Proceedings of the Institute of Acoustics

A STUDY OF RAIL NOISE AFFECTING NEARBY RESIDENCES

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1. ABSTRACT

This paper looks at the various aspects of rail noise which are likely to affect nearby residences. It is based on studies carried out locally as well as overseas, and includes objective measurements carried out at residences near railway lines as well as subjective evaluations based on social surveys.

It also looks at the various factors affecting the annoyance effect of rail noise, the likely sources of noise, methods of reducing the noise as well as the various units currently in use in assessing such noise.

2. INTRODUCTION

The recent UK Government's published intent to encourage rail based transportation at the expense of road transport has prompted fresh interest in this area.

Some recent statistics on rail transportation in this country include 34.4 billion passenger kilometers in 1988, and freight of 150 million tonnes in the same period [1]. It has also been estimated that over 170,000 people live with railway noise exceeding an LAeq (24 hours) of 60 dB, nearly 60,000 to over 65 dB and nearly 18,000 to over 70 dB [2].

There have been relatively few new railways built in this country and a part of this paper is based on studies carried out which originated in the Republic of Singapore. This was carried out during the planning and construction of the rail-based Mass Rapid Transit system there and then continued back in this country.

The Mass Rapid Transit system is a major all-new rail system running partly along some existing roads but also on new ground. The system runs for part of its length on ground level but also on elevated structures elsewhere, as well as underground in the city centre. At some points it passes very close to high rise buildings some of which are residences. This new transportation system supplements the hitherto only rail system in the country, the north-south railway line, linking Singapore with its northern neighbour Malaysia, on which much of the studies and measurements were based.

The study there was part of a comprehensive countrywide study on general community noise [3], road noise [4], and aircraft noise [5]. Studies were also carried out to predict noise from road traffic [6] and from rail [7]. All this followed from the considerable pressure on availability of land there.

Continuing urbanisation in Britain has also put considerable pressure on the availability of land especially around existing urban areas, although the spread of new-build areas have recently slowed somewhat with the current economic climate. However, it is expected that with the proposed higher volume of rail traffic and little improvement to the existing tracks or the engines, noise levels would become significant and in some cases intolerable. Rail traffic increase could also lead to problems of congestion and in some cases lead to increased night-time traffic.

It is timely therefore to look at this issue, the existing rail noise problems as well as likely new problems and at more effective ways to minimise the effect of rail noise especially in its affecting residences nearby. It is also perhaps timely to try to agree on a suitable unit to give adequate description of rail noise annoyance.

3. INSTRUMENTATION AND MEASUREMENTS

The studies were carried out using various equipment as shown in Figures 1 to 3. These were carried out at a total of 37 sites located near railways, of which 2 were schools, a hospital and the rest were residences. These sites were chosen to be as suitable as possible in terms of a reasonably free run, straight and level track, minimum likely intruding noise sources, unobstructed view, free from reflections etc. Noise measurements carried out at various distances were normalised to a mean distance of 25m from the centre of the track. Measurements were carried out over a period of 24 hours. LAeq 24 hr were computed from the hourly Leq values measured.

Tape recordings were also made on analogue tapes and more recently on digital tapes (Figure 4). These were then analysed in the laboratory for frequency content using manual narrow band filtering as well as on a real time frequency analyser. A computer was used which produced output in the various units as well as with graphical output on frequency or on time bases (Figures 5 and 6). The subjective surveys of a sample of 257 residences situated near to the rail tracks were carried out based on a system of house to house personal interviews at the selected sites and the results analysed on a PC computer.

4. RESULTS

Annoyance is a subjective response and this was evaluated from the results of the social surveys carried out. This was correlated with objective measurements of noise levels at the various locations.

It is necessary to use suitable objectively measured units to try to correlate with subjectively derived annoyance responses. There are many noise units currently in use for the objective measurements.

The simplest unit is the 'A' weighted sound pressure level in dB(A) or LA which fluctuates with time. The maximum level (LAmax) measures the 'A' weighted maximum sound pressure level with the sound level meter set at fast response (0.125sec time constant). The statistical Ln units include the traditional units L10, L90 etc and measures the statistical 10% and 90% exceedance levels. The former is often used in road traffic studies [6].

The 'A' weighted equivalent continuous energy sound pressure level unit, LAeq, is now often used in most areas of noise studies mainly because of the rise of simple integrating sound measurement instruments. The duration of the measurement giving the period of integration is specified accordingly eg 24hr. A useful relation between this unit and the LA10,18hr, often used for road traffic studies, is suggested in [8].

Other derivatives of the Leq units are also used. Many noise indices include other factors to take into account eg time of day or the number of occurances, eg Ldn adds 10 dB to all night time occurances (2200 - 0700hrs) before taking the average over 24 hours.

The Composite Noise Rating (CNR) measures not only average noise levels but also takes into account the presence of discrete frequencies, impulsiveness, repetitiveness, background noise, time of day as well as the history of previous exposure. There is some disadvantage due to complexity of some of these units.

