

Noise Reduction by Urban Traffic Management

Victor Desarnaulds^a, Gilbert Monay^a and António Carvalho^b

^a Bureau ing. G. Monay, 25, av. Vinet, CH-1004 Lausanne, Switzerland, desarnaulds@monay.ch

^b Univ. Porto, Fac. Engineering, Acoustics Lab., P-4200-465 Porto, Portugal, carvalho@fe.up.pt

Abstract

This paper reviews the main studies on traffic management and analyzes the numeric noise results of several current options. It was found that between speed cushions or humps the noise reduction is about 1 to 2 dB(A) but there is an increase of 2 to 3 dB(A) (depending on vehicle and hump types) and annoyance (harsh deceleration and acceleration) near the humps. Speed reduction induced by diminution of road width can lead to a noise reduction of 1 to 3 dB(A) especially if it is combined with other traffic management measures. Road noise models usually introduce a penalty up to 3 dB(A) near intersections. The introduction of traffic lights coordination or roundabouts can locally reduce the noise from 1 to 2 dB(A) (free flowing according to interrupted traffic). Speed limitation (from 50 to 30 km/h) induces a noise reduction of 2 to 4 dB(A) for passenger cars and 0 to 2 dB(A) for heavy vehicles (and 2 dBA more for the maximum noise level). Other measures investigated are the selective limitation of the traffic and the low noise driving.

1. Introduction

Traffic management is one of the main tools to reduce noise in cities and should be optimally used. This report presents a synthesis of the principal quantitative results after a bibliographical review of studies relating to the noise effects of traffic management devices: speed reducers (humps, speed cushions, etc); zones of reduced speed (30 km/h zones), road narrowing and crossroads (with roundabouts or traffic lights).

2. Road speed reducers

Many studies were done by the Transport Research Laboratory (TRL, UK) on speed reducers. A study on humps (also named *sleeping policemen* or *speed bumps*) with a height of 75 to 100 mm, shows that the speed reduction depends on the initial speed and on the spacing between the humps [1]. The speed cushions (a form of road hump occupying part of the traffic lane in which is installed) can involve a great reduction of traffic noise (especially for cars) [2]. A spacing of 50 m between speed cushions (for a speed

of 30 km/h) minimizes the difference in speed on and between cushions.

A report on the towns of Slough and York [3] shows that the effectiveness of speed cushions depends on the reduction in speed on and between humps (the slope between the reduction of noise level and the difference in speeds between the cushions, from 2 to 12 km/h, is 0.45 dBA/km/h). The noise reduction is about 8.5 dB for light vehicles and 3.9 dB on daily traffic (expressed in $L_{A10,18h}$). The variations of the maximum noise level by vehicle depend on the type of speed reducer, the speed and the type of vehicle. For cars the reduction is from 6.6 to 8.7 dB(A) for speed cushions and about 10 dB(A) for humps. For buses, the reduction is negligible for speed cushions and approximately 4 dB(A) for humps. For commercial vehicles, the speed cushions involve an increase of 2 to 7 dB(A) and the humps an increase of 6 dB(A) (round top) or a reduction of 2 dB(A) (flat top). For the total traffic, they induce a reduction of the noise level of 5 dB(A) (cushions) to 7 dB(A) (humps) where the traffic consists only of cars. The wide cushions or the humps do not have an effect for a rate of 1% of buses and commercial vehicles and they increase by 6 dB(A) the noise for 1% of buses and 10% of commercial vehicles. In presence of heavy vehicles, narrow cushions or round top humps are preferable (no noise increase and even a 3 to 5 dB(A) decrease with 1% commercial).

Bendtsen, in Denmark, [4] shows that humps lower the noise thanks to the speed reduction they induce. There is a slight increase in the noise before and after the speed reducers due to braking followed by acceleration of the vehicles. The analysis of noise measurements showed that: the speed reducers induce a deceleration from 5 to 14 km/h; between humps the noise reduction is about 1 dB(A); at the level of the humps there is a reduction from 2 to 4 dB(A); for low speed streets (30 to 40 km/h) at 10 m of the speed reducer the noise level is 2 to 4 dB(A) higher compared to that measured at the level of the hump.

