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PREDICTION OF COMMUNITY RESPONSE TO NOISE FROM URBAN LIGHT RAIL SYSTEMS

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Introduction

Since its opening in 1987 the Docklands Light Railway (DLR) in East London has been a source of noise annoyance to numerous residents living close to the track. This is despite the fact that the noise limits specified by the DLR (table 1), which are generally adhered to or only marginally exceeded in certain areas, are well below those generally considered to cause serious complaints. The apparent failure of L_{Aeq} levels to predict accurately community response to this noise has been the subject of previous papers (1,2,3) wherein the applicability of both L_{eq} and dB(A) to this task has been questioned.

The most serious complaints of noise from the DLR arise near the new elevated sections of track where interaction between the trains and the structure generates high levels of low frequency sound. Measurement of this sound in dB(A) therefore significantly underestimates the total amount of sound energy radiated. When the levels in dB(A) are averaged to give an L_{eq} level, the serious nature of the problem is further underestimated.

The House of Lords Select Committee which sat from 21 February to 3 March 1989 to consider the Bill to extend the DLR eastwards from Poplar to Beckton was petitioned on the subject of noise by representatives of residents living close to both the existing and proposed railway. One of the main contentions between the residents and the DLR was the noise level at which sound insulation would be provided to affected dwellings.

Current criteria

The original noise specification for the Docklands Light Railway was based on the Fields and Walker survey (4) of response to the noise of British Rail trains. In addition to this the DLR included in their noise policy tabled to the House of Lords Select Committee a clause offering sound insulation to dwellings where the 24 hour L_{eq} exceeds 70 dB(A) at the facade. This is the level at which British Rail propose to provide sound insulation to residents affected by the Channel tunnel rail link, and is based on the recent paper by Walker (5) which suggests that 70 dB(A) 24 hour L_{eq} is a tolerable level for train noise.

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Existing regulations relating to new road traffic schemes require sound insulation to be installed if noise levels exceed an 18 hour L_{10} of 68 dB(A), which is approximately equivalent to a 24 hour L_{eq} of 65 dB(A). The corresponding criterion proposed by British Rail and the DLR is thus 5 dB(A) above that used to regulate road traffic noise. This reflects the conclusion of the Fields and Walker report (4) that railway noise is less annoying than noise from other forms of transport.

The authors feel that noise from an urban light transit system cannot be equated with noise from British Rail trains. The Fields and Walker survey was based on railways 'with at least 20 passes a day'. In other words, it can be assumed that their survey included places where an average of less that one train an hour passed. However the frequency of trains on a light rail system is likely to be as high as one per minute at peak times. It could therefore be argued that a light rail system is more akin to road traffic than main line railway traffic.

In many towns, as has occurred with the DLR, a new urban light rail system will pass very close to dwellings where previously there has been no railway line. Some of the people included in the Fields and Walker survey had lived next to a railway all their lives, and it was reported that in such cases, as might be expected, there was low annoyance response. As no new British Rail lines have been built in this country since the early years of this century, it must be assumed that others in the survey had moved to their homes in the full knowledge that there was a railway line nearby. Their response is likely to be very different from that of people who have a new railway built a few metres from their homes. Indeed Fields and Walker reported that they found very little adaptation to noise over time.

Character of the noise

In addition to the possible differences in reaction to the noise from light rail trains and main line trains, due to the different service frequency and the proximity of trains to dwellings, the apparent difference in the character of the noise may also be significant.

A survey of noise levels along the DLR (2,3) showed that the noise causing most annoyance to residents is the noise being radiated by the new viaducts, which contains a very significant amount of low frequency sound. Figure 1 shows typical octave band spectra of noise measured near the new elevated structures on the DLR. It can be seen that all these spectra have their peak in the octave band centred on 63 Hz.

In contrast to the noise caused by the new viaducts, noise occurring near at grade ballasted track or where the track passes over older brick viaducts or embankments has a comparatively flat spectrum, as shown in figure 2. The authors know of no complaints of noise near these sections of the railway.

The annoyance caused by, and adverse community reaction to, low frequency noise is being increasingly recognised (6,7,8). The likelihood of underestimating this annoyance by the use of dB(A) has also been discussed (9,10) and attempts have been made over the last few years to develop more suitable criteria for the measurement of sound containing high levels at low frequencies (7,10,11).

The problem of assessing low frequency noise is also addressed in the latest draft of BS4142 (12): 'When the specific noise contains significant low frequency components the procedure for assessing the noise from measurements of the 'A' weighted sound level may not be sufficient to determine the likelihood of complaints'.

Our measurements and observations show that in many places where the original specifications are either complied with, or exceeded by only a few dB(A), considerable distress is being caused to residents near the railway. Table 2 lists the day time, evening, and night time L_{Aeq} levels for various sites near the railway, and compares them with the DLR specification. It can be seen that complaints arise where the evening and night time levels are exceeded by 2 or 3 dB(A).