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The Noise and Number Index (NNI), which accounts heavily for the number of events occuring, is used mainly for aircraft noise. The Noise Exposure Forecast (NEF) is another rather complex unit used for airport noise predictions [5].

The single event level (SEL) or LAE, is the sound level of a one second burst of steady noise which would have the same sound energy as the whole actual noise event.

Some of the simplest units looked at which were easily obtained on many of the more recent equipment included the hourly LAeq, LA0 and LA95.

Of the units studied, it was found that the 24hr LAeq was one of the simplest and also correlated well with the annoyance surveys carried out. Others have had similar conclusions in the measurement of noise and annoyance units. [2] found that LAeq 24 hr was the most suitable for predicting annoyance and disturbance and [9] found it had the best correlation with annoyance.

The LAeq 24hr is often computed from sampling measurements over various periods, and in this case, of the hourly LAeq. The study gave typical noise levels, normalised to 25m, varying between 55 and 77 dB LAeq 24 hr.

A summary of the results obtained are presented in Table 1.

Noise level LAeq 24 hr	Annoyed	Very annoyed
55 dB	1%	0
60 dB	9%	1%
65 dB	23%	9%
70 dB	49%	21%
75 dB	81%	42%

Table 1. Summary of results

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5. OBSERVATIONS

The problem is basically to move large numbers of people quickly from one point to another efficiently and this study looks at the noise problem associated with this aim.

As a part of the study was carried out in Singapore which is a small country with a high population density, it is noted that many here live in very heavily built up areas. Most residences are high rise apartment blocks of hard concrete construction, situated beside busy roads and highways. Homes as well as schools and hospitals in the hot humid climate have their windows open almost all year round so that noise is a particularly widespread problem. On the other hand, most commercial buildings and offices are fully air conditioned with all their windows closed and often well sealed.

A similar problem exists in this country in summer when open windows and doors let in the noise or when residents are outside in their gardens.

There are different problems encountered in road traffic noise to that causing rail noise. The main noise source in rail-based systems is the interaction between the wheel and rail. A major factor in the noise emitted is the actual rail construction. The use of the continuously welded tracks has reduced rail based noise considerably. Other methods considered include the use of vibration isolation mounts and damping pads, sleeper construction, ballast, mass inertia blocks and rubber tyres.

Acoustic shielding such as barriers and earth mounds, parapet walls, perspex tunnels and walls are also used to reduce the impact of rail noise especially where tracks run near residences.

The engines in rail based systems which are mainly electric or diesel-electric are not significant sources of noise except the older or larger ones or where the track causes them to travel slowly or when stationary.

The noise from maintenance associated with rail based systems is found to be significant.

Adverse ground surface conditions, a sharp bend or steep gradient climb due to topography or over obstacles can cause significant noise increases. This can be made worse by reflections off buildings, increased traffic etc.

The effect of railway noise on people is complex, ranging from annoyance, to interference with conversation, to physiological ill effects encountered. The tolerance to such noise may vary according to the benefits expected from living near the railway line and utility i.e. ease of fast and cheap rail transport. In Singapore in particular, personal car transport is prohibitively costly and is known to be actively discouraged by the Government.

The choice of a suitable noise scale to accurately reflect human response is not at all straightforward. Factors to be considered include time of train operations, day / night effects, duration of passby, frequency of trains etc. These can be exceedingly complex if all are to be accounted for. Although in this study the LAeq 24hr was found to be satisfactory, one of the main attractiveness in its use here must remain its simplicity.

The social surveys were both people as well as time consuming, and great emphasis was placed in not directly revealing only the noise aspects of the survey. This was reflected in the planning and the questionaire which had to be both brief and selective.

6. CONCLUSIONS

The noise caused by rail-based vehicles can be a source of great distress to residents living near to such lines. It is found that the degree of annoyance caused is affected by other factors such as the respondents expected benefit from, as well as intended use of, the rail system.

Although some researchers [10], [11] have found that rail noise in some cases is more annoying than than road traffic noise, this study like some others [9] has found the converse to be the case. However it is clear that the same criteria cannot be applied to both road and rail noise without careful consideration of the individual merits as well as the unit of measurement to be used.

The LAeq 24 hr is found to be both simple to use as well as agreed well with the annoyance studies carried out.

From the studies carried out, despite the ever present pressure for urban development, it is proposed that a facade level of 65 dB LAeq 24hr be a maximum allowable limit for sensitive developments such as residences. Noise attenuation measures should be provided as a matter of course wherever residential developments are to be permitted within this range.