An EPFL study [5] shows, with regard to speed cushions, if two pieces are set on the same axis, the speed reduction imply, in current section, a very light reduction in noise (about 1 dBA). Near the speed cushion the effects of braking and acceleration cause

an increase in the noise level (maximum +2 dBA). This increase is definitely more appreciable in the vicinity of isolated speed cushions (from 3 to 4 dBA). The short speed cushions influence only imperceptibly the noise levels. On the other hand, noise measurements reveal phenomena of noise shocks of rolling on the paving stones and vehicles' vibration, representing increases in noise locally between 2 and 6 dB(A) (and up to 10 dBA with heavy lorries).

3. Road narrowing

A TRL report on horizontal deflections [6] specifies the installation conditions to optimize their effects.

According to the experiments in Geneva [7] a road narrowing can lead to decrease in noise up to 2 dB(A). The setting of suitably dimensioned works (central blocks, traffic islands, parking bays, cycle tracks, etc.), reservation of a way for public transport for each direction of circulation, the reduction of the number of ways for individual traffic, the creation of parking bays and the increased distance from the centre of traffic to the facades, allowed a reduction of 2 dB(A).

The refitting of cycle tracks allows a lowering of the noise from 1 to 3 dB(A) [8]. The development of cycle tracks constitute one of the most spectacular measures of the plan against noise of Hennigsdorf (Germany) [9].

In France, a study [10] showed that a policy of promoting the bicycle and walk in detriment of the car could lower the urban noise by 2.2 dB(A) thanks to the deceleration of the traffic related to the moderating effect of the many cyclists.

4. Crossroads

4.1 Street noise models

The effect of crossroads on noise appears through the analysis of the various models of road noise adapted to the urban environment [10].

In Switzerland the noise model for street traffic [11] does not propose a particular correction for signal-controlled junctions (treated like outlets). The OFEFP simplified model [12] distinguishes various types of crossroads. A supplement from 2 to 3 dB(A) is allotted to the noise level average of the two adjacent segments taking into account the transverse traffic. The improvement of the traffic fluidity (for example by roundabouts) can reduce noise from 2 to 4 dB(A).

EMPA model STL86 gives a 0 to 3 dB penalty near signal-controlled junctions according to distance [13].

The Austrian standard ÖNORM S5021:1976 recommends a penalty of 7 dB for crossroads with traffic lights.

4.2 Signal-controlled junctions

A Japanese report [15] studied the effect on the noise of the installation of traffic lights according to various traffic conditions. The noise level close to a signal-controlled junction was higher 2.4 dB(A) on average than a continuous equivalent traffic.

A study in Beirut [16] analyzes noise reductions in congested crossroads by the installation of physical separations between the ways (reduction from 1.5 to 3.5 dBA) by the separation and the reduction of the traffic (reduction from 0.1 to 1.3 dBA) and by the change of type of road surface (reduction from 2.3 to 3.3 dBA).

Measurements in Geneva [7] show that the active adaptation of traffic lights according to vehicles speed (favouring the vehicles rolling near the speed limit) had a profit up to 2 dB(A). The optimization of the traffic fluidity by traffic lights control can gain up to 2 dB(A) [17].

According to Hofmann [18], the modification of a crossroads (establishment of a crossroads or light signals) can modify the noise emissions. The passage from a fluid to a pulsated traffic mode (stop-go-stop) increases noise by about 2 dB(A). However, a judiciously installed traffic light decreases noise up to 2 dB(A).

4.3 Roundabouts

According to an American study [17], the roundabouts (traffic circles) decrease noise problems compared to signal-controlled junctions. Compared to a continuous traffic (without intersection) the acceleration of the vehicles at the exit of roundabouts has a noise increase of 1 to 2 dB(A).

According to Stalder [19], the transformation of an intersection regulated by traffic lights or stops into roundabout makes possible a reduction of 1 dB(A).

In Geneva [7], the installation of roundabouts had a notable effect of traffic moderation outside the city with a reduction from 1 to 2 dB(A). However, the noise reduction of cars which approach the roundabout slowing down (-5 to -10 dBA) is compensated by the noise increase of those that accelerate by leaving it (+3 to +8 dBA).

According to a Swedish study in Katrineholm [20], the increase of the intersection height reduces the traffic of heavy lorries by half and lowers the speed at the level of the crossroad by 20 km/h (in a 100 m zone) and the mean noise level by 2 dB(A). However, the maximum level increases by 2 dB(A) due to the heavy vehicles noise when passing the humps.

5. Zones with reduced speeds

A Swedish study analyzed the effect of speed reductions to 30 km/h in towns [21] and shows that

they lower the noise level. This reduction depends on the type of driving behaviour after the introduction of the speed restraint measures. The change from 50 to 30 km/h involves reductions from 2 to 4 dB(A) for cars and 0 to 2 dB(A) for heavy vehicles. The maximum level is lowered by an additional 2 dB(A).

