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PROGRESS IN INVESTIGATING BLAST NOISE FROM MINE SHAFT SINKING OPERATIONS.

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Introduction

As part of an on-going research project investigating the propagation of noise from blasting operations, measurements have been made on the new Selby coalfield where several mine shafts are being sunk using explosives. The Selby project is the largest single coal mining project ever undertaken in this country and a total of 10 shafts at five sites are being sunk over a period of 4 yrs. Although essentially a rural area, a significant number of complaints arose during early work at the shafts, sufficient to give rise to some concern.

In the long term the Coal Board intend to open several new coalfields, some in fairly heavily populated areas. It is thought that a knowledge of the nature and level of blast noise that can be expected at these sites will help allay fears of the local population and help future planning. This paper describes the initial measurements and problems encountered and comments on the results obtained to date.

Mine Shaft Sinking Using Explosive Techniques

Although the development of the techniques of using explosives to sink mine shafts is based on extensive experience throughout the world, it is several years since any were sunk in the relatively denely populated U.K.

The normal procedure is to freeze the ground in the immediate area of the future shaft and to a depth below that of the normal water bearing strata. The overburden is removed by mechanical means and explosive used to excavate the open foreshaft to a depth of approximately 40 metres. At this stage the top of the shaft is enclosed with the headgear and work on sinking the main shaft commences. A typical work pattern is known as full sump firing. It entails the drilling of approximately 100 holes in a predetermined pattern on the floor of the shaft to a depth of 2 metres (the pull) and to charge these with a total of 100 kg of explosive. After firing the debris is removed and the procedure is repeated once every shift. At suitable times the shaft walls are concreted. The depth of pull is varied depending upon the type of strata being worked.

INSTRUMENTATION FOR ACOUSTIC MEASUREMENTS

The instrumentation used on site was more fully described in ref 1 and comprised a low frequency microphone unit and FM tape recorder. The low frequency cut-off of the system was 0.3 Hz and measuring range extended from 80 to 150 dB. Also described in ref 1 was the method of analysing the data to obtain frequency spectra using a linear averaging ⅓ octave band real time analyser. Single figure descriptors of the blast noise, e.g. Peak Lin, Impulse B were obtained by replaying the signals into an impulse precision sound level meter. The C weighted Sound Exposure Levels (CSEL) were derived from the ⅓ octave band spectra which were adjusted to give the equivalent energy in each band over 1 second.

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ACOUSTIC MEASUREMENTS ON SITE

The procedure adopted was governed by site conditions. The warning of an impending blast was so short that the measurer had to have visual sight of the shot firer. In addition other activities similar to those experienced on a normal construction site raised considerably the level of background noise, particularly at lower frequencies. Early results showed that under normal day time conditions measurements at any distance would not yield meaningful answers and night time measurements, when the background noise was lower, would be more reliable. However, measurements over any distance were subject to greater variation from weather effects and ground attenuation. A compromise was therefore reached and so measurements were made on site at times of low activity and only under favourable weather conditions. (Low wind speed and no precipitation). The object was to establish the typical blast noise level at the site boundary and to obtain a measure of its variability particularly with shaft depth. Having established the information predictions of likely noise levels at any distance from the site could be made using distance and weather variability factors established elsewhere. Spot checks would be made on the viability of using such information.

WAVEFORMS AND SPECTRA

Figure 1 shows the waveform of a blast at one of the shafts on 8.11.78. The holes are fired in groups with approximately $\frac{1}{4}$ second delay between each group or shot and the pulse associated with each shot can not only be seen in the waveform but also clearly heard as separate components in the total acoustic impulse. However, the reverberant acoustics of the shaft and possibly the associated head gear causes the sound between each explosion to die away slowly thus smoothing out the sound pressure level variation and giving rise to low frequency components in the spectrum. The peak level of each shot may vary depending not only upon the no of holes fired simultaneously but also on whether adequate stemming has been used .

The spectrum of such a blast is shown in figure 2 adjusted to give the equivalent energy over 1 second. The higher frequency data, above 500 Hz, is a little difficult to determine. The restricted dynamic range of FM recorders results in this detail being lost in the background noise unless the low frequency high level content is filtered out and the remaining signal amplified and recorded on a separate track. There are also additional restrictions placed on handling the data in digital analysers which unless they have a large storage capability must be 'windowed' along 'impulses as long as five seconds in duration.

However, it can be seen that the predominant frequencies occur below 50 Hz and these are important in determining vibration response of buildings. The relative importance of such high level low frequency information in determining subjective response has still to be determined.

SINGLE FIGURE DESCRIPTORS

Clearly describing the noise by either waveform or spectra is difficult when one is looking for small changes and a single figure description is sought.

Work described in refs 2 & 3 suggests the continued use of peak linear as a descriptor for blast noise particularly when considering subsequent vibration response of buildings and provided the measuring device has adequate low frequency characteristics. Other work (4) supports the US Environmental Protection Agency recommendation that CSEL be adopted as a descriptor for 'medium size quarry blasts' and similar sources. This assumes that duration of the event is of some importance in describing annoyance and structural response as well as level. However, some caution must be exercised in using C weighted data in relation to structural response because it excludes the natural frequencies of major structural elements. There is evidence to support (5) the use of C slow as a 'poor mans' CSEL at least for pulses up to 1 second in duration. One object of the current investigation is to see if the correlation is relevant to the 5 second mineshaft blasts.

