Effective Noise Barrier Design and Specification

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ABSTRACT

There is a general lack of confidence in the noise barrier industry in the design and specification of effective noise barriers. There is also a need for clear guidance in the application of appropriate standards. The aim of this paper is - To enable informed choices to be made using best practice in the detailed design and specification of noise barrier systems both for industrial and transport noise and to give an update of the latest developments in noise barrier design standards and technology to the benefit of the future Australasian Market.

NOISE BARRIER SPECIFICATION STANDARDS

This paper is a practical examination of the emergence of new standards for noise barrier design and specification both in the UK and in the continent of Europe as a whole. Whilst a few of these standards are specific to the originating countries most are general and of direct relevance to the Australasian market also.

EMERGING EUROPEAN STANDARDS

Across the continent of Europe highways noise has been dealt with as an environmental problem that requires environmental solutions. Noise Barriers have been used to ensure that communities are protected from vehicle noise. In contrast, historically, the UK's policy had been to offer non-environmental "solutions" such as secondary double- glazing or even compensation to residents. Neither of these solves the problem.

The result was a growing need in the UK for correct specifications based on certified laboratory tested acoustic performance to ensure that effective long-lasting barriers are built that significantly reduce noise levels and public complaints.

Design Guidance: HA65/94, HA66/95

About eight years ago, the UK Highways Agency issued HA65/94, a *Design Guide for Environmental Barriers* giving guidance on installation regarding the appearance of noise barriers in their environment.

Coupled with this is HA66/95, *"Environmental Barriers, Technical Requirements"*. Of specific importance is the requirement to build barriers for a 20 year low maintenance and a 40 year operational life.

What has followed over the last few years is the emergence of new European EN performance standards for highway noise barriers to serve as the back-bone for noise barrier specification. These have broken with the previous UK traditional approach that had assumed that noise barriers equalled timber fences! Instead barrier design and material depended on the application and environment and the starting point was the very purpose of the barrier itself – acoustic performance -

EN 1793: ACOUSTIC PERFORMANCE

EN 1793 groups the family of noise barrier standards dealing with intrinsic acoustic performance. These are all *product* performance tests. Some are internal laboratory tests based in classical reverberation test chambers. Others are in-situ test methods for outdoor test beds or for application of in situ barrier environments. Although some are still at the development stage they list as follows:

EN 1793-1(1998): Road traffic noise reducing devices – Test method for determining the acoustic performance – Part 1: Intrinsic characteristics of Sound Absorption.

EN 1793-2(1998): Road traffic noise reducing devices – Test method for determining the acoustic performance – Part 2: Intrinsic characteristics of Airborne Sound Insulation.

EN 1793-3(1998): Road traffic noise reducing devices – Test method for determining the acoustic performance – Part 3: Normalised traffic noise spectrum.*

EN/TS 1793-4(2003): Road traffic noise reducing devices – Test method for determining the acoustic performance – Part 4: In situ values of diffraction. **

EN/TS 1793-5(2003): Road traffic noise reducing devices – Test method for determining the acoustic performance – Part 5: In situ values of sound reflection and airborne sound insulation. ***

** Although the method of assessment is applicable to other barrier application it must be remembered that the ratings in these standards are specifically based on a traffic spectrum.*

*** The in-situ test method for diffraction is useable for specification, however it is still in the development process at European CEN level.*

**** The in-situ test method for in situ values of sound reflection and airborne sound insulation is useable for specification, however it is still in the development process at European CEN level.*

EN 1793-1 (Lab Test for Sound Absorption)

Carried out in a nationally accredited laboratory, a sample panel up to 12 m^2 is mounted on the floor of the reverberation room. To mimic in situ conditions, a post is included within the sample with the exact same fixings and sealing as those employed on site. The level of absorption is then measured across a frequency range from 100Hz to 5KHz.

A detailed description of test conditions, fixings and all component sizes and densities are included as a vital part of the final test report. This is to ensure that the tested barrier can be closely compared to the final barrier built on site. *(There have been many instances where the laboratory tested panel has used denser material or tighter fixings than those used on site).*

Absorption DLα is then categorized using a single number rating system:

Category **A0** : DLα = **Not determined**

Category **A1** : DLα = < 4

Category **A2** : DLα = 4 **to** 7

Category **A3** : DLα = 8 **to** 11

Category **A4** : DLα = > 11

DLα is the single-number rating of sound absorption performance expressed as a difference of A-weighted sound pressure levels, in decibels.

