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MONITORING THE RESPONSE OF BUILDINGS TO AIRBLAST FROM QUARRYING

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INTRODUCTION

As part of a much wider study into airblast propagation and effect, the University of Salford has had the use of an empty farmhouse situated some 750 metres from a large limestone quarry. This has been instrumented to help in a study of the way airblast affects buildings and has provided the opportunity to assess building response to both confined and unconfined blasting over a long period. Although by no means complete, the research has yielded useful information on monitoring problems, and the purpose of this paper is to present some of this information.

DESCRIPTION OF PROPERTY

The farmhouse is built of stone in the traditional Derbyshire manner. A ground floor and first floor room were used in the investigation. The intervening floor was replaced with a structure built to current UK Building Regulations. One half comprised a floor/ceiling section of 12mm T & G boarding 230mm x 50mm joists at 400mm centres with a 12mm skimmed plasterboard ceiling. The other half was a standard ceiling section with 75mm x 50mm joists and 12mm skimmed plasterboard. Additional timber hangers tied the section to the original roof joists.

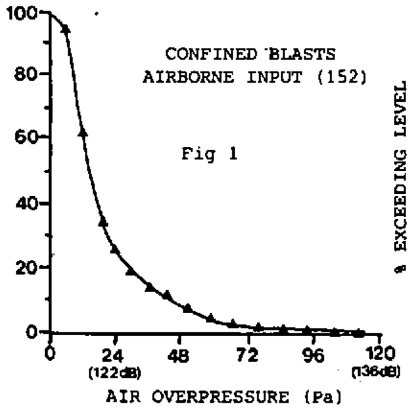
INSTRUMENTATION

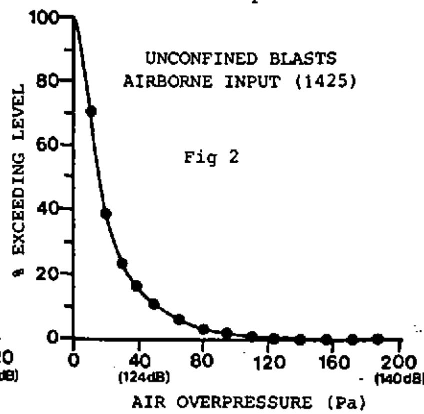
A four track FM recorder was used, one track measuring external sound levels and the other three the vibration of either the ground floor, front wall, ceiling or suspended floor. In order to allow monitoring in all weather conditions, a hydrophone was used to measure the external sound level. This had a flat frequency response to below 1 Hz and could detect signals in the range 90dB to 160dB. Accelerometers were used to measure the vibration levels, either directly or via active integration networks to give velocity.

STATISTICAL ANALYSIS OF RESULTS

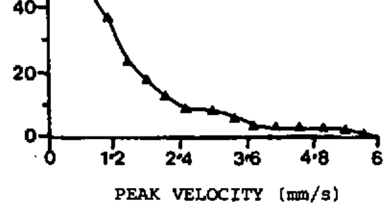
By carrying out a statistical analysis on the levels measured over a long period of time the total variations covered by changes in such parameters as charge weight, number of holes, burden and stemming, distance and of course weather, can be readily seen.

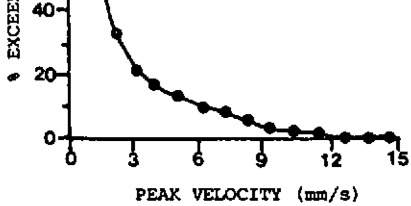
Figure 1 shows the variation of peak sound levels produced at the farm due to confined blasting over two years (152 blasts). The level ranged from 94 to 135dB. The distribution of unconfined blast peak sound





levels is shown in figure 2. There were a considerable number of blasts (1425) resulting in a somewhat smoother distribution and the maximum levels were slightly higher, extending to 139dB.