The variation of both Peak Lin and CSEL with shaft depth are shown in figure 3 This data has been adjusted to a reference position 100 metres from the shaft top using the results of a multiple regression analysis which showed a factor of approximately 5 dB/doubling of distance within the confine of the site. Peak Linear and 3.2 dB/doubling for CSEL.

Clearly there is little change in either measure as the shaft is sunk.

CALCULATION OF LEVELS OUTSIDE THE SITE

Using the data and other information on propagation with distance of the not dissimilar quarry blast noise (6 dB/doubling of distance) it is possible to calculate the levels to be expected under normal conditions at some distance from the shaft. For example at 800 m and a shaft depth of 200 m 98 dB Pk Lin and 86 dB CSEL. Such levels are well below the maximum permitted levels suggested by the US Beaureu of Mines (6) but could on the basis of data obtained elsewhere be expected to induce perceptible vibrations in dwellings. (2).

However to such data must be added the effect of local weather variations particularly wind and such adverse conditions as temperature inversions which can cause local focussing.

Work to calculate these factors and other variable that affect overpressure levels is continuing.

References

1. G Kerry & D J Saunders. Proceeding IOA 15.F5 1.
2. G Kerry & D J Saunders. Proceeding IOA 20 Q4 1.
3. D E Siskin. Proceedings 18 US Symp on Rock Mechanics June 1977.
4. P A Schomer. J.ASA. Vol G2 No 2 Aug 77.
5. Kamperman Associates Dec 1975 Illinois Institute for Environmental Quality.

Acknowledgement

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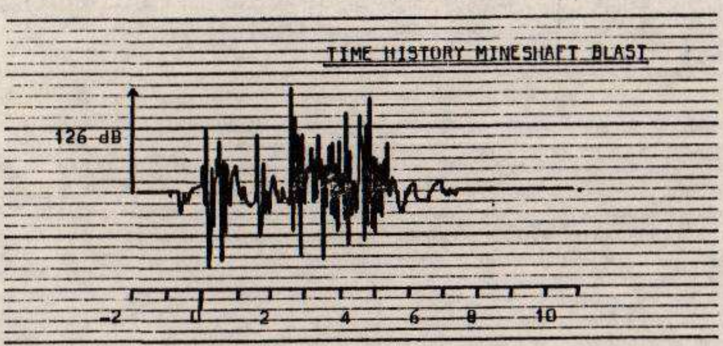

Fig 1

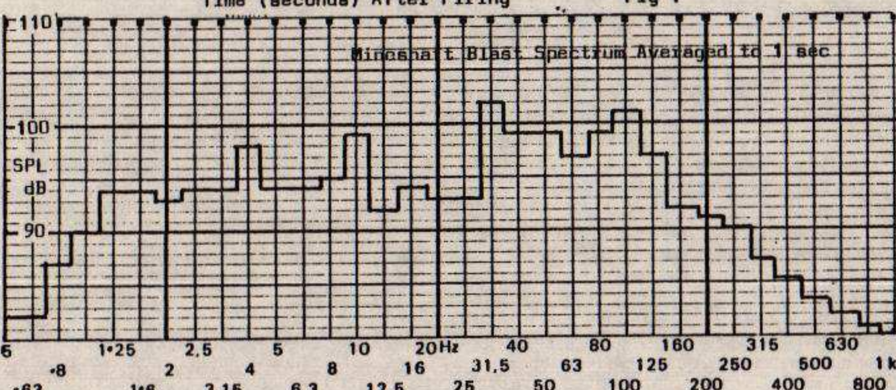

Fig 2

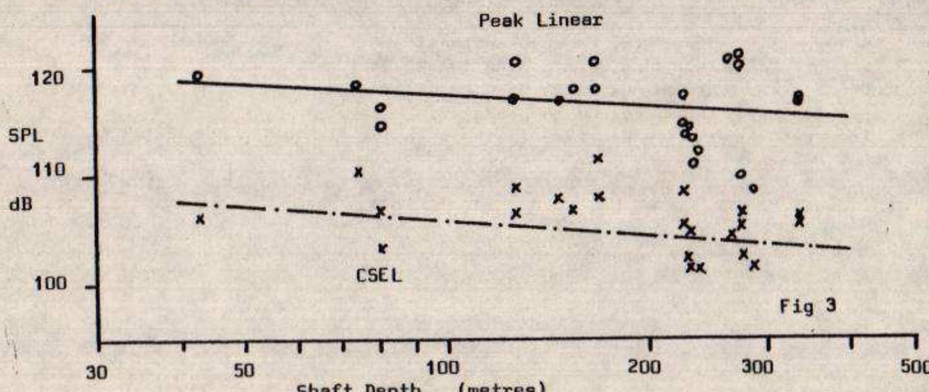

Fig 3