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NOISE FROM OPENCAST COAL SITES - COMPARISON OF PREDICTIONS WITH MEASUREMENTS

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1. INTRODUCTION

Opencast coal mining is the extraction of shallow seams of coal by surface mining methods. It is different from most other forms of surface mining in that a large amount of overburden has to be excavated to extract the coal. Typically, for each tonne of coal, twenty tonnes of overburden is excavated. In order to provide room to excavate the initial coal, the overburden which is excavated is stored in a mound. Once the void is large enough, the excavated material is used to fill in the void after the coal has been extracted. Finally, the overburden mound is used to fill in the final void. The main consequence of this method of operation is that more activity takes place above ground compared with most other surface mining activities.

Hepworth Acoustics were requested by British Coal Opencast to carry out a study to look at the correlation between predicted and measured noise levels for opencast coal sites. This study arose because of questions which had been raised at various public inquiries into the accuracy of predicted noise levels carried out on behalf of British Coal. Previous predictions were carried out using the basic procedures contained in British Standard 5228 (1), with a statement that the noise levels would be overpredictions, due to the factors in the basic method in BS 5228 which lead to overprediction. In the absence of research to prove this statement, objectors at several Public Inquiries (including several consultants) stated that noise levels would be higher than those predicted. In order to answer these arguments, a study was devised.

2. NOISE SURVEYS

Measurements were carried out at ten working opencast sites for between two and five days at each site. Between two and four locations were monitored each day. The monitoring was carried out from 7.00am to 7.00pm (the working day at many opencast sites). The results of the measurements were compared against predictions carried out using the various options contained in the Sitenoise computer program.

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The ten opencast sites were chosen to obtain a representative sample of the different sizes of British Coal opencast sites in England, Scotland and Wales. At each site the monitoring locations were chosen to provide information on various aspects of the noise propagation. The sites had all reached the stage of coal production, and therefore all had activities being carried out in a void. At each site, one monitoring location was established on the edge of the void, in view of most of the activities being carried on within the void. This location was chosen so that predictions could be compared with measurements where the main activities were unscreened. The results from these locations provide information on how accurate the prediction method is at predicting the 'source' noise from the activities within the void. Other locations were then chosen at varying distances from the void and with various amounts of screening, in order to assess how the prediction methods coped with screening and, to a lesser extent, soft ground. All measurements were carried out within the site boundaries of the sites, although because of the size of the sites, it was possible to carry out measurements up to 500m from the edge of the void.

The measurements were carried out during the period June - October 1992. All of the measurements were carried out using Type 1 Integrating Sound Level Meters, with results generally obtained for 5 minute intervals throughout the day. Whilst the measurements were being carried out, a record was kept of which items of plant were working and in what areas. The notes recorded the numbers of plant using the various haul roads on the site, and any extraneous noises such as low flying aircraft were noted for exclusion from future analysis. Measurements were also carried out of wind speed and direction.

Whilst the long term monitoring was being carried out, measurements were also taken of the working items of plant on site. These were activity L_{Aeq} measurements, carried out over a few cycles of operation, e.g. a shovel loading several trucks. These measurements therefore took into account the waiting time between cycles of activity and provide a good estimate of the average noise output of the machine whilst it is working normally. The observations of the working periods of the plant took notes of when the plant were idle for any extended period of time e.g. due to breakdown.

Survey information was provided by British Coal on the topography of the site at the time of the noise surveys. This information together with photographs taken throughout the monitoring enabled the various items of plant and haul roads to be accurately located.

3. NOISE MODELLING

The sites were modelled using the Sitenoise computer program. This works by creating a three dimensional model of the site and its surroundings. The program contains options to use different screening and soft ground attenuation measures, and was used by WS Atkins in the work which led to the Control of Noise at Surface Mineral Workings report (2).

A model of the site was created for each day's monitoring. This contained the location of each item of plant and each segment of haul road used on site throughout the day. The various noise sources in use during each period of the day were then summed to provide a total noise level for each working scenario. Depending on the variability of working within the voids, up to 10 scenarios were modelled for each day. The computer modelling was carried out by staff who had been involved in carrying out the noise monitoring on the sites, thereby avoiding errors which sometimes occur when data is modelled from plans without the benefit of a site visit.

