Innovations that make infrastructure and construction noise control more effective

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ABSTRACT
Many of the traditional measures used to manage noise during demolition, construction and maintenance projects are not only “site implementation hostile” (costly and time consuming to use), but they are often acoustically ineffective. This has made it increasingly difficult for organisations to comply with ever tighter noise regulations without incurring much higher costs due to the extended project timescales associated with noise induced limitations on working hours. However, the new generation of temporary noise control measures has combined the results of technical and psychological research with new acoustic materials. This has created noise control options that are not only acoustically highly effective, but which can also be deployed on sites very fast with minimal labour. In some cases, the extended working hours made possible by this enhanced performance and practicality can even make implementing noise mitigation packages a highly profitable exercise. Products based on these technical advances provide acoustic engineers and consultants with new tools that they can use to mitigate noise on previously “difficult” projects. This paper summarises the innovative acoustic and mechanical developments involved, using multi-media case studies from projects across the globe to illustrate the technical features.

Keywords: Barriers, Demolition, Construction. I-INCE Classification of Subjects Numbers: 31.1; 33

1. INTRODUCTION
Whilst temporary acoustic barriers fitted to fencing and scaffolding have been used for some time, the field attenuation achieved on site has often proved disappointing. Moreover, deployment has also been a time consuming and costly problem. This paper provides a summary of the acoustic and physical features incorporated into a new generation of temporary acoustic barriers that provide additional tools for acousticians and others to reduce the noise from construction, demolition, infrastructure and other related noisy activities. It highlights the innovative acoustic features and materials used and that have to be combined with the “mechanical” design elements necessary to achieve high attenuation on site and not just in the laboratory. However, whilst the benefits that are actually achievable using the latest acoustic barriers in real applications are substantial, they are usually only a fraction of those suggested in the hyperbolae associated with theoretical laboratory data often quoted in product literature.

2. MEETING REAL-WORLD CONSTRAINTS FOR GOOD FIELD PERFORMANCE
There are 6 elements that have to be balanced in order to develop temporary acoustic barriers that will be effective in practice on site. In order to achieve a high attenuation in practice, the requirement was to determine the optimum combination of acoustic and structural elements that would provide the best performance under the constraints of real world applications and then to design a barrier with these features.

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2.1 Barrier geometry re noise sources – casting a long shadow

The position of barriers in relation to noise sources is the key determinant of the overall attenuation. The closer to the source, the better, as it then creates a larger acoustic shadow. Unless the barrier is very close to the source, most of the noise passes over the top rather than passing through it.

![Diagram of barrier position](image)

Figure 1 - ideal barrier position

Consequently, barriers have to be easy to deploy with a minimum of personnel and it must also be very easy to relocate the barriers as project progress so that they stay as close as practical to the noise sources. It is not uncommon to see conventional barriers left in place a long way from noise sources as it is too difficult to move them. If deployment is too personnel intensive, they may only be partially installed or left on the pallet.

The primary objective was to design barriers that can be installed or moved twice as fast as traditional barriers using half the personnel to make it easy to create, and maintain, the best geometry and therefore the highest attenuation.

2.2 Sound absorption – halls of acoustic mirrors

High frequency sound is more directional than lower frequencies, which means that barriers cast larger, and deeper, shadows at higher frequencies. Low frequencies are more difficult to screen as they diffract round barriers. In order to screen lower frequencies, the barrier must not only be higher, but, conventionally, the acoustic absorbent layer would also have to be considerably thicker to provide significant absorption.

The solid barriers (hoardings) often used on site boundaries (wood, steel, PVC etc) reflect virtually all the sound that strikes them, amplifying the sound. This means that the local noise level can double or treble (3 – 5dB increase). Acoustic barriers are generally fitted with acoustic absorption materials on the side that faces the noise source to reduce reflections and thereby increase the attenuation. Classically, materials such as fibreglass or rockwool (hazardous to handle on site) or foam have been used. Unfortunately, all these materials also soak up water which adds weight, creates more handling problems and reduces the acoustic absorption (see 2.3 below).

The solution was to develop a (patented) design, hi-tech absorption composite that is an effective acoustic absorbent and yet is waterproof (to BSEN60529), even when totally submerged in water.

Moreover, in terms of achieving the maximum barrier performance, the key frequency range is c 300Hz – 1500Hz (higher frequencies are easier to screen). Conventional absorbent materials have to be thicker to absorb lower frequencies (whilst 25mm thick absorbent works well at 4kHz, c 100mm thick absorbent would be required to provide high absorption at 250Hz). This limits the lowest frequency at which conventional barriers have good absorbent properties before the trade-off between the acoustic performance and the handling issues caused by the added thickness and weight becomes a serious practical problem.

In addition to designing an absorbent composite that is waterproof, it was also tuned to provide much higher absorption at the key lower frequencies, comparable with conventional materials of twice the thickness.
Note: some barriers have “absorbent” layers that are very thin. Any thickness less than c 20 - 25mm is inadequate as an absorbent for this type of application.

