq indicator from 8 am to 10 pm to two different Leq indicators, one for daytime with a limit of 60 db(A) and the other for night-time at 55 db(A). These limits can be lowered still further to 57 db(A) and 52 db(A) for environmentally sensitive buildings. This decrease is highly significant when expressed on a logarithmic scale (10 times less energy for 10 dB(A)).

The following points must also be taken into consideration:

- variations of propagation conditions due to the weather, compulsory for distances over 250 m.
- extending statutory measures to the whole network and not just the main road network.
- a commitment to results and therefore to control by the public contracting authority.

This means that new projects must conform to very severe constraints, reinforcing France's performance based approach founded on maximum energy sound levels that must not be exceeded at frontages. These requirements are ensured by on-site acceptance checks at the end of the works, carried out according to a well-known and recognised procedure (NFS-31085).

This "noise" law also gives details on how black-spots should be eradicated (project initiated in 1982), a situation that has never been dealt with satisfactorily. It should be noted that the "noise" report (C. Lamure – 1998) stresses the importance of making up for this shortcoming for both road and rail transport.

Another innovation in the direction of sustainable environment consists of reformulating impact assessments, giving emphasis to the idea of a sound observatory, i.e. controlling the acoustic situation within five to ten years. This is an important new concept that makes the durability of the acoustic environment for frontage residents a contractual obligation.

Although we are entitled to be satisfied with the progression of the way road-traffic noise is taken into account by French public authorities, Europe has nonetheless played the role of precursor on several levels. Firstly, by instituting an initial law in 1970 on the intrinsic noise produced by road vehicles (engines, exhaust, etc.). This law limited sound levels produced on acceleration by reducing light and heavy vehicle noise to 82 dB(A) and 91 dB(A) respectively. These restrictions were then toughened to attain 74 and 80 dB(A) in 1995. They have permitted the reduction of engine noise by 8 dB(A) for light vehicles and 11 dB(A) for heavy vehicles, a considerable gain in terms of energy (85%). Along the same lines, the "tyre" directive published in 2001 is the first step in regulations that will undoubtedly become more stringent as time goes by. Besides these aspects, the third part of the "road-traffic noise" system (vehicles, tyres, road surfaces), which concerns regulating the acoustic characteristics of road surfaces (rolling noise), seems to have come up against certain problems, in particular related to measurement procedures.

However, the essential development in the European Union is set out in the recent European directive (July 2002) concerning the' exposure of frontage residents to traffic noise. This ambitious directive provides for the supply of objective information on noise exposure for inhabitants of large cities of over 250,000 people. The L_{DEN} indicator was chosen to produce noise maps, which will be obligatory by 2008. It is still an energy indicator that "adds up" and weights" Leq levels for three periods: day-time, evening and night-time. A night-time indicator has also been chosen for sanctioning certain specific night-time situations.

Thus it can be seen that restrictions implemented to protect frontage residents from traffic noise over the past few years, mainly concerning energy, have been reinforced and extended. Have improvements in knowledge been sufficient to adapt the effectiveness of protective measures in order to satisfy these restrictions?

4. MEANS OF PROTECTION

Actions at source – rolling noise

The European statutory requirements mentioned above have forced the automobile industry to deal very seriously with intrinsic sources of vehicle noise (engines, exhaust, etc.) Considerable efforts have been made and they have generated improvements, though they are inadequately taken into account in the ISO-R362 measurement standard, now being updated. Indeed, under normal running conditions, light vehicle noise may be well below statutory limits.

As a result, noise originating from the contact between tyres and road surface has become the dominant factor for relatively low speeds and above (Speed>50 km/h). Two physical phenomena can be identified: tyre vibration and air resonance (these mechanisms can also be antagonistic). It is now clear that the type of wearing course is the main factor in terms of effect and that this is where margins for progression in understanding are greatest. Discovered "by accident" in 1986, during comparative tests carried out in the context of Franco-German cooperation at Wantzenau, the acoustic properties of self-draining bituminous concrete triggered exceptional national research efforts that brought together researchers, industry and operators from public and private sectors.

The results of measures of traffic in transit (Franco-German method that became standard NFS-31-119) have permitted building a database on different types of road surfacing. Analysis of the database has identified self-draining surfaces as being the least noisy, with a reduction of about 5 dB(A) for an isolated vehicle. Over the past ten years, the reduction in rolling noise by absorption due to effective porosity has been tackled by two different approaches. The practical approach, based on experimental works, has led to the development of high-porosity materials, 25% and over, that meet basic road safety requirements. Absorption modelling makes it possible to explain the performances obtained (INRETS), the main parameters being thickness, particle size and communicating void content.

The results up to now are convincing and mention is made here of the most important. The know-how of companies in laying thick (4 to 8 cm) self-draining surfacing, with a high porosity ratio and low particle size (0/8, 0/6), endowed with better acoustic properties than in traditional sealed-porosity materials. These types of surfacing perform well in a heavy-traffic, high-speed context. However, certain disadvantages have been observed such as clogging, which inevitably leads to a drop in performance through time, together with the need for special treatment to make the roads practicable under winter conditions. Very fine layers (BBTM) and even ultra-fine layers (BBUM) have recently been developed for use in urban applications. These layers are less porous and therefore less sensitive to the disadvantages mentioned above. Even so, their acoustic performance is still interesting.