24 hour L_{Aeq} levels are also given in Table 2 and show that complaints have occurred where the 24 hour L_{eq} is less than 60 dB(A).

L_{Aeq} is increasingly used as a measure of environmental noise, and as a predictor of the likelihood of complaints from new noise sources. Because of the underestimation of low frequency noise by dB(A) and hence by L_{Aeq}, and the annoyance caused by low frequency sound, it would seem necessary when planning new noise sources, to include some criterion which takes account of the low frequency sound content.

Tables 3 and 4 show the average maximum levels of trains measured at all sites on various dates in both dB(A) and dB(C). Both tables are arranged in ascending order of sound level, and also indicate where complaints are known to have occurred.

Although this is by no means a systematic social survey, it strongly indicates that the level in dB(A) is not a totally reliable predictor of likely annoyance. It would however appear from Table 4 that the level in dB(C) is much more indicative of public response to the noise.

These figures indicate that further research is necessary to assess whether or not dB(C) would provide a more suitable criterion than dB(A) for the assessment of situations where low frequency noise is likely to occur.

In view of the high levels of low frequency noise occurring in this case (levels as high as 100 dB in the 63 Hz octave band were recorded) it should perhaps be borne in mind that dB(A) was originally intended only for the measurement of sound up to 55 dB. dB(B) was introduced for sound levels between 55 dB and 85 dB, and dB(C) for sound levels greater than 85 dB.

Examination of the peak levels that are occurring on the DLR therefore reinforce our view that the use of L_{Aeq} alone as a measure of the effect on the community of environmental noise can be misleading. It would appear necessary to also include some measure to account for the presence of low frequency noise.

Conclusions

The extent of complaints to noise on the DLR is in excess of what would be expected from observation of L_{Aeq} levels alone. It can therefore be deduced that L_{Aeq} has not proved to be a reliable indicator of community response in this case. Possible reasons for this are the high levels of low frequency noise which call into question the applicability of dB(A) as the sole predictor of subjective response; the much greater frequency of service on the DLR than on the main rail lines of previous studies; and the proximity of the DLR to dwellings in a densely populated urban area. It would appear that criteria for acceptability which have been developed for main line trains should not be applied in the significantly different situation of urban light transit systems without proving their relevance.

Twelve urban light transit systems are planned for this country. The evidence from community response to the Docklands Light Railway suggests that there is an urgent need to develop appropriate measurement scales and criteria relating to noise from these systems, in order to protect urban commumities nationwide from unacceptable levels of noise. These may involve the specification of maximum levels in dB(A) and/or dB(C) as well as period L_{Aeq} levels, or a completely different sound index may be necessary.

The House of Lords Select Committee on the Docklands Light Railway (Beckton) Bill reported their decision on 15 March 1989. They requested an undertaking from the DLR that their noise policy be amended to provide sound insulation where the 24 hour L_{eq} exceeds 65 dB(A).

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TABLE 1 - DLR NOISE SPECIFICATION

The free field L_{eq} levels should not exceed the following:

Daytime	Evening	Night
(0700-1900)	(1900-2300)	(2300-0700)
60 dB(A)	55 dB(A)	50 dB(A)

TABLE 2 - L_{Aeq} LEVELS AT SITES NEAR THE DLR

Location	Date	L_{Aeq}				Complaints
		Day	Eve	Night	24 hr	
Cable Street	24/11/88	62	60	56	60	Yes
Noble Court	24/11/88	51	50	46	50	
Gill Street	8/9/87	55	54	50	53	No
Undine Road	31/1/89	56	55	50	54	No
Thermopylae Gate	21/5/87	61	59	54	59	Yes
Thermopylae Gate	31/1/89	58	57	53	57	Yes
East Ferry Road	8/9/87	58	57	54	57	Yes
East Ferry Road	31/1/89	58	57	53	57	Yes
Manchester Road	8/9/87	57	56	53	56	Yes
Manchester Road	31/1/89	59	58	53	58	Yes
DLR specification		60	55	50		

TABLE 3 - AVERAGE MAXIMUM LEVELS OF TRAINS IN DB(A)

Location	Date	Max dB(A)	Complaints
Glengall Grove	3/11/87	61.6	Yes
Jamaica House	23/10/87	66.2	Yes
Undine Road	8/9/87	69.5	No
Gill Street	8/9/87	71.3	No
Thermopylae Gate	21/5/87	71.5	Yes
East Ferry Road	9/10/87	72.1	Yes
Manchester Grove	5/10/87	72.1	Yes
Undine Road	31/1/89	72.2	No
Manchester Road	5/10/87	72.8	Yes
Manchester Road	8/9/87	73.1	Yes
Thermopylae Gate	6/11/87	74.2	Yes
Thermopylae Gate	31/1/89	74.5	Yes
East Ferry Road	8/9/87	74.7	Yes
East Ferry Road	31/1/89	75.3	Yes
Newell Street	8/9/87	75.4	No
Manchester Road	31/1/89	75.5	Yes
Noble Court	24/11/88	75.6	
Cable Street	24/11/88	77.4	Yes
Marsh Wall bend	8/9/87	77.6	
Noble Court	14/9/87	78.3	Yes
Marsh Wall bend	24/11/88	85.1	
Cable Street	8/9/87	85.4	Yes

