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METHOD OF EVALUATING NOISE FROM CONSTRUCTION SITES

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1. Introduction

Prediction of noise generated from construction or demolition sites enables one to estimate the noise exposure to be expected at a specific location as a result of site operation in circumstances where measurements of the noise may be either unattainable or impossible.

This paper outlines a method of assessing the environmental impact of construction noise upon the community in terms of A-weighted Equivalent Sound Levels (Leq) integrated over a 24-hour period at a specified point.

2. Method of Evaluating Noise Exposure from Construction Sites

A procedure for predicting the A-weighted Leq over 24 hour period at a given receiver position from construction sites is outlined below. A distinction has to be made between stationary and moving sources for this prediction method.

2.1 Stationary Sources

The procedure for estimating the noise exposure from stationary sources is outlined below:

2.1.1 Calculation of Sound Pressure Level at the Receiver Point

(a) From Information on Sound Power Level of the Source

Sound pressure level (SPL) at the receiver position is given by equation

$$L_p(A) = SWL_{(A)} - 20 \log_{10} d - 8 \text{ dB(A)} \qquad (1)$$

where $L_{p(A)}$ = A-weighted SPL at distance d from the centre of the source.
$SWL(A)$ = A-weighted SWL of the source (dB. ref. 10^{-12} watts).
d = Distance from the source to the receiver position (m).

(b) From Information on Sound Pressure Level at a Reference Point

Sound pressure level at the receiver position can also be calculated by using equation (2):

$$L_p(A) = L_p(A)_{ref.} - 20 \log_{10} \left(\frac{d}{d_{ref}}\right) \quad \text{dB(A)} \qquad (2)$$

where $L_{p(A)}$ = A-weighted SPL at a distance d from the centre of the source.
$L_{p(A)ref.}$ = A-weighted SPL at a reference distance $d_{ref.}$
d = Distance from the source to the receiver position (m).
$d_{ref.}$ = Distance from the source to the reference position (m).

It is also important to note that one could substitute the reference sound pressure level ($L_{p(A)ref.}$) with the reference source activity L_{eq} levels, and perform similar calculations, as outlined in this section. The activity L_{eq} level would take account of the variation in plant cycle times and the interactions between various items of plant during the activity.

2.1.2 Adjustments to be made to the calculated sound pressure level

(a) Screening effects of a barrier.

The theory of shielding by long thin barriers is well documented. Empirical relationships of the type shown in equation (3) relating expected attenuation at a given frequency to the difference in length between the direct and over-the-barrier ray paths are also available (1,2).

For $N \geq 0$

$$\text{Barrier attenuation} = 20 \log_{10} \left(\frac{\sqrt{2\pi N}}{\tanh\sqrt{2\pi N}}\right) + 5 \text{ dB} \qquad (3)$$

where N is the Fresnel's number,

$N = \frac{2}{\lambda}$ (Path difference between direct and over-the-barrier ray).

For $-0.3 \leq N < 0$

Barrier attenuation can be obtained from Figure 1. This figure was plotted from results given by Maekawa (Ref.1).

The overall dB(A) barrier attenuation may be found by subtracting the calculated attenuations in each frequency band from the spectrum at the source and then obtaining the difference between the two spectrums on an overall dB(A) scale. Some of the results are shown in Figure 2, which shows expected dB(A) barrier attenuation as a function of path difference for various construction equipment.

(b) Reflection of Sound at a Building Facade

Reflection from building facade typically causes a 2.5 dB(A) increase at a receiver 1 metre from that facade (3). This value has been adopted as a standard in this method.

(c) Atmospheric Absorption.

This effect could be significant over relatively small distances for a source with an appreciably high frequency energy content, such as pile drivers and concrete breakers.

There are several applicable expressions, but the most recent and accurate is that suggested by Sutherland (4).

The overall dB(A) atmospheric absorption may be estimated from the information on the attenuation per unit distance for each frequency band as outlined in section 2.1.2(a).

(d) Other Allowances

When sound travels close to the ground the sound levels may be reduced by ground cover and texture. At present there is no great experience and understanding of the ground attenuation effects to be expected at construction sites and for the purpose of this prediction method this effect has been ignored.

Sound levels may also vary due to wind and temperature gradients or air turbulence effects. These effects are very difficult to predict and also vary greatly from day to day. These factors are also ignored for the purpose of estimation.

2.1.3 Proportion of Day in Use

Determine the proportion of the time that each source is active.

If T = Total time (24 hrs); t = Duration of activity

Then percentage 'on time' (t%) = t/T x 100 %

Correction factor would then be given by:

$C_T = 10 \log_{10} (t\%/100)$ dB

2.1.4 Overall Equivalent Sound Level

The energy received at the receiver position over 24 hour period from each of n sources is

$$L_{eq}(A)_{24hr} = 10 \log_{10} \left(\sum_{i=1}^{i=n} 10^{1/10(\text{adjusted SPL for each of n sources, with all the corrections})} \right)$$

where i represents the ith of n source types. (5)

2.2 Noise Exposure from Moving Sources

The procedure for estimating the noise exposure from moving sources is outlined below.

