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URBAN NOISE MEASUREMENT AND EVALUATION

EFFECTS OF GRADIENT ON TRAFFIC NOISE IN URBAN MAIN ROADS.

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Recordings were made on hilly main roads in Greater London to determine the effects of gradient on L_{10}, L_{50}, and L_{90}, the sound levels in dBA exceeded for 10, 50, and 90 per cent of the time. In each case the microphone was located 1.2 m above ground level and 15 m from the middle of the road, on the side where traffic moved uphill; at this distance one can assume that the sound originates effectively from the centre line of the road. Observations were restricted to single-carriageway roads, having uniform gradients and being subjected to speed limits, and measurements were made well clear of impediments to traffic movement (e.g. parked cars, intersections, pedestrian crossings, etc.). Thus one could generally expect a free flow of vehicles at a mean speed of 45 ± 5 km hr^{-1}. The road surfaces were uniform in character, i.e. made from "stony" asphalt, and recordings were made only when the weather was dry and winds were light. Only sites having fairly open aspects were chosen for the observations.

Determinations of L_{10}, L_{50} and L_{90}, and the rates of flow of both heavy and light vehicles, together with sample speed checks, were made at 18 different locations, each having a uniform gradient within the range from 0.3 to 10.9 per cent. An average of 46 sets of readings were obtained for each of the sites.

Using the following theoretical relationship for L_{10}, applicable to the conditions under which the observations were made and valid when the rate of flow H of heavy vehicles is greater than 50 hr^{-1} and exceeds 4 per cent of the total (1):

$$L_{10} = H/500 - \log_{10}^{-1}(1 - H/270) + K \qquad (1).$$

Here K is a constant, being equal to L_{10}, when H = 325 hr^{-1}. This equation indicates that only the noise from heavy vehicles contributes to L_{10}, under the conditions stated above.

For every observation, K was calculated from equation (1) and the mean and standard deviation obtained for each of the sites. The average standard deviation was $\pm$ 3.0 dBA. Because of uncertainties in the characteristics of individual sites, it was decided to calculate mean values of K (i.e. L_{10} when H = 325 hr^{-1}) for groups of sites, classified according to ranges of gradient, i.e. 0-2, 2-4, 4-6, 6-8, and over 8 per cent. These are shown, together with standard deviations in Fig.1. The standard deviations, which are high compared with those for individual sites, are indicative of the variations in characteristics of traffic flow and in environment.

Because both L_{50} and L_{90} depend on the total rate of flow Q, as well as the rate of flow H of heavy vehicles, a much larger number of observations than those actually obtained from each site is required to establish valid relationships for these variables. However it has been shown possible, for steady flows of traffic at speeds of 45 km hr^{-1}, to relate L_{50} and L_{90} to single parameters R_1 and R_2, respectively, which combine the rates of flow of heavy and light traffic, using the following approximations (2) :

$$L_{50} \doteq 10 \log_{10} R_1 + K_1 \qquad (2)$$

$$L_{90} \doteq 10 \log_{10} R_2 + K_2 \qquad (3)$$

Here $R_1 = Q + H^2/50$, $R_2 = Q + H^2/100$ and K_1 and K_2 are constants.

In each case L_{50} and L_{90} were standardised to the values for which R_1 and R_2, respectively, are equal to 1000 hr^{-1}, using equations (2) and (3), and mean values calculated for the sites and for the groups of sites. Figs. 2 and 3 showing how the standardised values of L_{50} and L_{90}, respectively, vary with ranges of gradient.

It has not been possible to obtain any conclusive evidence of variations of L_{10}, L_{50} or L_{90} with gradient for single-carriageway urban main roads for conditions of steady flow. Difficulties arise from the comparatively large standard deviations for each range of gradient, brought about by differences in the characteristics of the sites. More conclusive results may be obtained by making use of a larger number of locations, but suitable sites are not easy to find and, for further work, it may be necessary to operate in other parts of the country.