When an absorptive barrier is being specified, in layman's terms, most highways projects would require A3 or above for a suitable level of absorption. A4 should be reserved for close "corridors", high barriers (> 3 metres) and reverberant locations where higher levels of absorption would be justified.

A2 is relevant where a composite barrier is being tested (eg an absorptive barrier with a reflective transparent top) where only a section of the barrier is absorptive. A1 should be discounted as impractical.

A0 is reserved for reflective barriers where absorption need not be tested.

EN 1793-2 (Lab Test for Airborne Sound Insulation)

Carried out in a nationally accredited laboratory, a sample panel is mounted in the window between two adjoining reverberation rooms (~ 10m^2). To mimic in situ conditions, a post is included within the sample with the exact same fixings and sealing as those employed on site. The level of airborne sound insulation is then measured across a frequency range from 100Hz to 5KHz.

A detailed description of test conditions, fixings and all component sizes and densities are included as a vital part of the final test report. This is to ensure that the tested barrier can be closely compared to the final barrier built on site. *(There have been many instances where the laboratory tested panel has used denser material or tighter fixings than those used on site).*

Airborne sound Insulation DLR is then categorized using a single number rating system

Category **B0** : DLR = **Not determined**

Category **B1** : DLR = < 15

Category **B2** : DLR = **15 to 24**

Category **B3** : DLR = > 24

DLR is the single-number rating of airborne sound insulation performance expressed as a difference of A-weighted sound pressure levels, in decibels.

It is generally agreed that these categories are too wide for practical use. Most highways projects would require B3 giving a DLR of at least 24 dB. For low barriers, (<2metres), B2 can be sufficient but it is important to specify a DLR level of at least 20dB. Any lower than this and the barrier would be too thin to deal with low frequency noise levels. A specifier should also question the robustness and longevity of any barrier design incapable of achieving a DLR of 20dB.

B1 in practice is rarely considered.

B0 is reserved for "open" barrier designs. That is, barrier designs which incorporate a gap in the design making them impossible to test to I.S.EN 1793 part 2.

Specifiers should not use Category B0 as a way of tenderers avoiding testing. All Highways noise barriers should be certificated and tested.

EN 1793-4 (In Situ Test for Sound Diffraction)

Although in its infancy, Part 4 quantifies a new parameter: Sound Diffraction. With the emergence of new barrier-top or added devices to improve a barriers performance, this method was developed to determine the acoustic benefit of adding such elements.

The method can be used to qualify products before the installation along roads as well as to verify the compliance of installed added devices to design specifications. Repeated application of this method can be used to verify the long term performance of added devices.

The test report will express the result of the test as a single number rating of "diffraction index difference" ΔDI.

ΔDI is the difference between the results of sound diffraction tests on the same reference wall with and without an added device on the top, in decibels.

Still in its development phase, this standard is yet to be adopted and applied in the European highways market.

EN 1793-5 (In Situ Test for Sound Absorption and Airborne Sound Insulation)

Part 5 was developed as a result of concern over the validity of internal laboratory tests for external environmental barriers. Physically EN 1793 Parts 1 and 2 are not wholly representative of the installed operating conditions for a noise barrier.

Still in its development phase Part 5 is already being used widely in Europe as an alternative expression for barrier acoustic performance in product sales literature. It has also been used in specifications for products that cannot be tested in internal laboratory conditions (for example many green screens or profiled barriers take up too much room in a reverberation chamber to provide meaningful test results.

Some barrier designs also rely on gaps such as open barriers. These cannot be tested in normal internal lab conditions for airborne sound insulation.

The test method can be applied both in situ and on barriers purposely built to be tested for product qualification. In the second case the sample shall be built at east 4metres long and

4 metres high (inclusive of posts and fixings as per normal installation conditions).

Results are expressed in terms of:

Sound Reflection Index (Absorption) DL_{RI}

DL_{RI} is the single-number rating of sound reflection performance weighted to the normalised traffic spectrum defined in EN1793-3 and expressed in decibels.

Sound Insulation Index (Airborne Sound Insulation) DL_{SI}

DL_{SI} is the single-number rating for airborne sound insulation performance weighted to the normalised traffic spectrum defined in EN1793-3 and expressed in decibels.

The method is currently as reliable as the laboratory test method especially for typical flat barrier products, though needs further enhancements to cope with more profiled products.

