inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 3.1

AN EXPERIMENTAL INVESTIGATION INTO THE ACOUSTIC PERFORMANCE OF EARTH MOUNDS COMBINED WITH SHORT NOISE BARRIERS

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Keywords:
MODELLING, EARTH MOUNDS, BARRIERS, SCREENS

ABSTRACT
Despite an increase in the number of complaints about environmental noise action to reduce its impact has had a lower priority compared to other environmental problems. According to the European Commission Green Paper on Future Noise Policy [1], around 20% of the European Union's population or 80 million people suffer from noise levels more than 65 dB(A). These levels are considered by health experts to be unacceptable. As well as environmental implications noise has economic costs to society. This paper presents some of the work being carried out on a novel method of screening road traffic noise consisting of earth mounds combined with short barriers. Physical scale modelling was used to measure the performance of eight different configurations. A sample of the results is presented and discussed.

1 - INTRODUCTION
Research into the design of environmental noise barriers is currently undertaken at Sheffield Hallam University [2]. Earth mounds have been identified as having the advantage of being aesthetically pleasing and environmentally friendly. Due to their natural appearance they blend into the local environment and the public perception of these barriers is high. Depending on the availability of sufficient space and local fill material, their construction can be cost-effective. Therefore earth barriers are given priority over wall type barriers even though a flat-topped grass-covered earth mound has been shown to perform slightly less than a thin vertical wall of an equal height [3]. With so many factors favouring the applications of earth mounds, less effective acoustic performance can be remedied by making them higher. An increased height in the case of earth barriers have less visual impact and is not subjected to structural limitations such as wind loading.
The performance of this type of barriers is being investigated using a physical scale model. Early results obtained from the measurement of noise reduction due to various configurations of mounds are presented in the forthcoming sections.

2 - PHYSICAL SCALE MODELLING
In order to assess the effect of earth mounds topped up with short screens, a physical scale model was used. Various research workers have used different scale factors depending on the specific constraints they encountered [4,5,6]. Typical scaling factors range from 1:10 to 1:80. For the purpose of this investigation a scale of 1:10 was used. This scale was adopted because ultrasonic frequencies could not be produced or detected, given the range of measuring equipment available, had a larger scale been used. Using this scaling factor, frequencies ranging from 100 Hz and 2000 Hz were modelled (at 1/3 octave interval) giving a "modelled" range between 1 kHz and 20 kHz.
An earth mound of trapezoid shape was modelled to which 2 different heights of screens and an absorbing material were added to create the eight configurations shown in Figure 1. The physical dimensions of the mound were 24 m long, 7 m wide (base) and 3 m high with a 45 degree slope (in both directions) giving a width of 1 m at the top. The model was constructed from 12 mm thick medium density fibreboard and the absorbing material used was glass fibre quilt. The experiments were carried out in an irregular

shaped room 12.6 m long 6.3 wide and 6.3 m high. The set-up was placed on top of a bench in the centre of the room with the source-receiver axis being parallel to the room length.
The walls of the room were reflective and therefore the model was placed away from the walls as much as possible to minimise the effects of reflected rays.
Frequencies under investigation were 1/3 octave band frequencies from 1 kHz to 20 kHz.

3 - EXPERIMENTAL STUDY

The sound source used in the experiment was a 0.05 × 0.05 m tweeter loudspeaker enclosed in a box. The source was located on the bench, 0.6 m away from the centreline of the model. The receiver was 1 m from the centreline of the model, positioned on the opposite side of the model and resting on the bench.
The reference noise levels were measured 0.05 m from the source. The direct component of the sound was not subjected to any effect of geometrical spreading, air absorption or the reverberant field. This distance was thought to be close enough to the source to give a good representation of the output noise levels, and to characterise the source accurately. The source was connected to a random noise generator and an amplifier. The capacitor on the speaker ensured that the low frequency component of the random noise was suppressed. The sound level meter was run through a frequency sweep both at the reference point (5 cm from the speaker) on the source side and at the receiver position. The difference between the two levels for each frequency band gave the relative acoustical performance of each modification at the receiver position under investigation. The combination of a single basic barrier shape, two screen heights and the use of absorptive material, eight different configurations were investigated. These are shown in Figure 1.