However, the histograms indicate a possibility of an increase in sound levels with slope, to a peak of about 5 per cent gradient followed by a decrease. It has been observed that heavy vehicles often change gear at a gradient of about 5 per cent and, for higher gradients, they tend to reduce their speeds. Very steep hills are usually avoided by heavy vehicles.

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References.

1. Blitz, J. Acustica 1973 (awaiting publication).

2. Blitz, J. Proc. Inter-Noise 73, Lyngby, Denmark, 1973, paper E24z10.

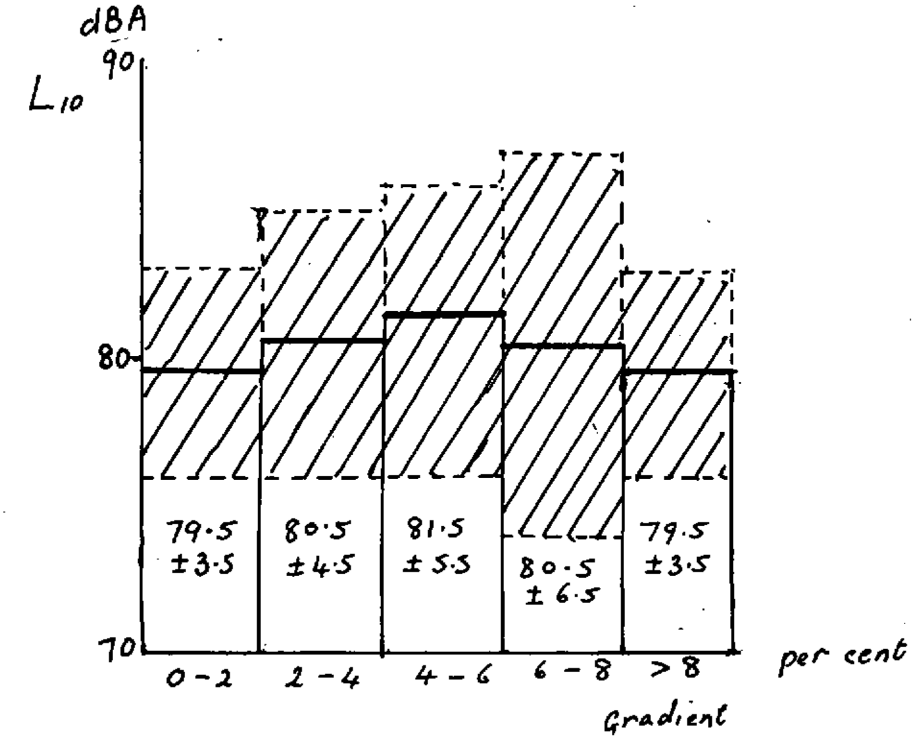

Fig.1. Variation of L_{10} with gradient for a rate of flow of 325 hr^{-1} for heavy vehicles. Figures indicate mean values for each range of gradient.