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TABLE 4 - AVERAGE MAXIMUM LEVELS OF TRAINS IN DB(C)

Location	Date	Max dB(C)	Complaints
Undine Road	8/9/87	75.5	No
Gill Street	8/9/87	78.2	No
Newell Street	8/9/87	79.6	No
Undine Road	31/1/89	80.8	No
Glengall Grove	3/11/87	81.8	Yes
Jamaica House	23/10/87	82.2	Yes
Noble Court	24/11/88	82.9	
Manchester Grove	5/10/87	82.9	Yes
Noble Court	14/9/87	85.6	Yes
Cable Street	24/11/88	86.7	Yes
Manchester Road	8/9/87	88.2	Yes
East Ferry Road	8/9/87	89.8	Yes
East Ferry Road	9/10/87	90.3	Yes
Thermopylae Gate	21/5/87	91.6	Yes
Cable Street	8/9/87	92.5	Yes
Thermopylae Gate	31/1/89	93.3	Yes
Thermopylae Gate	6/11/87	93.6	Yes
Marsh Wall bend	8/9/87	94.3	
East Ferry Road	31/1/89	95.2	Yes
Manchester Road	5/10/87	96.3	Yes
Manchester Road	31/1/89	96.8	Yes
Marsh Wall bend	24/11/88	97.1	

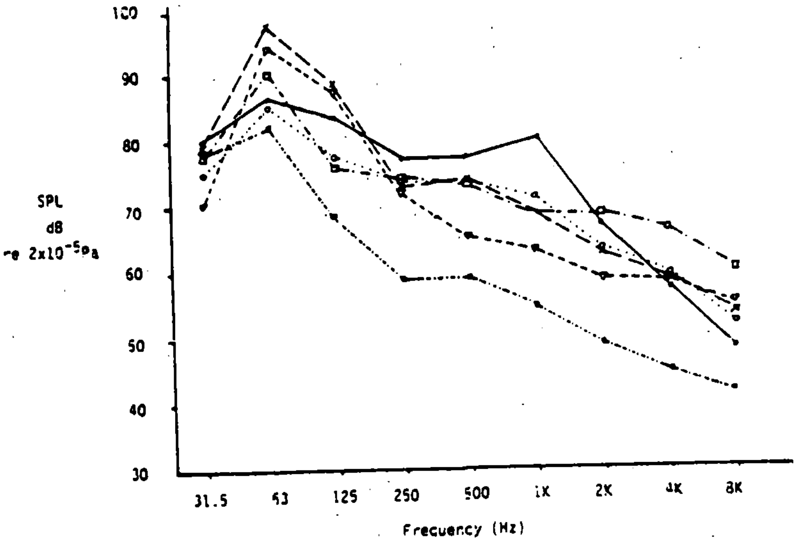

Figure 1. Average noise spectra measured near elevated structures.

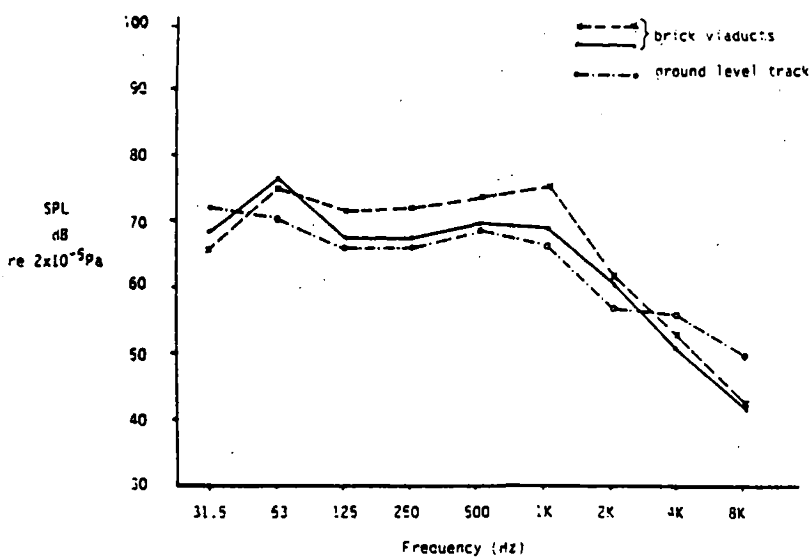

Figure 2. Average noise spectra measured near brick viaducts and ground level track.