Currently parts 1 and 2 are used in barrier specifications for highways. Eventually the desire may be to replace both of these with part 5 as a way of expressing noise barrier performance. This however will require strong correlation between the two methods which will require more research a familiarity with the test methods.

EN 1794: NON-ACOUSTIC PERFORMANCE

BSEN 1794 covers the elements of barrier performance other than acoustic. Whilst noise reduction defines the purpose of the barrier, how it performs mechanically and structurally is vital for its longevity as is its safety and environmental requirements.

EN 1794-1

This standard covers the mechanical and stability requirements of a noise barrier. By means of either test or calculation this includes the following:

Wind load and static load
Self Weight
Impact of Stones
Safety in Collision
Dynamic Load from snow clearance.

EN 1794-2

This standard covers general safety and environmental requirements of a noise barrier. By means of either test or calculation this includes the following:

Resistance to brushwood fire
Danger of falling debris
Environmental protection
Means of escape
Light reflection
Transparency

Obviously, not all these areas are required for each project. Wind load and static load and safety in collision are vital in every instance to ensure that the barrier meets the requirements of the National Highways Authority. Other areas such as light reflection, or danger from falling debris are more site specific and will vary from location to location.

EN 14389: Durability

Although HA66/95 requires barriers to be built for a 40 year operational life, many barriers fail after only 5 or 10 years due to poor quality of construction. This has highlighted the need for a method for assessing the long term performance of a noise barrier both in terms of its acoustic and non-acoustic characteristics.

Two recent standards are emerging that deal with the durability of the barrier product design:

EN 14389-1(2005) – (Acoustic durability):

Title: *Road traffic noise reducing devices – Procedures for assessing long term performance – Acoustic characteristics.* This standard has been issued in the last year. It provides a method for assessing acoustic durability utilising the in situ test procedure EN 1793-5.

This standard allows a manufacturer to declare the estimated reduction in the acoustic performance of the noise barrier after 5, 10, 15 and 20 years service in given exposure classes assuming its maintenance in accordance with the manufacturer's recommendations. It also provides a method for the customer to return to an existing barrier and re-test it in situ to determine how well it is lasting.

EN 14389-2(2004) – (Non-Acoustic durability)

Title: *Road traffic noise reducing devices – Procedures for assessing long term performance – Non-Acoustic characteristics.* Already published, this standard provides a method for assessing non-acoustic aspects of durability primarily by descriptive means.

The concept of assessing the durability of noise barrier performance has caused the industry some anxiety. It is important to highlight that it is only a method of assessment. This does not necessarily mean it will be regularly used. (*In Germany, a method for assessing long term performance has existed for 18 years though barely used!)*

EN 14388 : (2005) – SPECIFICATIONS

All the current EN standards are 'grouped together within the 'Specifications' standard. This acts as an umbrella standard and will become the first port of call for any noise barrier specifier for highways schemes.

SPECIFICATION DETAILS FOR TIMBER BARRIERS

Despite producing the most robust specification, problems often arise at installation. The need for comprehensive site supervision during the barrier build process is essential to ensure the built barrier matches the specified barrier. Practical aspects should be highlighted within the design specification. Experientially, many of the aspects of workmanship highlighted in this section relate only to timber based barriers. However some of them apply to non-timber schemes also.

Acoustic Tightness

The weakest point of a barrier system's performance is so often the joints or posts fixings. Noise leakage at posts can render a barrier virtually useless and yet it is a simple to avoid both at the design and installation stage.

It may sound obvious, but barriers must reach the ground! Where timber barriers are built onto a gravel board this is rarely a problem. Where the barrier is designed to sit onto a concrete plinth, the self-weight of the bottom panel should provide a sufficient seal however, often gaps are allowed to occur compromising the barriers performance. This can be easily remedied with, for example a strip of compriband to close the gap.

Timber barriers are most commonly built in situ. It is important to ensure that the barrier is then built up to the quality of a professionally designed product. A noise barrier's performance relies on no gaps though the whole barrier surface. With multi-layered timber barriers, sometimes inner panels are not fitted together tightly. This is then covered up with a thin cover strip and the gaps are hidden. If the Customer relies only on a final snagging process, the errors are already invisible but the barriers performance is drastically impaired.

Timber Sustainability

Sustainability is a current priority for the UK Highways Agency. It is essential to ensure that the barrier manufacturer can fully demonstrate that he has a system for providing timber that has *originated from a sustainable source*, and also that he is following that system for the given project.