According to a German study [14], the introduction of 30 km/h zones into residential streets allows a reduction up to 3 dB(A). In Baden-Württemberg [22], the introduction of these zones on the whole of a city allows reductions up to 2 dB(A). Another German study [23] concluded that the change from 50 to 30 km/h lowers 5 dB(A) the maximum level and 3 dB(A) the equivalent level.

In Graz [24], the reduction in speed limit decreases noise from 0.9 to 1.9 dB(A) on the equivalent level and 0.9 to 2.5 dB(A) on the maximum level.

The OFEFP road noise simplified model [12] gives a noise attenuation of 0.5 dB(A) per step of 5 km/h, that is, 2 dB(A) for the change from 50 to 30 km/h (similar value was found by Stalder [19]).

Bonanomi [25] states that a 30 km/h limit compared to 50 km/h has a reduction from 5 to 6 dB(A) of the peak noise level (at 7.5 m) and from 3 to 4 dB(A) of the noise mean equivalent level.

6. Other measures of traffic moderation

6.1 Selective limitation of the traffic

In Austria [26], the following selective limitations are encouraged to decrease noise: change of a bidirectional street to one-way involving a traffic easier to manage and more homogeneous; traffic moderation (one-way, speed limitation with monitoring, road narrowing, shift of the axis, partial paving, humps, etc.) can discourage the motorists and reduce the traffic; temporary prohibition of traffic (night); partial prohibition of traffic (trucks).

In several German cities, prohibition to circulate at night in certain streets leads to a reduction in noise annoyance [13]. In Baden-Württemberg' rules [22] the introduction of such limit allows a decrease up to 6 dB(A). In Hong-Kong [27] and Geneva [7] night prohibition for certain types of vehicles on some roads made possible a reduction up to 2 and 5 dB(A) respectively. Studies in Italy and France showed a reduction by 3 to 8 dB(A) by the closing of traffic in certain streets [28].

In London the introduction of an urban toll as well as the restriction of the car parking zones also aim at limiting the harmful effects (especially at night) related to noise [29].

Svensson reviewed the consequences on noise of traffic restrictions downtown [30].

6.2 Driving modes

Any action producing a positive effect on traffic fluidity will induce a positive impact on noise [34].

A Swedish study calculated the effect of the various driving modes (regular and aggressive) according to 30 or 50 km/h speed limits [21].

A German study [14] shows that about 39% of the drivers carry out a noisy speedy departure ("burning tires") with an increase of about 5 dB(A).

The speed regularization can be an indirect effect of the speed limits. On the zones with 30 km/h [31], accelerations and decelerations are less frequent and less abrupt. At the same time as speed, also the noise decreases.

Eco-drive training scheme encourages for low noise driving style [32].

Zurich Noise Strategy [33] mentions that it is necessary to regularize speed and avoid the "stop and go" effects.

Nelson [17] summarized studies on the analysis of the effect on the noise of various traffic types.

7. Conclusions

From the analysis of the noise effect of road humps one can conclude that:

- Between speed reducers the noise reduction can be 1 to 2 dB(A);
- At the level of the hump one can have a reduction or an increase in noise from 2 to 3 dB(A) following the situations;
- To limit noise one can not isolate the humps (optimal distance of 50 m) and should clearly mark their presence (to avoid abrupt braking and accelerations);
- Persons near the humps are usually more annoyed due to the strong variation in noise level due to braking and acceleration.

On road narrowing measures one can conclude that:

- These devices can limit noise up to 2 dBA;
- The judicious refitting of cycle tracks lowers noise 1 to 3 dB(A).

About crossroads one can conclude that:

- The road noise models introduce a 0 to 3 dB penalty proportional to the distance from the crossroads to take account of an increase in noise related to the pulsated traffic (related to brutal accelerations);
- The time coordination of traffic lights can increase traffic regularity and lower the noise level;
- The roundabouts (if correctly designed) can reduce noise locally (from 50 to 100 m) from 1 to 2 dB(A) compared to a pulsated traffic.

On the zones with reduced speed reduction, the change from 50 to 30 km/h reduces from 2 to 4 dB(A) for cars

and 0 to 2 dB(A) for heavy vehicles and the maximum level is lowered by an additional 2 dB(A).

Other positive measures are the selective limitation of traffic (especially heavy vehicles) and low noise driving to avoid stop-and-go and high motor speed practices.

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