![Graph showing absorbance performance](image)

**Figure 2 – Tuned, waterproof acoustic absorbent**

### 2.3 Water absorption reduces performance – wet blanket looks and handling issues

Virtually all barriers use porous acoustic absorption materials that behave as a sponge when it rains. Such barriers not only take on the physical characteristics of a waterlogged duvet, but the acoustic absorption can also be halved when wet.

As far as we are aware, no company publishes sound absorption data for wet barriers, despite the effect this can have on the absorption coefficient. The new waterproof designs have the same sound absorption characteristics wet or dry.

### 2.4 Barrier weight and sound attenuation – weight-watching

Reducing the transmission of sound requires mass. The heavier the material, the higher the transmission loss. However, for temporary barrier application geometries, most of the sound goes over, and not through, the barrier. Consequently, it is possible to calculate the optimum mass for most typical site geometries above which there is little additional benefit and below which the attenuation falls.

![Diagram of sound transmission paths](image)

**Figure 3 – Sound transmission paths contributions**

The new design is as light as is possible without compromising attenuation under the vast majority of practical geometries. This provides substantial deployment, installation and handling benefits. In the rare cases where more mass is required, they have also been specifically designed to facilitate being doubled-up locally to provide additional transmission loss.

This circumvents the problem associated with heavy barriers in that they are not “temporary” in the sense that they cannot easily be moved. Once installed, they are usually fixed for the duration of a project. Consequently, as the relationships between the barriers, noise sources and the receivers often
change dramatically, these barriers will no longer provide high attenuation due to the poor geometry. Lighter barriers that can be moved very easily allow sites to maintain geometries that provide high attenuation as projects progress and noise sources move. In addition, independent field test results have shown that lighter barriers can provide a higher attenuation at low frequencies than would be expected from the laboratory test data (see results in section 3).

2.5 Site Practicability – stealth, health and efficiency

The barriers have been designed (low weight and bespoke fittings) to be installed by half the staff in half the time compared with conventional barriers. This not only dramatically reduces handling issues and hence installation costs, but it also makes acoustic control practical in circumstances where conventional barriers cannot be installed quickly enough (e.g. night-time rail maintenance, trenches etc where there is very little time available).

Extensive end user testing resulted in the design of a high-speed barrier fitting kit available for both fencing and for scaffolding and the unique “roll-up” option (with integral strap) that were integral parts of the overall approach to achieve the maximum attenuation on site. As highlighted above, this facility often dramatically improves the attenuation actually achieved as it facilitates maintenance of good geometry (2.1 above) over a project. If barriers are difficult to move, they are often not moved.

In addition, the barriers were also designed to be hung one from another to create an easily moved curtain when fitted to scaffolding.

The use of fibrous materials such as rockwool and fibreglass were ruled-out early in the design process as they pose an unacceptable safety hazard on site (dermatitis). Even when enclosed (as in conventional blankets), they will often tear and rip, exposing skin to the hazardous materials during handling. In addition, conventional blankets also store large quantities of dust that creates an inspiration health hazard when handled.

2.6 Psychological Silencing – if it looks good, it sounds good

Based on research and past experience, it was evident that aesthetics can play a significant role in determining the perceived annoyance to local residents caused by site noise. Barriers that are aesthetically pleasing, well finished and that carry a message about noise attenuation provide an extra “placebo” attenuation equivalent to an additional objective noise reduction of around 3 – 5dB over conventional barriers. This feature alone can dramatically reduce the likelihood of noise complaints about a site.

Consequently, it was considered important to ensure that the new barrier had as high quality aesthetics and finish as possible. After trials, it became evident that this could only be achieved by developing a new production line to manufacture and hand-finish the acoustic barriers in-house. The selected materials and manufacturing methods also ensure that the barriers have a high degree of robustness and durability to ensure that they maintain their high quality appearance over prolonged use on site in all weathers.

An added spin-off associated with these material and manufacturing quality features is that they also provide substantial benefits in terms of projecting company (and project) site image. They are also
designed to be printed with information, company logos and messages to enhance communication.

3. LABORATORY DATA V FIELD PERFORMANCE

Much as a drunk uses a lamppost more for support than for illumination, the technicalities of the acoustic laboratory tests are often used to obscure rather than to inform end users about the real-world performance of products such as temporary noise barriers. The field performance of these barriers is almost always only a small fraction of that obtained in the laboratory tests for transmission loss.

Misleading phrases such as “up to 32dB attenuation” are often used in technical literature. This figure is taken from the laboratory data at 8kHz for the testing a hermetically sealed material sample. In the field, there are leaks between panels and, of course, space for the sound to pass over the top of the barrier. In practice, on site, the maximum attenuation that can typically be achieved is around 10dB – 20dB, no matter whether the barrier is made from lightweight PVC or from bricks with ten times the mass.

However, in some circumstances, it is actually possible to achieve field attenuations that are higher than laboratory results, particularly where acoustic reflections are an issue. For example, this graph shows the field results obtained by an independent consultant using the new barriers to attenuate the noise from a diesel powered trenchless excavation drill. The field attenuation results are significantly better (by 5dB or more) than the laboratory test transmission loss data.

Figure 5 – Field attenuation can be higher than laboratory values