The specification may read as follows:

> The Contractor shall demonstrate compliance with the specification requirement that timber shall be supplied from legal and managed sustainable sources by providing suitable records of the supply chain for the timber. The responsibility for compliance is with the appointed contractor and not just with their timber supplier.
>
> The contractor shall provide evidence of full compliance with this requirement. Such documentary evidence shall be supplied by the contractor to the Overseeing Organisation with the Contractor's tender submission, prior to appointment and further substantiation relating specifically to the timber and wood actually used shall be supplied by the Contractor to the Overseeing Organisation during the execution of the Works.
>
> Any timber and wood contained in the products supplied or used, whether used for permanent or temporary works, not complying with the requirements of this clause shall be removed from the works at the insistence of the Overseeing Organisation and replaced with material complying with this clause at the expense of the Contractor.

In the UK, prior to the contract being let, the contractor could provide certification detailing BM TRADA Chain of Custody registration to ensure that the timber they normally use does come from a sustainable source thus demonstrating his ability to comply. It is equally important for the customer to examine the documents that come with the actual timber used for the project to ensure that it has does indeed come from that source.

Cutting of Timber On-site

Correctly pre-treated timber will last. Whilst some cutting and drilling of timber on site is unavoidable, wholesale cutting during in-situ installation should be avoided. Furthermore, it is essential that procedures for treatment re-coating of cut surfaces is fully adhered to. Again, this needs to be supervised since most of the timber surfaces are hidden in the final barrier.

Panel Storage On-site

Pre-built modular panels do give an acoustic benefit. They are normally far tighter in construction than panels built in situ. However, it is essential that pre-built panels are correctly stored on site. Better still, if possible that site storage of panels is avoided and that they arrive directly for installation.

The Contractor shall ensure that all panels and materials stored on site or at a designated compound, are held or supported in such a way as to prevent warping, damage or deterioration. Finished products such as modular panels that need to be stored on site or in a compound shall be supported and protected to prevent damage or deterioration prior to installation. This shall be done to the Engineer's approval.

Again, it is recommended that any panels found to be damaged in storage should be removed and replaced at the contractor's expense. This does require a description and examination of how panels are stored on site.

Testing of Acoustic Performance

Should the contractor need to carry out laboratory testing of barriers, it is essential that this follows correct procedures to required standard. For example for European Highways, EN 1793 Parts 1 and 2 must be followed for testing of sound absorption and airborne sound insulation. *(note timber panels arriving at the laboratory in a saturated state should not be tested as their excess weight due to water will distort their test results for insulation*).

In EN 1793, the test for both Sound Absorption and Airborne Sound Insulation requires that the barrier panels are held in place with the same fixings as designed to be used in situ. At the edges, it is allowable to seal, however no sealant can be used on the barrier surface or for example around posts and joints *unless* the contractor intends to do this on site also. Otherwise the noise test will be giving test results for silicone sealant and not for a noise barrier!

Maintaining the Barrier Height

Where the barrier line drops below the line of the kerb, the Contractor shall ensure that the designed barrier height above the kerb is maintained. Where the barrier is set above the kerb, the designed barrier height is the physical height of the barrier. This must be clear in the specification to avoid ambiguity during manufacture and installation.

Gates and Openings

Where access is required through a barrier it is vital to ensure that the gate construction is to the same quality and similar acoustic performance as the barrier itself and that there is no leakage through gaps around the gate frame. Often the gate design is an after thought and the resulting quality is very low.

An alternative and preferable solution would be to create an absorptive overlap in the barrier design for the point of access. Designed correctly, this wouldn't even require a gate. Working like a silencer, a walkway through the barrier would be created with the inner faces being absorptive. Most of the noise from the road is trapped in the walkway zone and the barrier integrity is maintained.

Drainage of Mineral Wool

Common to well designed absorptive barriers, is the inclusion of a *drainage path* for the mineral wool. All too often in metal absorptive barriers, the wool mattress is tightly sandwiched in the barrier cassette. After a while, rain water saturates the mattress and it either slumps in the frame or disintegrates. Since it is internal, this normally passes unnoticed but the barrier is no longer functioning.

This is best avoided in the design of the barrier panel itself by supporting the mineral wool mattress away from the walls of the panel cassette (for example by supporting it in an internal frame). The wool can then drain naturally and saturation is avoided.