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CAN NOISE GENERATION FROM ROAD TRANSPORT BE ABATED BY DESIGN AND PLANNING ?

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INTRODUCTION

A great public awareness of the traffic noise problem has resulted in greater efforts to decrease its effects in recent years (1). This is reflected in the current imposition of motor vehicle noise emission standards and noise exposure regulations at national and international level. While there is slow development in minimising vehicle noise at source, road and building designers and planners can no longer carry out their work according to economic and traditional geometric elements alone. They must also consider such environmental factors as noise. It is necessary to minimise the extent of the noise problems, and also to develop standards of planning and design objectives, especially in built-up contexts, where knowledge is particularly incomplete.

This paper deals with the evaluation of the most appropriate means of traffic noise control in urban and suburban areas, and reports the noise prediction models developed by the author for various urban and suburban purposes. Fig 1 shows the typical elements of noise control.

SOURCES OF TRAFFIC NOISE

The principal sources of traffic noise in built-up situations are those due to many vehicles, consisting of a combination of individual noise generators and travelling at changeable speeds and in varying conditions through various road configurations surrounded by buildings. Such noise is also associated with interruptions in traffic flow caused by various types of junctions. In general, the origins of motor vehicle noise fall into two distinct categories, firstly, power system noise which relates to engine speed, and secondly, coasting noise which relates to road speed. The noise from the power system is mainly generated by the fan and engine. Coasting noise originates mainly from tyre-road contact and wind. The relative importance of these various noise generators depends on the maximum produced dB(A) noise level. Thus the noise of major sources must be reduced to minimise the total vehicle noise.

It is twenty-five years since the well known studies, such as that in Britain (2,3), were carried out to examine the problems of road vehicle noise, and a remarkable number of recommendations were issued to limit the maximum emitted noise level (4). But the results of this development can be summarised in three points. Firstly, there has been a 4dB(A) reduction of goods vehicle noise levels in accordance with European regulations, from 92 to 88 dB(A). Secondly, the hope for lorries with maximum noise levels of 80 dB(A) is still a projection for the next decade (5). Thirdly, there is no feasible alternative (e.g. electric vehicles) to vehicles with internal combustion engines. The main reason is that the possibility of attenuation of motor vehicle noise at source is dependent on a number of complex situations. These include:

1. The available technology.
2. International agreement.
3. Vehicle markets and user demands.
4. Problems of vehicles already in use.
5. The accompanying increase in cost of new quiet vehicles.
6. Competition between motor companies.
7. Economic status of motor industry.
8. Development in current motor vehicle plants.
9. Time needed.
10. Identification of acceptable noise levels.
11. Price and availability of oil.
12. Difference in measurement methods for acceptable vehicle noise limits.

Taking into account the slow progress in this area during the years and considering the above situations, it is doubtful that any radical change will be fully perceived before the year 2000. The alternative, therefore, is to work during the design and planning procedures on traffic noise-reducing features, through the path and receiver, to reduce noise exposure and noise annoyance.

DESIGN AND PLANNING

The future of road transport is beyond doubt; in spite of the resulting deterioration of the environment. Great efforts, therefore, must be made in order to estimate how the better use of motor vehicles can be achieved and how the traffic noise problem can be overcome.
The increasing public awareness of the drawbacks of vehicular traffic and the enforcement of noise exposure regulations has put pressure on city engineers and planners to consider noise with the traditional parameters in their plans, in order to be able to evaluate existing and future environmental changes. In other words they have to prevent noise from being transmitted from source to receiver (i.e. people). So the design procedures of roads and buildings, and planning for separation of noise generation and noise-sensitive developments are effective measures which should be employed to a greater extent for decreasing the negative influences of road traffic noise in urban and suburban areas. The following points illustrate the advantages of considering noise at the planning and design stages.

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1. People in their daily life are subject to traffic noise emitted by streams of vehicles, rather than by specific individual vehicles.

2. Traffic noise levels are dependent on those features found in built-up areas. Thus, it is best to modify the features which contribute to the high level of noise.

3. Recent government regulations (6) allow compensation to be paid in terms of either a cash grant or insulation to appropriate members of the public who are exposed to road traffic noise above specific levels.

4. Existing vehicle noise limits are subject to available technology and other factors, while the acceptable traffic noise limits must be determined (usually by combined physical and social surveys) according to the adverse effects that noise produces in everyday routine operations.

Planners and designers, therefore, cannot wait an indefinite period for the inception of quiet transport, and the appropriate method to hand is to modify the features which are responsible for the propagation of the noise and also to isolate the receiver.