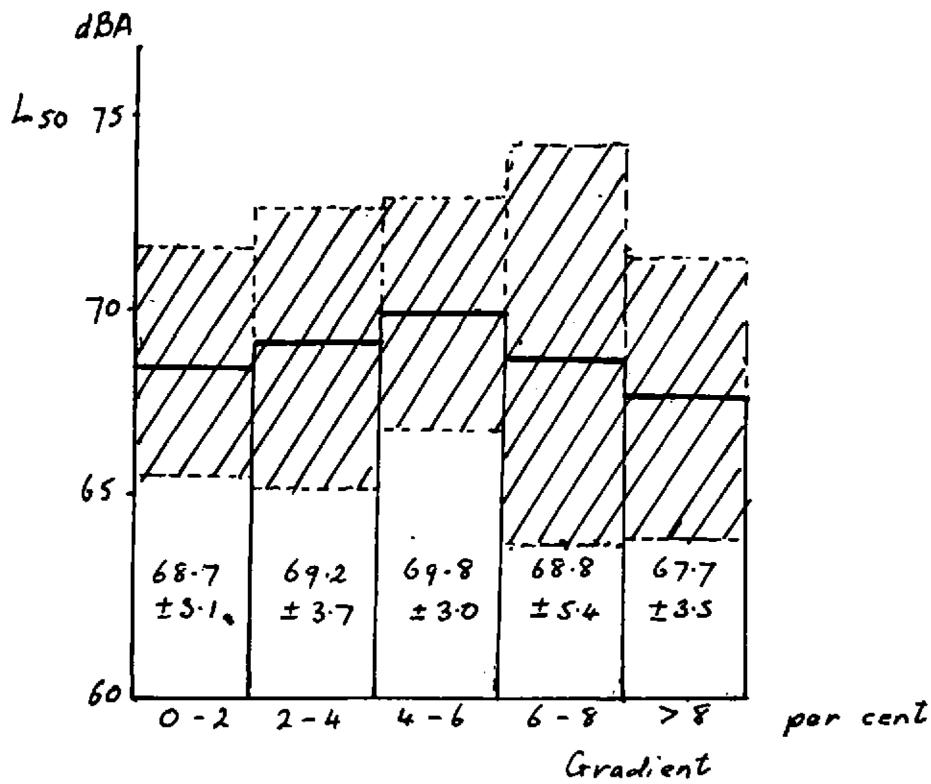

Fig.2. Variation of L_{50} with gradient for R_1 = 1000 hr^{-1}. Figures indicate mean values for each range of gradient.

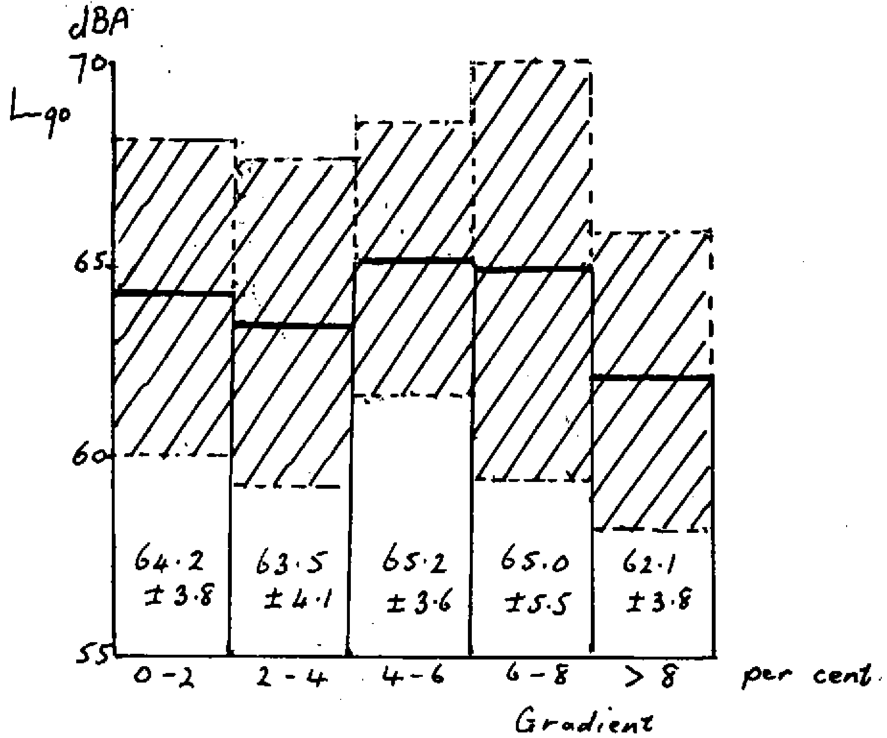

Fig.3. Variation of L_{90} with gradient for $R_2 = 1000\ hr^{-1}$.
Figures include mean values for each range of gradient.