Numerous research projects are under way at present in both France and throughout Europe with the aim of predicting road surface acoustic levels both quantitatively and accurately. These projects concern perfecting models for improving the way the texture and flexibility of road surfaces (impedance) and the generation/absorption interaction in acoustic dispersion (particularly the dihedral effect) are taken into account. These objectives should be attained within the next few years. Similarly, the need for a continuous system for measuring road surface acoustic properties has been recognised by all the participants, in order to evaluate the acoustic quality and homogeneity of the wearing course. Uncertainty concerning results related to this procedure, now in the process of standardisation, must be compatible with the interests at stake.

In the field of tyres, "priority" functions, such as durability, road grip and cost conflict with noise reduction. The need for compromise therefore limits strictly acoustic possibilities despite the substantial efforts made by manufacturers.

Noise screens

Noise screens entail the installation of an obstacle to prevent traffic noise propagation in a context of severe constraints, i.e. a reasonable height for the screens in question, together with their length and integration in urban areas.

The main advantage of this type of noise reduction system, used in France for over twenty years, is in its lasting efficiency in the region of 8 dB(A) for a correctly sized and positioned screen.

Methods used for calculating the dimensions of an ad hoc noise screen for a given site, the infrastructure, natural ground and buildings to be protected, have derived considerable benefit from the potential offered by microcomputers. As a result, the use of the nomograms in the Noise Guide (1980), which remains the reference, has practically been abandoned to the benefit of the much more accurate “ray tracing” technique. These automated methods permit the comparison of numerous varieties of screen and therefore optimise protection levels.

Moreover, over the last few years, the importance of the visual aspect of this type of installation has been emphasised vis-à-vis its acoustic impact on frontage residents and thus of its perceived efficiency.

The products and systems proposed by the profession have progressed considerably. Absorbent barriers have become by far the most common over the last ten years,. The variety of products, that are sometimes used in combination, and the different shapes used for the works, which are very new in France in comparison with neighbouring countries, enable integrating architectural and acoustic efficiency.

Screen wall crowns have recently made their appearance in France with the aim of reducing wall heights while keeping the same levels of acoustic efficiency. This line of research seems promising and is the subject of active investigation (CSTB).

Parallel to the marked progression of acoustic barriers in France, a European regulation is being prepared (TC 226/WG6) that will certify the quality of material used in these works (in laboratories and on-site) This orientation towards validating resources upstream rather than checking performance downstream – which is usual practice in France - must be assimilated by professionals in France.

Insulating building frontages

This is the “final, though most efficient solution” in terms of acoustic efficiency (35 to 45 dB(A)). This type of protection involves closing all windows and therefore creates the need for air-conditioning, not always accepted by the building’s inhabitants. Whatever the case, to be efficient air inlets need to be installed in the shell of the building exposed. These air inlets are often the weak link, since this type of system is subject to contradictions between aeraulic and acoustic requirements. Systems currently available for high-performance situations (> 38 dB(A)) are few, since thermal constraints have always been dealt with in priority in the past. However, progress is expected in this field, despite market difficulties.

Preliminary calculation methods have existed for many years, but the procedure for checking insulation on a frontage (NFS 31-059) is not easy and, unfortunately, has not often been subjected to verification.

Mixed solutions

It is clear emphasis must be given to ”at-source” solutions, in particular by combining low-noise road surfacing and noise screens. However, their overall efficiency is not linear and the advantages provided by road surfacing are slightly reduced under these conditions.

The solution of screen plus acoustic insulation on the upper floors of frontages is often used for high buildings (4 storeys), when the limits of the screen’s efficiency due to diffraction phenomenon have been reached. In this case, the building’s immediate surroundings are protected.

5. PERSPECTIVES

Effective taking into account of traffic noise is a new phenomenon ("Noise" law of 1992). Consequently, the means of protection used and the control of their performances are relatively recent. Moreover, contributions made by research are disparate due to the difficulties encountered.

At present, significant research is being carried out in France and Europe on low-noise road surfacing, although the results anticipated are not emerging as rapidly as industry and operators would like. Despite this, significant results should emerge in the next few years in both modelling and practical approaches (measuring).

The possibilities anticipated by installing crowns on the top of screen walls should permit the optimisation of these systems by using an approach that combines acoustic efficiency with visual integration.

A paradoxical situation has arisen in a context of constantly increasing road traffic, that is to say that on the one hand there is a commitment to results with respect to forever more severe constraints, while on the other, there does not appear to be any lasting means of protection at source. At present, noise screens represent the only really efficient means of protection, though they are accepted less and less by frontage residents.

Therefore, the challenge of carrying out research into rolling noise appears essential, with the aim of achieving sustainable development.

Lastly, we must bear in mind the enormous merit of statutory requirements for acoustics, as in other areas of the environment, which spur scientific progress and lead to implementing the results of research. Mention should also be made of the importance of educating the public.