2.2.1 Estimation of L_{eq} at the Receiver Position

For a motion symmetrical on either side of the receiver, equation (6) is applied to estimate the A-weighted L_{eq} over 24 hour period at receiver position with an extra term to include an excess attenuation correction factor, i.e.

$$L_{eq}(A)_{24hr} = L_{p(A)} + 10 \log_{10} (\alpha dN/v) + \text{Excess attenuation correction} \quad (6)$$

where $L_{eq}(A)_{24hr}$ = A-weighted equivalent sound level measured over 24 hr period
$L_{p(A)}$ = A-weighted peak sound pressure level at distance d.
α = Angle subtended by roadway at the receiver (radians)
d = Perpendicular distance to centre of roadway (m)
N = Number of vehicles passing during 24 hr period
v = Source velocity (m/hr)

If the motion is not symmetrical on either side of the receiver, equation (7) is applied to estimate the A-weighted Leq over 24 hr period at receiver position with an extra term to include an excess attenuation correction factor i.e.

$$L_{eq}(A)_{24hr} = 10 \log_{10} \left(10^{1/10(L_{p(A)} + 10 \log_{10} (\gamma dN/v) + \text{Excess attenuation})} \pm 10^{1/10(L_{p(A)} + 10 \log_{10} (\theta dN/v) + \text{Excess attenuation})}\right) \quad (7)$$

where $L_{eq}(A)_{24hr}$, $L_{p(A)}$, d, N and v are the same parameters as for equation (6)
γ and θ are shown in Figure 3.

The expressions within the logarithmic term of equation (7) are added, i.e. taking + ve sign if

$Y_2 \geq s$ (viz. Motion is between points A and D) and the expressions are subtracted i.e. taking -ve sign if

$Y_1 < s$ (viz. Motion is between points A and B)

Y_1, Y_2 and s are shown in Figure 3.

If A-weighted peak sound pressure level ($L_{p(A)}$) information is available at some other reference distance, then this is to be corrected for a receiver at a perpendicular distance d from the centre line of operation. The procedures outlined in sections 2.1.1(b) and 2.1.2(c) should be applied.

2.2.2 Adjustments to be made for Excess Attenuation

(a) Screening Effects of Barriers

If a source is moving behind a barrier in a straight line and parallel to it, the attenuation of the A-weighted Leq is slightly reduced compared to the stationary source. This is because the path difference is reduced at oblique incidence. A computer program has been developed for a motion symmetrical on either side of the receiver, to estimate such a correction factor as a function of angle $\beta(= \alpha/2$ in degrees) subtended by the source at its furthest point. This is to be subtracted from the values obtained from Figure 2 to obtain the overall A-weighted Leq attenuation by a barrier. One example of the results for several maximum path differences are shown in Figure 4 for 'off highway' dump truck as a source.

(b) Reflection of Sound at a Building Facade

Apply the standard correction of 2.5 dB(A) as outlined in Section 2.2.2(b).

(c) Atmospheric Absorption

For simplicity, the correction outlined in section 2.1.2(c) is applied when the source and the receiver are closest to each other. There is no satisfactory method of including this correction unless a computer program is written to take account of all the source positions along the line.

2.2.3 Proportion of Time in Use

This is already taken care of in equations (6) and (7) by a parameter N.

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2.2.4 Overall Equivalent Sound Level

Use the energy summation principle as outlined in section 2.1.4 if operating parameters vary between groups of sources.

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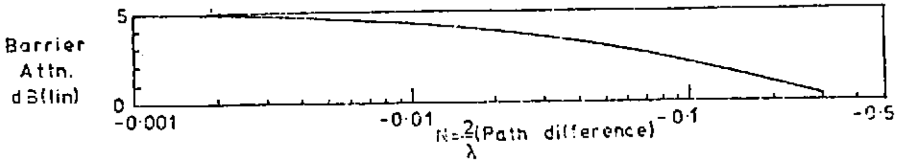

FIGURE 1 - Excess barrier attenuation of the sound from a point source by a rigid barrier as a function of Fresnel number N.

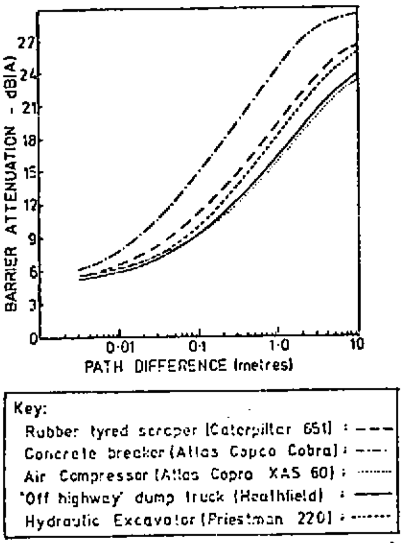

FIGURE 2 - Theoretical thin barrier peak attenuation in dB(A) of noise from various construction equipment.

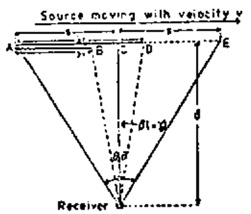

FIGURE 3 - Geometric arrangements for a moving source

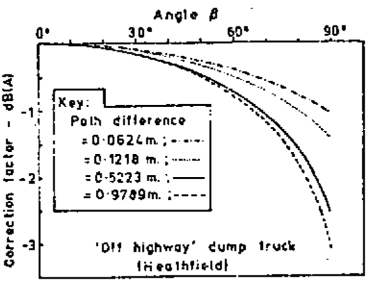

FIGURE 4 - Correction factor dB(A) as a function of angle β(=α/2 degrees) subtended by the source at its furthest point for 'off highway' dump truck (Heathfield).