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Enhancements to noise barrier design standards for European highways

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ABSTRACT

This paper is an update of recent proposed enhancements to the noise barrier design specification standards for road highways in the European Union. With the growing importance of value management and ongoing barrier maintenance becoming an increasingly costly exercise, the use of durable low maintenance noise barrier systems is becoming essential. These proposed changes would be made to ensure that the reduction in noise emissions from highways can be sustained for the life of a barrier through the specification of effective and durable noise barrier designs. Changes include: 1) Defining higher categories for the specification of acoustic performance for tall barriers both in terms of sound absorption and airborne sound insulation, 2) Requiring outdoor noise testing of all barriers under direct sound field conditions instead of the classical indoor laboratory test regime, 3) The potential use of in situ acoustic testing of barrier durability as a tool for barrier maintenance and asset management.

NOISE BARRIER SPECIFICATION STANDARDS

This paper concentrates on recent proposed improvements to the European specification standards for the acoustic performance of highway noise barriers for the duration of their working life. These improvements respond to the need for acoustically effective, durable, low-maintenance systems as well as taking into account the growing need for the higher acoustic performance of products both in terms of sound absorption and airborne sound insulation.

VALUE MANAGEMENT

In the current European economic climate where the construction of new highways is deemed harder to justify, the need to maintain the integrity of existing assets on highways is becoming all the more important. Older existing noise barriers, though of a lower specification, are considered primary assets and often require repair, retro-fitting, or in many cases a complete upgrade replacement.

In the UK particularly, any closure of busy operating motorways for routine maintenance is becoming a very costly procedure. The cost impact of lane closures is further compounded in the UK by its impact on the factor *Journey Time Reliability* or JTR. This is roughly defined as a cost that is set against the predicted increase in journey time due to motorway maintenance work.

It is therefore a high priority that the design specification of any replacement barrier system is high performing, durable and as close to zero-maintenance as possible so as to keep the number of maintenance visits for routine repair over the working life of the barrier to a minimum. This in turn keeps the whole-life-cost of the barrier scheme low.

Recent proposed improvements to existing standards allow for higher noise barrier acoustic performances to be specified at the design stage and also allow for the in-situ assessment of acoustic performance. This enables the value of the barrier-asset to be managed over its complete working life.

EUROPEAN STANDARDS FOR ACOUSTIC PERFORMANCE

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. These have been rejected in favour of noise barriers and low noise road surfacing.

As a result the need has grown for Europe to have an agreed set of noise barrier design specifications based on certified laboratory tested performance to ensure that effective long-

lasting barriers are built that significantly reduce noise levels and public complaints.

What has followed over the last fifteen years is the emergence of new European EN performance standards for highway noise barriers to serve as the back-bone for noise barrier specification and to help create a fair market for barrier products across the continent.

EN 14388 (2005): SPECIFICATIONS

All the current EN standards for highways noise barriers are grouped together under the umbrella standard EN 14388 (2005) – *Road Traffic Noise Reducing Devices - Specifications*.

This standard covers acoustic, non-acoustic and long term performance, but not aspects such as resistance to vandalism or visual appearance. For product conformity, that is for a noise barrier to be considered for the European highways market this standard requires that the barrier product would need to have been assessed and categorised in accordance with the required parts of EN 1793 for acoustic performance and the required parts of EN 1794 for non-acoustic performance (mechanical, structural, environmental and safety).

EN 1793: Acoustic Performance – Prior to Changes

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. In 2008, prior to any proposed changes the list of acoustic standards was 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: (1997) Road traffic noise reducing devices: Test method for determining the acoustic performance – Part 3: Normalised traffic noise spectrum.

CEN/TS 1793-4: Road traffic noise reducing devices: Test method for determining the acoustic performance – Part 4: In situ values of diffraction. This is currently a TS or test standard.

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

EN 14389-1(2007): Road traffic noise reducing devices: Procedures for assessing long term performance: Acoustical characteristics. This is currently a TS or test standard.

PROPOSED MODIFICATIONS TO THE ACOUSTIC STANDARDS

Standards are always subject to periodic change for improvement. Any changes detailed below are considered improvements but are at present proposals awaiting full agreement of all the member states. They will then be accepted as full replacements to the exsiting standards.

Primary Changes to EN 1793-1

EN 1793-1 provides a test method to categorize the sound absorptive performance of a noise barrier as a single number rating. Currently these categories range A0 to A4 covering a DL_α range from *Not determined* to > *11dB*.

It is acknowledged that under diffuse sound field conditons: high sided barriers, tunnels and covers, high sound absorption levels may be required. The proposal is to add a higher category A5 for DL_α values > *15dB*.

This would give the revised categories of absorptive performance as follows:

Table 1
Categories of Absorptive Performance

Category	DL_α dB
A0	Not determined
A1	$DL_\alpha < 4$
A2	4 to 7
A3	8 to 11
A4	12 to 15
A5	> 15

Source: prEN 1793-1 (2010)*

* *prEN* denotes that this version is currently a working document awaiting full approval as a revised standard.

Primary Changes to EN 1793-2

EN 1793-2 utilises the test facility described in EN ISO 140-3. Because of the reverberant nature of the laboratory it is proposed to limit the scope of the standard to diffuse sound field conditions only. The title of the standard would be changed to: *Road traffic noise reducing devices: Test method for determining the acoustic performance – Part 2: Intrinsic characteristics of Airborne Sound Insulation under diffuse field conditions.*

The Scope would clarify that this standard is not intended for noise reducing devices that are to be installed on roads in non-reverberant conditions. This would greatly reduce the use of this standard in favour of the new standard prEN 1793-6 which is considered a more representative method for direct sound field condions.