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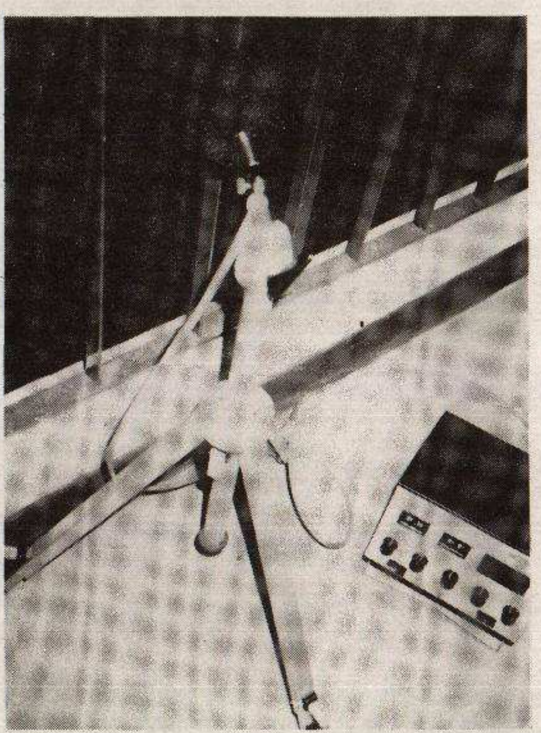

Figure 1. Noise measurement equipment

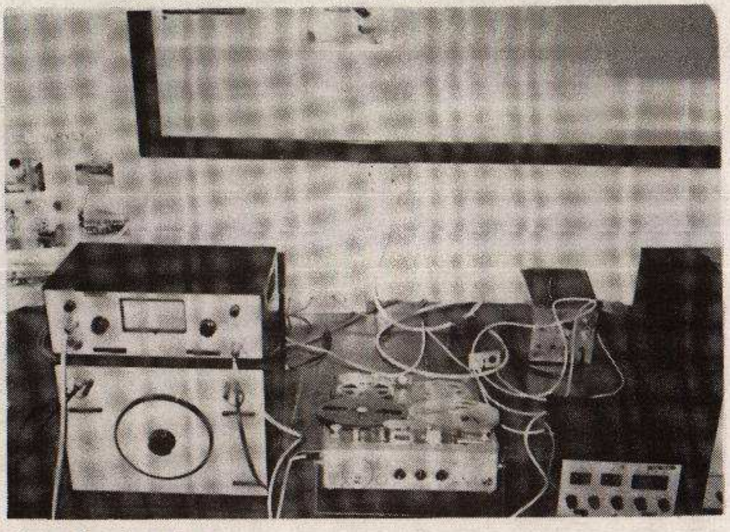

Figure 2. Frequency Analysis

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Figure 3. Dual channel analysis

Figure 4. Digital tape recording

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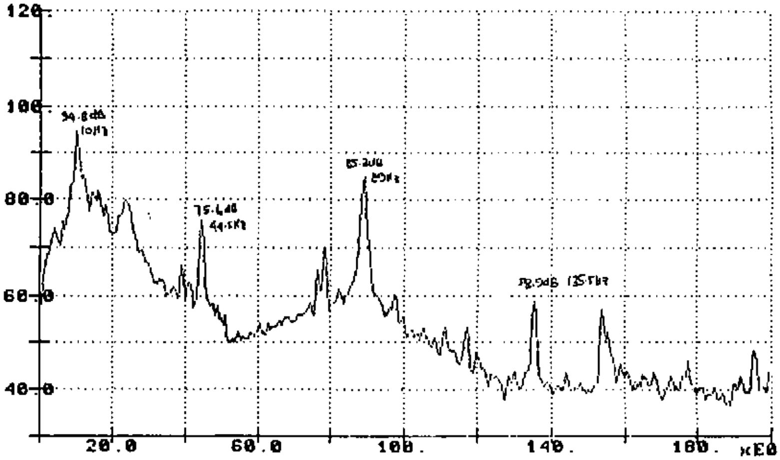

Figure 5. Computer plot of frequency analysis

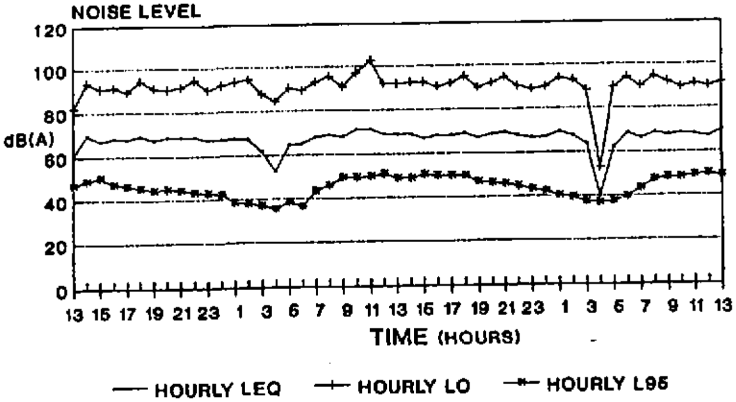

Figure 6. Computer generated 24 hour time plot

7. ACKNOWLEDGEMENT

I would like to acknowledge here the assistance of my many former students at the Sheffield City Polytechnic as well as at the National University of Singapore in obtaining the data for this work.

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