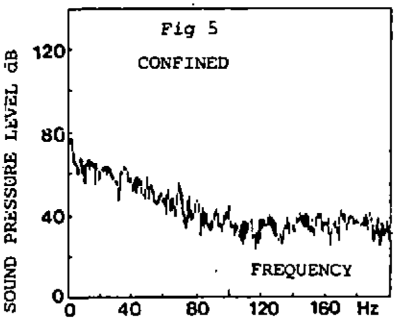


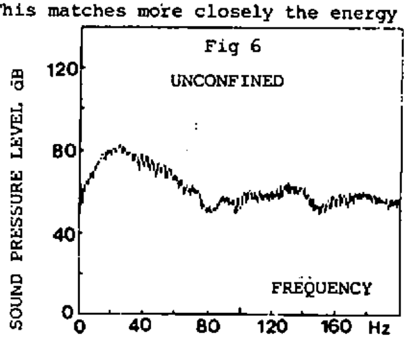


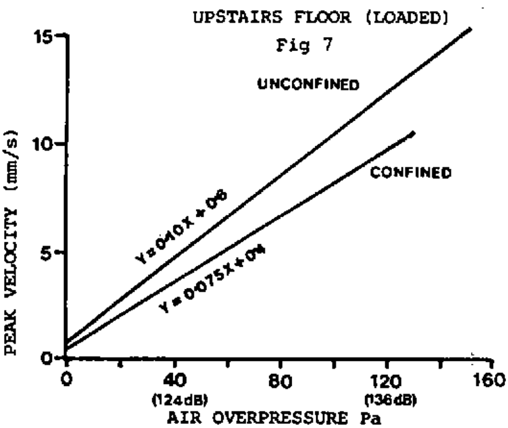
Similar distributions are shown in figures 3 and 4 where the resulting vibration response of the upstairs floor is considered. The extent of the variation demonstrates the need to monitor the effects of a number of blasts before a true picture of likely maximum vibration levels, can be determined at a particular location.

DISTRIBUTION OF ENERGY IN AIRBLAST WAVES

Fourier analysis gives the distribution of energy in the incoming waves with regard to frequency, and the difference between confined and unconfined blasts is shown in figures 5 and 6, with the energy in primary blasts being contained at much lower frequencies. This is important when considering the response of building elements subjected to blast waves. For instance, the upstairs (suspended) floor has a natural frequency at about 20Hz. This matches more closely the energy contained in unconfined rather than confined blasts, and as a result the floor responds more to the former. This is demonstrated in figure 7 which shows the result of a regression analysis on the response of the floor to the two different blast types.







MAGNIFICATION OF VIBRATION LEVELS BY THE STRUCTURE

It is common practice to monitor the vibration of buildings resulting from blasting by placing the sensor on the door threshold or other part of the ground floor structure securely anchored to the ground. Whilst this may give an adequate description of the ground-borne input it will not necessarily demonstrate the maximum levels produced on floors in the buildings, nor will it give a true indication of the effect of the airborne input. By monitoring simultaneously on the ground floor and first floor, it was possible to obtain average magnifications between the two for different types of input. These are calculated in figure 8. Again, the effect of better energy coupling with secondary blasts can be seen.

	Primary Blasts		Secondary Blast
	Groundborne Wave	Airborne Wave	Airborne Wave
Upstairs Floor / Downstairs Floor (solid)	4	14	50
Upstairs Floor Centre / Upstairs Floor Edge	3	7	4

Average Magnification Factors for Floor Vibrations
Figure 8

There are, of course, other factors to be considered. For instance, the location of vibration transducers can be critical particularly on suspended floors. The magnification factors between two positions on the upstairs floor are also shown in figure 8. Floor loading can also influence response. However, at the Farm the effect was more apparent as a shift in natural frequency than a significant change in peak level.

COMMENTS

Monitoring airblast and its effect on buildings requires a modified approach to that normally adopted for groundborne blast. Some account must be taken of the variability of airblast particularly as distance from source increases and any sensor should be located to detect both groundborne and airborne vibration.

ACKNOWLEDGEMENT

The author wishes to acknowledge the support provided for this work by both ICI Ltd and SERC.