Six prediction options were used in assessing the data. All of the methods are based on the BS 5228 calculation method with an angle of view correction used on the haul roads. The angle of view correction is taken from Calculation of Road Traffic Noise (3). The six options used were:-

0) Basic method with BS 5228 barrier and no soft ground
1) Basic method with CRTN barrier and no soft ground
2) Basic method with BS 5228 barrier and CONCAWE soft ground
3) Basic method with CRTN barrier and CONCAWE soft ground
4) Basic method with BS 5228 barrier and CRTN soft ground
5) Basic method with CRTN barrier and CRTN soft ground

(The numbers relate to the option number in the Sitenoise program)

In modelling the sites, a judgement had to be made on what to model as soft and hard ground. As we were unsure on whether excavated material would act as hard or soft ground, we decided to treat both the void and surrounding areas as soft ground for Options 2-5.

4. RESULTS

In all we had 58 sets of results to work with. Each set of results was a measurement and prediction for a monitoring location over a working day. Initially, we looked at the average difference between

the six prediction options and the measurements. In all cases the calculation options were overpredicting, as is shown below.

Sitenoise Option No.	Average Overprediction in dB(A)
0	3.5
1	2.4
2	1.3
3	0.3
4	0.9
5	0.1

These initial results indicated that the four options which use a soft ground correction provided the most accurate predictions, with option 5 being the most accurate. However, further investigation of the results showed that all of the options using a soft ground correction were achieving their apparent accuracy because overpredictions at some distance from the void were being balanced by underpredictions at the locations adjacent to the opencast voids. In order to obtain a better impression of the accuracy of the prediction options, regression analysis was carried out on the data. The results of this analysis is shown below.

Option No.	Intercept	Slope	R squared
0	27	0.62	0.92
1	21	0.69	0.89
2	29	0.54	0.85
3	23	0.63	0.84
4	28	0.56	0.87
5	21	0.64	0.88

If a prediction method correlated completely with the measured data, the intercept would be 0, the slope would be 1.0 and the R squared value would be 1.0. This analysis shows that option 1 approaches more closely to this ideal than the other options, it has the joint lowest intercept, the highest slope and the second highest R squared value.

5. DISCUSSION

Although the differences between the various values in the table above may appear small, they are significant enough to warrant the choice of option 1 as the most accurate prediction method at present. The detailed results show a very good level of correlation for monitoring locations situated on the edge of the void, with an increasing overprediction as you move away from the edge of the void. The locations on the edge of the voids generally had an unscreened view of most of the activities being carried out within the void. The results for these sites demonstrate that the basic method of predicting the noise generated by the operations is accurate for unscreened situations. The divergence between measurements and predictions happens when screening (and soft ground) intervenes between the noise sources and the receptor.

The large differences (up to 15 dB(A)) between measurements and predictions at large distances from the void are not due to the effects of wind. Care was taken not to carry out measurements in conditions where the average wind speed was above 5 m/s. An analysis of the effect of wind on the results has been carried out. The results are shown in the table below.

Wind condition at monitoring location	Average overprediction in dB(A)	Number of results
Upwind	2.6	12
Downwind	1.3	11
Crosswind	3.8	19
Still	1.4	16

The results show a spread of approximately plus or minus 1 dB(A) about the mean. This clearly indicates that other factors are accounting for the large differences between predicted and measured levels at locations away from the void.

One factor may be that the prediction method only takes into account the single most effective barrier in the calculations. No account is taken of any additional barriers between the source and receiver. Calculation of Road Traffic Noise allows a maximum of 3 dB(A) extra barrier attenuation to take into account the effect of a second barrier. The absence of a correction for additional barriers may be contributing towards the overprediction, but it

still only explains a small amount of the overprediction. Other factors are obviously involved in the overprediction. We have not had the opportunity to explore this further, but our initial thoughts are that there may be some soft ground effect in addition to the barrier screening as opposed to the either/or approach which is used for these two corrections at present.

6. CONCLUSIONS

The study has confirmed that the basic BS 5228 prediction method enhanced by using the CRTN barrier correction, an angle of view correction for haul roads and an accurate figure for the sound output of working plant provides the best correlation with measured noise levels for working opencast coal sites. This method is very accurate for locations such as the edge of the void which have a direct line of sight to the opencast operations and are relatively close to the operations. For locations which are fully screened, the prediction method progressively overpredicts with increasing distance from the activities. The reason for this has not been fully established, although it has been confirmed that the effect of wind has a minor effect on the noise levels recorded.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

[1] British Standard 5228, 'Noise Control on Construction and Open Sites Parts 1-3' (1984)

[2] WS Atkins Engineering Sciences, 'The Control of Noise at Surface Mineral Workings' (1990)

[3] Department of Transport, 'Calculation of Road Traffic Noise' (1988)