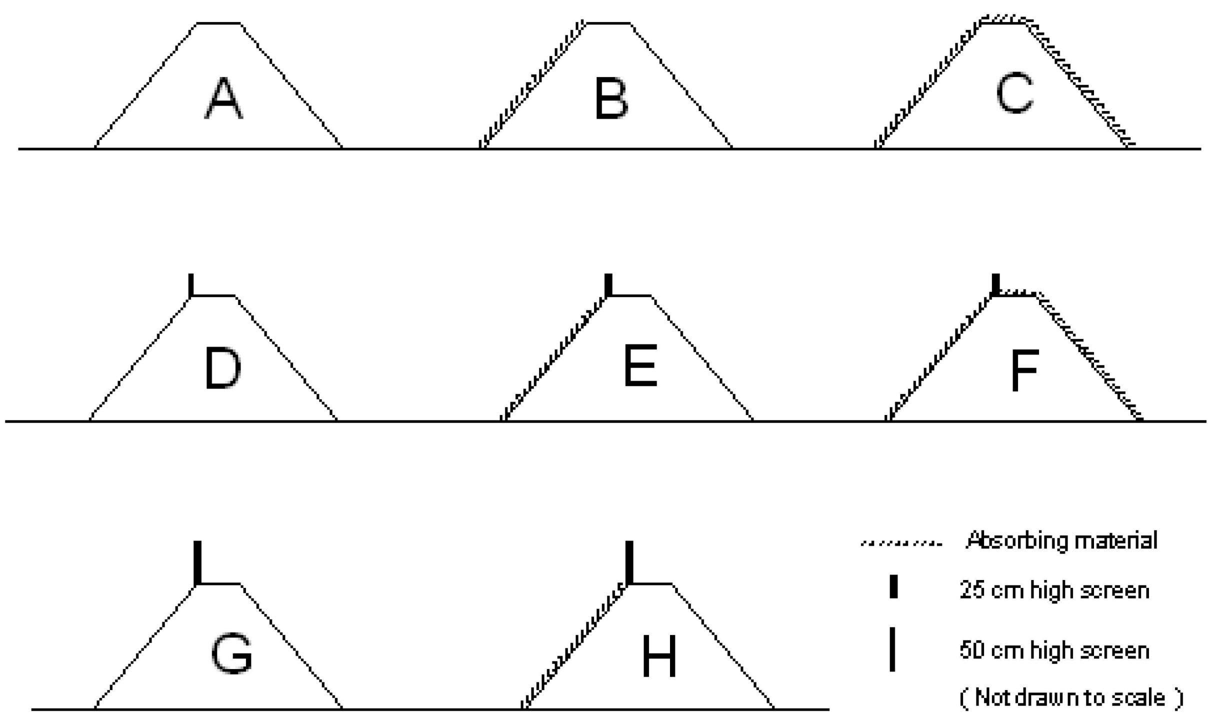

Figure 1: The various configurations of barriers investigated.

4 - RESULTS

The summary of results in Figure 2 show the difference in the Sound Pressure Level between the reference point and the receiver position for the eight configurations investigated. Note that the SPL difference plotted at each frequency is the resulting average of 4 sets of readings.

5 - DISCUSSION

In order to illustrate the effect of the absorbing material on the performance of the mound, cases A, B and C are compared. Between the fully reflective case (A) and the fully absorptive case (C), there is