EN 1793-2 provides a test method to categorize the airborne-sound insulation performance of a noise barrier as a single number rating. Currently these categories range B0 to B3 covering a DL_R range from *Not determined* to > *24dB*.

It is acknowledged that for high sided barriers, high airborne-sound insulation levels may be required. The proposal is to add a higher category B4 for DL_R values > *34dB*.

This would give the revised categories of airborne sound insulation performance as follows:

Table 2
Categories of Airborne Sound Insulation

Category	DL_R dB
B0	Not determined
B1	$DL_R < 15$
B2	15 to 24
B3	25 to 34
B4	> 34

Source: prEN 1793-2 (2010)*

* *prEN* denotes that this version is currently a working document awaiting full approval as a revised standard.

Primary Changes to EN/TS 1793-5

CEN/TS 1793-5 in its current form gives a test method for determining in-situ values of both sound reflection and airborne sound insulation. Currently whilst the in-situ method for determining airborne sound insulation is considered reliable, the method for sound reflection requires more research.

Because of this, it was decided to split the method into two new standards:

CEN/TS 1793-5: Road traffic noise reducing devices: Test method for determining the acoustic performance – Part 5: Intrinsic characteristics – In-situ values of sound reflection under direct sound field conditions.

prEN 1793-6: Road traffic noise reducing devices: Test method for determining the acoustic performance – Part 5: Intrinsic characteristics – In-situ values of airborne sound insulation under direct sound field conditions.

Using prEN 1793-6

EN 1793-6 is intended for the following applications:

- determining the airborne sound insulation of a noise barrier to be installed along roads, to be measured either in-situ or in laboratory conditions.

- determining the airborne sound insulation of a noise barrier in actual use.

- comparing the design specifications with actual performance data after the completion of the construction work.

- verifying the long term performance of a noise barrier with a repeated application of the method.

- designing new products, including the formulation of installation manuals.

prEN 1793-6 is not intended for determining the airborne sound insulation of a noise barrier to be installed in reverberant conditions eg: tunnels, deep trenches or covers. The scope of prEN 1793-2 would cover this.

prEN 1793-6 would provide new categories of airborne sound insulation performance: DL_{SI}. Again these would be presented as a single number rating. Since these are determined by a different method and under different conditions, the values would not be numerically the same as those obtained using prEN 1793-2 however it is intended that they are coincident with them.

The values are as follows:

Table 3
Categories of Airborne Sound Insulation

Category	DL_{SI} dB
D0	Not determined
D1	$DL_{SI} < 16$
D2	16 to 27
D3	28 to 36
D4	> 36

Source: prEN 1793-6 (2010)*

* *prEN* denotes that this version is currently a working document awaiting full approval as a revised standard.

Long Term Performance

The acoustic characteristics of a noise barrier can deteriorate significantly over the duration of its working life if it is not installed or maintained in accordance with the manufacturer's recommendations or if the materials are not approporiate for the roadside environment. EN 14389-1 (2007) defines the means of evaluating their acoustic durability.

The sound absorption is characterised by the reflection index DL_{RI} as defined by CEN/TS 1793-5. The airborne sound insulation is characterised by the airborne sound insulation index DL_{SI} as defined by prEN 1793-6*

** The standard currently only references CEN/TS 1793-5. This will be updated to show the change to prEN 1793-6.*

Assuming prEN 1793-6 is accepted as a European standard, this will provide an agreed method for the in-situ acoustic testing of barrier durability.

FURTHER SPECIFICATION DETAILS FOR TIMBER BARRIERS IN THE UK

Having utilised the European Standards in EN 14388 (2005) to produce the most robust contract specification problems can still arise at the installation phase. In the UK this has especially been the case for timber-based barriers.

The need for comprehensive site supervision during the barrier build process has been essential to ensure the built barrier matches the specified barrier. Practical aspects relating to the installation process need to 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 points of a barrier system's performance are 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 is essential to ensure that the interface between the barrier and the ground is permanently sealed with no potential of gaps opening up in the future.

To ensure that this is the case, it is recommended that the barrier is constructed with a gravel board embedded to a depth of at least 100mm below the ground surface or the barrier itself rests on a concrete sill embedded to a depth of 100mm. The gravel board itself shall be constructed from material resistant to rotting in contact with the ground

Where the barrier is designed to sit onto a concrete sill, the self-weight of the bottom panel should provide a sufficient seal. Supporting a timber barrier panel simply on the post fixings without a solid base is insufficient as it could result in the panel deforming substantially over its working life. It could also result in gaps forming under the barrier panel itself.

Traceabililty of Timber Sources

Sustainability is a 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 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 process should 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 should 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 should be supported and protected to prevent damage or deterioration prior to installation.

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.

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 for timber barriers 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 walkway in the barrier design for the point of access. Designed correctly, this wouldn't even require a gate. Working like a physical silencer, a walkway through the barrier would be created with the inner faces being absorptive. Most of the noise from the road would be trapped in the walkway zone and the overall barrier acoustic integrity is maintained.

Drainage of Mineral Wool

Common to mineral wool based absorptive barriers, is the need to include a *drainage path* for moisture. Both in timber and metal based 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.

REFERENCES

1 Giles Parker, "Effective Noise Barrier Design and Specification" (Proceedings from ACOUSTICS 2006, Christchurch New Zealand)