inter-noise 83

AN ATTEMPT TO PREDICT THE PROPAGATION OF SOUND LEVELS FROM BLASTING OPERATIONS

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1 INTRODUCTION

It is well known that the propagation of noise is affected by local meteorological conditions (1,2,3). For a number of years the University of Salford has been investigating this phenomenon in an attempt to produce a method for predicting the spatial and temporal distribution of blast noise. A series of trials held in conjunction with the MOD and carried out under various measured weather conditions using unconfined explosive charges, has resulted in the development of a prediction method. We report here an investigation into the performance of this technique when applied to a practical quarrying situation and compare its performance with other sound level predictors.

2 PREDICTION METHODS

2.1 Ray Tracing

The technique of ray tracing through a stratified atmosphere having linear sound velocity gradients is well established (4,5,6). In our model wind and temperature data is required from the surface to 3000m. The speed of sound at the boundaries of each 150m layer are calculated to give a speed of sound profile for each direction of monitoring point from the explosive source. The paths of sound rays of initial angles 1,2,3 degrees etc to the horizontal are traced through the atmosphere until they either return to earth or leave the top of the model. Each ray returning to the ground is considered to contribute extra sound energy in the vicinity of its return point hence the local SPL is enhanced. If no rays return, then the sound velocity gradient in the lowest 150m layer is used to attenuate the SPL.

2.2 Salford Surface Wind Method

This method is based upon a regression equation obtained from the analysis of measured peak sound pressure levels during a three day period of a joint trial with the MOD. The resulting SPL is not only a function of weight and distance but includes surface wind as a parameter. The equation used is:

$$SPL = 204.6 + 11.9 \log W - 29 \log D - .28V \cos \theta \log D.$$

where W is the charge weight in kg
D is the distance from the explosive source in metres
V is the 10 metre wind speed in m/s
θ is the angle between the surface wind direction and the direction from the source to receiver)
(Wind Direction defined as the direction from which the wind blows.)

This simply adjusts the rate of attenuation with distance and is not capable of predicting sound pressure levels at a focus or under conditions of temperature inversion.

2.3 Base Line Method

This is a simple regression equation based on 815 measurements of peak sound pressure level made during a joint trial with the MOD. The equation used is:

$$SPL = 216 - 28.7 \log (D)$$

where D is the distance from source to receiver in metres.

3 MEASUREMENT PROCEDURE

During a period from June to September 1982 a total of 125 valid measurements of peak sound pressure levels from unconfined explosions, were made in the vicinity of a large limestone quarry in Derbyshire (Figure 1). Four fixed and several mobile measuring positions gave a range of distances from the explosive source between 200m and 17.5km, at various azimuths. The measuring equipment was capable of recording peak sound pressure levels at frequencies down to 2Hz. The Meteorological Office provided detailed synoptic weather data (forecast and aftercast) for each time of firing. In addition onsite measurements of the 10m wind speed and direction were made.

4 RESULTS

Table 1 shows a comparison between the prediction methods in terms of RMS errors, average errors and standard deviations calculated from the differences between measured and predicted levels. These errors are similar for both forecast and aftercast weather data (given in brackets). The Salford Surface Wind prediction has the least errors overall and performs well in the sound enhancement zone.

5 DISCUSSION

The apparent conclusion to be drawn from the trial is that the surface wind velocity can reasonably account for the variation in peak sound pressure level from small unconfined explosions observed during varying weather conditions. On a significant number of days in any year this may well be true but it should not be thought that it can always be relied on. The use of surface wind will obviously not work under temperature inversion conditions nor will it be able to predict sound focusing which occurs, mainly, under conditions of wind shear.

The ray tracing method used, developed from trials using detailed on-site meteorological data, did not perform well in this trial. This may be due to an inherent flaw in the method or that the estimated wind and temperature profiles lacked precision. In practice most prediction methods use averaged meteorological conditions, and hence it is unlikely that any method will be able to predict the level of individual short duration events, which will be influenced by the fluctuations in local meteorological conditions. The best that one can hope to do is predict an average level which together with a measure of variability allow the calculation of the probability of exceeding a given criterion level. It is felt that the ray tracing approach still offers the most hope for an all conditions prediction method.

PREDICTION TECHNIQUE	RMS ERROR dB	STANDARD DEVIATION dB	AVERAGE ERROR dB	NO OF DATA POINTS	COMMENTS
Ray Tracing	7.7(8.3)	7.7(8.1)	0.1(1.5)	125	All data
Ray Tracing	7.7(7.3)	5.3(5.8)	-5.5(-4.5)	44(33)	Enhancement
Ray Tracing	7.8(8.6)	7.1(7.8)	3.2(3.6)	81(92)	Shadow
Salford					
Surface Wind	5.6(5.5)	5.5(5.4)	-0.9(-1)	125	All data
"	4.8(5.3)	4.8(5.2)	-0.4(-0.4)	79(79)	Enhancement
"	6.6(5.9)	6.3(5.5)	-1.9(-2.0)	46(46)	Shadow
Base line eqn					
216-28.7 Log(D)	7.8	6.0	-5.1	125	All data

( ) Figures in brackets refer to aftercast data results.

TABLE 1

Errors (Measured SPL-Predicted SPL) For Various Prediction Techniques

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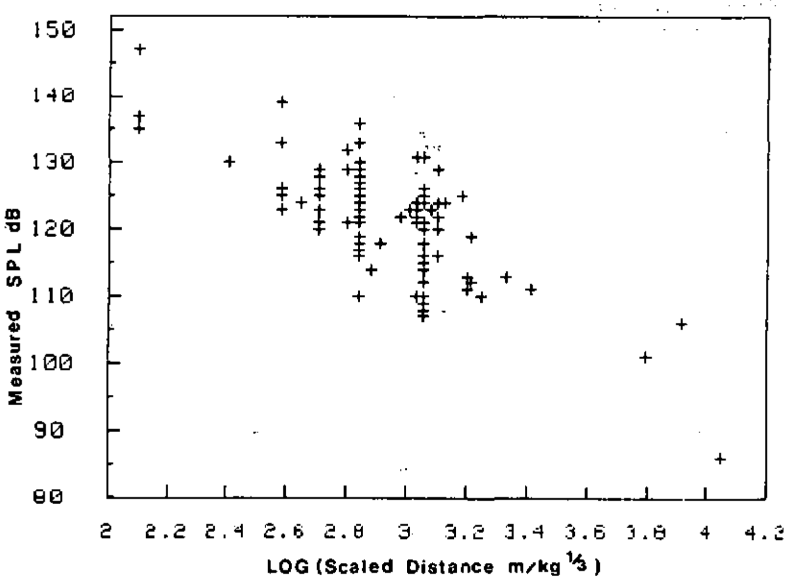

FIGURE 1