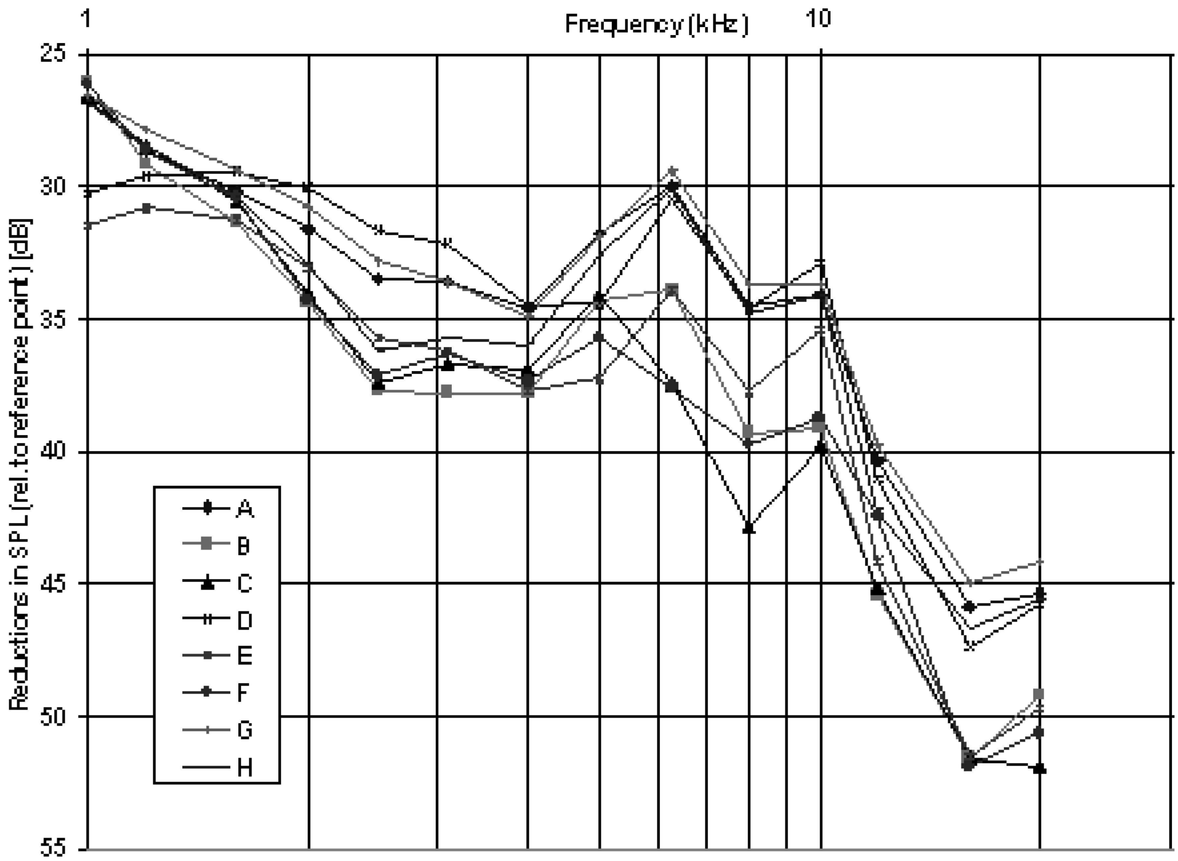

Figure 2: Relative performance of the investigated configurations.

3.8 dB difference over the whole spectrum. When the individual frequency bands are considered, the marked differences can be seen at the frequencies above 5 kHz. This difference is thought to be due to the performance of the absorbing material.

Placing absorptive material only on the source side (B) provides most of the beneficial effect caused by the fully absorptive case (C) as case (B) is only 0.5 dB short of the fully absorptive case. The former performed better, between $5 - 10$ kHz. This reflects the frequency range where the performance of the absorbing material is especially high, as mentioned above.

The effect of barrier height combined with fully reflective mound configurations can be shown by comparing cases A, D and G. Over the whole spectrum, there was no improvement in performance by introducing a 0.25 m screen, while a 0.5 m barrier had adversely affected the performance (-0.5 dB). When these two screens were combined with reflective mounds with 1 absorptive face (slope facing the source), the results followed an almost similar trend. Although there was little difference between the performance of the two screens (E compared to H), they both reduced the overall performance by around 2.5 dB compared to case (B).

At 8 kHz, the fully absorptive case (C) has a clear dip compared to other profiles. Maximum difference is approximately 9 dB compared with the worst performing profile at that frequency (G). Any modification to the profile diminishes the performance at 8 kHz considerably.

Above 6.3 kHz, the profiles associated with high absorptive material produced 5 dB or more better than the rest (B, C, F, E). Any modification degrades the performance at these frequency range.

Between 6.3-10 kHz, reducing the absorptive material from fully absorbing case (C) to partially absorptive case (B) yields reductions in performance of about 4 dB. This is the intermediate stage towards the fully reflective case (A) and the reductions in performance increase to about 8 dB. This shows which frequencies are affected most through the absorbing characteristics of the ground. The effect is visible especially at 8 kHz.

6 - CONCLUSIONS

The effect of both a top-up short barrier and an absorbing material on the performance of an earth mound was investigated. In the case where the slopes of an earth mound are reflective, a very small edge, of height 0.25 m, can be slightly beneficial. As the ground absorption increases, installing a barrier can affect the performance adversely. Under these conditions, as the height of the edge increases, the reductions in performance increase. The improvement in performance, when the absorbing material is present, is due mainly to the slope facing the source. The receiver side of the slope does not play a major role. Therefore, the slopes facing the traffic should be planted with grass and maintained regularly to maximise the beneficial ground effects.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. L.Goodwin for his help and support in carrying out the experimental work.

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