TRAFFIC NOISE ABATEMENT

It is practical to protect the environment (people in and around buildings) from the unwanted traffic noise in urban and suburban areas by means of the following:

1. Transportation Planning: At this stage there are three distinct levels at which noise evaluation needs to be considered. Firstly, long-term planning which usually looks ahead some 15 years. Secondly, road network position. At this stage a more detailed evaluation of the best alternative is required. Thirdly, network design. At the first two levels the scheme and its suitable position have been identified. At this third level detailed design and specifications of each road section are required. Simple and reliable noise prediction methods are needed for the first two stages, while the final stage demands a comprehensive tool.

2. Road Building: The benefit of new road schemes usually results from the movement of traffic in a more convenient way, e.g. lorries which had no alternative but to run on specific roads, causing noise annoyance, can operate in other directions.

3. Traffic Management: This is also a powerful means of attaining a better environment, e.g. by the separation of networks with light from those with heavy traffic.

4. Urban Planning: This is another course of action for a better environment, e.g. separation of industrial and residential areas.

5. Building Structure: This involves location, use, design and insulation of buildings (1). The preliminary evaluation of building location requires a simple prediction tool.
Points 2-5 above require the availability of thorough and reliable noise prediction methods.

PREDICTION METHODS

Prediction methods, therefore, have become more important as tools to be implemented for minimising 'unwanted sound'. Their main advantages are to be found in the saving of time and money, and in avoiding field measurements which require skill and expensive equipment. They give the decision-makers freedom to create the best system in terms of safety and comfort for the public. It is convenient also to have prediction tools which rely on existing transportation engineering methods.

However, existing prediction methods for noise from non-free flowing traffic, which usually operates in built-up areas, showed several limitations (7). This is due to the large number of contributory factors. There is also insufficient knowledge of people response to noise. An attempt has been made by the author to fill some of the gaps by establishing prediction models for various design and planning purposes, based on a wide-ranging programme of physical and social surveys. These surveys covered 3530 thirty-minute noise level measurements at 266 sites, including 23 signalised intersections, 6 roundabouts and 15 priority junctions. The sites also covered 6 categories of land use, 3 types of traffic conditions and 40 dependent and independent variables, in addition to the answers given by a sample of people to a questionnaire. The development models can fall into two families.

1. Simplified Models:
This group includes models in the form of equations (8,9,10). The models relate noise levels, L10, L50, L90 and Leq dB(A) to: traffic speed (V km/h); distance of farside facade (Fm) and nearside facade (Nm); distance of junctions (Jm); traffic composition (C v/h); traffic flow (Q v/h); and percentage of medium and heavy vehicles (P%). They are for urban conditions (v=48km/h) and for urban and suburban conditions (v=10-75 km/h).
Overall Traffic Noise Annoyance Index OTNAI, a scale for assessing the effects of noise, was also established by the author (11,12). It is the average of 19 response scores on a 5-point scale, and represents the essential factors of noise annoyance, e.g. classes of vehicles, junctions, indoor noise, and interference with people's activities. A prediction models were then issued relating OTNAI to L10, L50 and Leq dB(A).

The above models can provide rapid prediction of the anticipated noise exposure based on 'basic variables', and also prediction of noise annoyance. Such evaluation is needed for everyday requirements and early planning and design stages, e.g. the stage of long-term transportation planning. The models are simple, accurate and based on common variables.

2. Detailed Models:
This family includes a comprehensive computer model and graphic computer model (13). The difficulty of covering all the related variables mathematically necessitated the establishment of a new computer model to assess and predict road transport noise and noise annoyance under a variety of urban and suburban conditions. Apart from the 'basic variables', the model also considers the 'descriptive variables', e.g. land use. The model covers almost all the variables of built-up environments. It is designed to assess 2000 sites at each run, but the user may change the 2000 if a larger number is considered. A graphic computer model was also developed to evaluate any scheme by modifying the individual variables. The graphic model estimates 170 probabilities at each run associated with 29 figures. Both models utilised the aforementioned simplified models and proved their validity. They are an appropriate tool for a thorough and detailed policy, e.g. enviromental planning for urban areas.

EXAMPLE

The relationship between estimated noise exposure and annoyance with changes in traffic composition was examined. The investigation was associated with various percentages of medium and heavy vehicles, since these vehicles contribute to the high level of noise.

Two typical roads were selected as an example here and the results are given in Table 1, which shows how variation in the percentage of medium and heavy vehicles affects the level of traffic noise and the estimated OTNAI. It is obvious that tremendous changes are required in the structure of traffic to achieve significant improvements in the overall level of noise and to minimise public reaction. For example, reduction of P from 10% to 5% on an urban main road would result in only a 0.91 dB(A) reduction in noise exposure level, and 0.16 in OTNAI. Even in the cases where P=0, the level of noise still exceeds the official recommended level (e.g. the recommended British level is L_{10} = 68 dB(A)).

