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INVESTIGATIONS INTO LOW FREQUENCY BLAST NOISE PROPAGATION

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Introduction

Noise from quarry blasting is characterised by high level low frequency impulses which, if propagated towards sensitive populated areas, can give rise to widespread complaints of startle, excessive building vibration or damage. If an accurate prediction technique were available then some controls could be introduced to alleviate these problems. At the planning stage quarry development could be limited if it were predicted that on most days the blast noise would be propagated towards sensitive property. During operation firing could be delayed if an adverse prediction for that day were available or retrospective forecasts could be used for verification of complaints or damage claims. The peak linear SPL from a quarry blast is dependent on several factors. For a confined blast the amount and type of burden, the depth and type of stemming and the method of initiation influence source level as well as type and weight of explosive used. In the case of an unconfined blast it is the latter two parameters that are of importance. At an observer's position the peak linear SPL is obviously dependent upon distance, but local topography may also affect levels and perhaps more significantly so can meteorological conditions at the time of firing. In this paper we will be concerned with unconfined blast noise and the effects of meteorological conditions. Figure 1 shows the peak SPL plotted against scaled distance (i.e. distance from blast to observer divided by the cube root of the weight) for 70 face dressing shots obtained over a 12-month period at a fixed monitoring station some 800 metres from a large limestone quarry. This figure illustrates the large degree of variability in peak SPL for blasts of ostensibly the same charge weight and distance from the measuring position. In an attempt to reduce this variability several prediction techniques have been developed.

Explosive Noise Trial

A trial was carried out over a 4-day period at an MOD firing range to verify prediction methods for unconfined explosions. A total of 117 charges of special gelignite 80 were fired, of charge weights ranging from 1 to 17 kg. Simultaneous measurements of each blast were made at 17 locations at distances ranging from 100m to 15 km, a total of 1639 valid measurements were recorded. During the trial on site meteorological data was collected at 30 minute intervals. From these measurements average wind and temperature gradients were obtained for subsequent use in the various prediction techniques.

Prediction Methods

1. Larkhill Method: This method, described by Suggitt (1) and modified by Sills (2) uses wind and temperature data measured in the lower atmosphere to trace the paths of sound rays through the atmosphere until they either return to earth or leave the top of the model. The local SPL is enhanced by an amount proportional to the density of returning rays and distance from the source. The ray return densities are smoothed to avoid large variations in SPL due to small changes in meteorological conditions. If no rays return then the sound velocity gradient in the lowest 150m layer is used to attenuate the SPL.

2. USBM Method:[3] The United States Bureau of Mines proposed a method of predicting SPL's at a distance by modifying the rate of attenuation (quoted at 7.7 dB per doubling of distance) using a component of surface wind in the direction between the source and receiver. The predicted SPL is a function of charge weight distance and surface wind.

3. Salford Regression Method: This is a straightforward regression of all the data from the first 3 days of the MDD trial, used to predict SPL's on the 4th day. No met data is required and the predicted SPL is simply a function of charge weight and distance.

4. Salford Surface Wind Method: This is another regression of the first 3 days data applied to the 4th day but with the addition of surface wind as a parameter.

A Comparison of Prediction Methods

Table 1 shows a comparison between the four prediction techniques discussed in terms of average error, RMS error, and standard deviation. In addition, a parameter called the Heidke Skill Score (S) has been calculated. This compares predictions of a given method with those that would be expected by chance on a scale 0 to 1. A score of 0 indicates no skill in the method since the same result could be achieved by chance, conversely a score of 1 indicates a perfect predictor. A value of .5 or more indicates a high degree of skill in the predicting method.

Skill Score is defined:-

$$S = \frac{R - C}{T - C}$$

where R is the number of categories correctly predicted

C is the number expected to be correct by chance

T is the total number of predictions made.

From table 1 it would seem that the Salford surface wind method is the best predictor (S = .58) and the USBM the least successful (S = .34). The Salford regression (S = .47) is a reasonably good predictor and has the advantage that no weather data is required. However, all the above methods are not capable of predicting a sound focus. Hence the Larkhill method which is a good predictor (S = .52) and is capable of predicting sound focus situations, was adapted for use at the limestone quarry. A limited study has been performed using measured levels from blasting at the quarry and comparing these values with those obtained from the Larkhill prediction . A comparison was made between predictions using both synoptic and measured weather; both sets of predicted values were found to agree closely. Table 2 shows a comparison of the Larkhill prediction when applied to both the quarry situation and the explosive noise trial. Although the quarry data is limited to 14 sets of data it can be seen that the errors involved for the same categories are similar in both cases. This suggests that the Larkhill prediction may provide a useful tool in accurately predicting levels produced by unconfined quarry blasting. A more rigorous analysis is being carried out by retrospectively applying the prediction using daily synoptic weather data provided by the meteorological office. This should provide a good indication as to how much the variability in measured levels can be explained in terms of metorological effects. It is also intended to perform a trial that will test the Larkhill prediction under focus conditions.

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Prediction Technique	Skill Score	Average Error (Meas -Pred) dB	R.M.S. Error dB	Standard Deviation dB
Larkhill	.52	-3.6	8.3	7.5
USBM	.34	-7.8	10.9	7.6
Salford Regression	.47	-0.7	6.8	6.8
Salford Surface Wind	.58	+0.1	5.0	5.0

Table 1

A Comparison of Prediction Techniques - Day 4 only

Measured Level	Quarry Results			Noise Trial Results		
Range dB	R.M.S. Error	Average Error	Standard Deviation	R.M.S. Error	Average Error	Standard Deviation
120-129	7.7	2.9	7.1	6.9	3.4	5.7
110-119	3.8	-2.4	3.0	5.1	-2.3	4.5
110-129	6.6	1.0	6.5	6.1	.78	6.1

Table 2

A comparison of the Larkhill Prediction Techniques for both the Quarry and Noise Trial Situation

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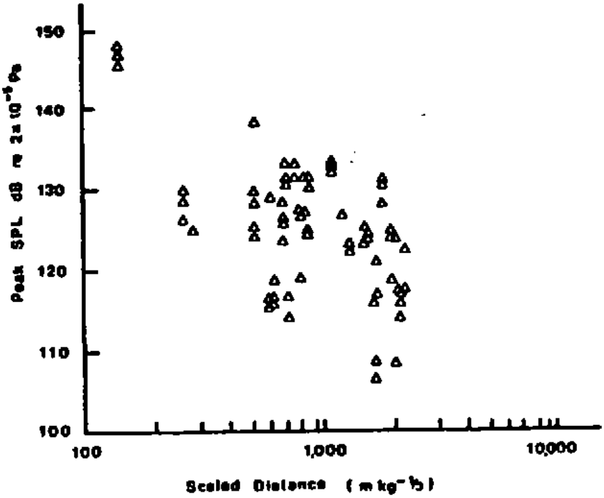

Fig 1. Measured Sound Levels

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