The above investigation indicates that people's annoyance will continue even if there are no vehicles which are individually noisy. This means that the traffic noise problem cannot be abated solely by minimising the noise emission of heavy lorries, which are the target of current programmes in many countries. So an effective noise policy in any urban and suburban area would require consideration of the total road traffic noise level and its variables as they operate in real situations, to satisfy public demand. This policy can be executed through the processes of design and land use planning.

Road	Q v/h	P %	Predicted L10 dB(A)	Predicted OTNAI
Urban main Road		0	79.89	3.481
V = 33 Km/h		5	80.81	3.642
J = 78.6m (Traffic light)	2750	10	81.72	3.800
N = 2.3m F = 15.8		20	83.55	4.120
Office area Road		0	78.25	3.190
V=18.99Km/h	1200	5	79.20	3.360
J = 37m (Traffic Light)		10	80.10	3.520
N = 3.3m F = 10.80m		20	81.91	3.830

Table 1 Effect of changes in the percentage of medium and heavy vehicles on the predicted noise level and noise annoyance (Based on L10 urban and surburban conditions model and annoyance model)

SUMMARY

While there is slow progress in minimising vehicle noise at source, it is increasingly important to have adequate methods of traffic noise prediction, so as to abate it by means of design and planning. Neither limiting vehicular traffic nor increasing the distance between buildings and the road network are easily achievable in built-up contexts. Application of the developed noise exposure and noise annoyance models has shown that a comprehensive policy would be the most convenient protection

against traffic noise disturbance. This must include consideration of traffic noise in the processes of transportation planning, road building, traffic management, urban planning and building construction.

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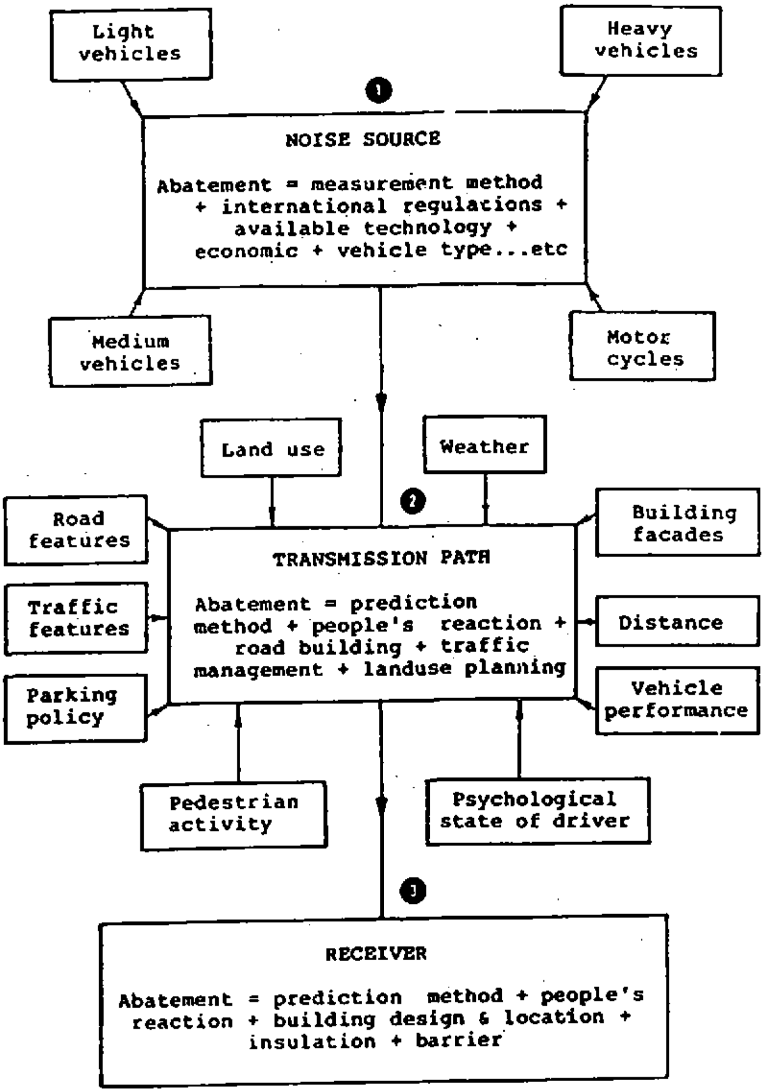

Fig 1 Elements of traffic noise control in built-up areas