Railway noise mitigation factsheet 02: Full-height noise barriers

1.1 Overview

Full-height noise barriers are defined in this factsheet as being barriers greater than 1.0m in height. When used on railways, these barriers are installed at the trackside, generally no closer to the track than the signal posts, electrification masts, etc. and are one of the most common forms of noise mitigation used on railways.

Noise barriers can provide screening from:

- Noise generated at the wheel/rail interface

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- Other sources such as powertrain noise, and aerodynamic noise
- Noise caused by passage of the pantograph

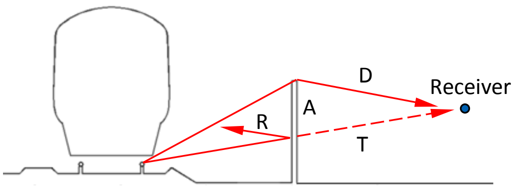
The effectiveness of the noise barrier in mitigating these different noise sources is dependent upon the height of the barrier. For trains travelling at high speeds (in excess of 340 km/h), aerodynamic noise sources will be the primary source of noise disturbance. Aerodynamic sources can be distributed over the full height of the train (see Factsheet 01, 'Overview of railway noise'); whilst noise barriers will screen sources of aerodynamic noise that are close to the ground and sources at mid-height, it is noted (WG Railway Noise, n.d.) that noise barriers less than 4m in height will have an insufficient screening effect on aerodynamic noise sources on the top of rolling stock, e.g. pantographs and their recesses.

Literature suggests that pantograph noise is most effectively treated directly at the source, e.g. by screening the pantograph directly on the rolling stock itself. There is a significant body of reported research in this area however this is outside the scope of this factsheet.

Care must therefore be taken, when modelling/calculating noise barrier performance, to use prediction models which are capable of addressing the contributions from aerodynamic noise.

1.2 Mitigation modes

Noise barriers reduce noise levels at a receiver behind the barrier by obstructing the direct transmission of airborne sound emanating from the source in front of the barrier (in this case, rail traffic). Sound waves are either reflected back from the barrier, absorbed by the barrier, transmitted through it or are diffracted[1] over the top of the barrier (see Figure 2).



To minimise the effects of sound transmission, the sound transmission loss performance of the barrier should be at least 10 dB(A) greater than the overall noise reduction required at the receiver. For example, if the target noise reduction at the receiver is 15 dB(A), the sound transmission loss provided by the barrier (measured in accordance with EN 1793-2) should be at least 25 dB(A). The presence of gaps in the barrier due to joints between elements, poor construction/installation, etc. will affect sound transmission performance. The significance of sound transmission increases dramatically when a barrier is required to provide a high level of noise attenuation and as the barrier height increases.

The level of mitigation offered will also be affected by the position of the barrier relative to the track and the local topography. The closer a barrier is located to the source, the greater the degree of screening that can be achieved.

[1] Diffraction is the bending of sound waves around an obstacle and is dependent upon the frequency of the sound and the size of the barrier or obstacle.

1.3 Noise barrier design

Barrier materials: Noise barriers can be constructed from a wide range of materials including timber, aluminium box sections/panels, concrete, porous concrete, wood cement (where the wood fibres are coated with cement to form a porous matrix of bound fibres. or stone (usually as gabion constructions). The material used can influence whether the noise barrier is constructed on site or from pre-fabricated modules. The choice of material can be influenced by the environment/landscape where the barrier is being installed; soil types and barrier dimensions will determine foundation requirements which might also influence choice of barrier materials (mass structures, e.g. concrete may require less foundations than conventional panels and posts). Timber noise barriers were used on HS1, however the physical condition of such barriers will deteriorate over time compared to other materials.

The use of sound absorptive noise barriers will help to reduce the impact of sound waves reflected between the body of the train and the noise barrier.

Transparent sections can sometimes be included to break up the visual impact of the barriers. It has been reported (Watts et al., 1999d) that human sensitivity to noise appears to be greater when the source of noise cannot be seen; in principle therefore transparent barriers may provide greater perceived sound insulation than opaque barriers of the same height, although it is not known if this has been evaluated in detail. There are further benefits to transparent screens in that there is less reduction in light levels and residents can see across the railway (although some individuals may prefer an obscured view). Downsides to transparent barriers include the need for regular cleaning and bird impact.

Vegetative barriers are those made of living vegetation; however these need regular irrigation and maintenance. Alternatively it may be possible to use the barrier itself as a support structure for vegetation such as climbing plants, etc. to mask the appearance of the noise barrier from the residential side; concrete barriers are particularly well suited for this purpose. However, regular maintenance of the plants will be required to control growth and maintain an appropriate visual aesthetic.

No information has been identified regarding materials or barrier types that are unsuitable for barriers on high-speed rail lines. However, careful design may be required when used on high-speed rail lines in order to take account of the cyclic dynamic loading caused by the repeated aerodynamic pressure and suction of passing trains.

Figure 3 shows examples of different types of noise barrier construction/materials.

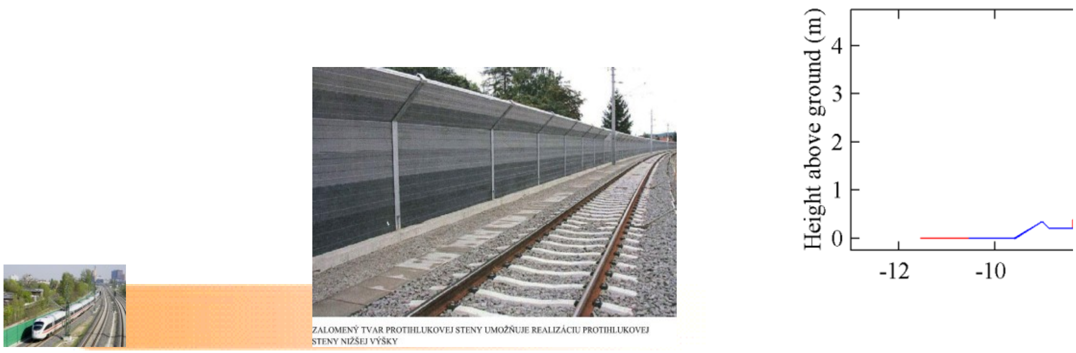
(a) Stone gabion barrier, Germany (Photo: Ferrondo GmbH)

(b) Aluminium barrier with transparent section, Germany (Source unknown)

(c) Wood cement barrier, Spain (Photo: Salduie Inversiones S.L.)

Figure 3: Examples of noise barriers constricted with different materials

Barrier shape/profile: Noise barriers are conventionally vertical. However, the shape of the noise barrier alters the level of mitigation offered. The primary objective will be to keep the top edge of the barrier as close to the railway as possible to maximise the diffraction effects offered by the barrier. The use of cantilevered or tilted designs allows for this whilst reducing reflections between the train and the noise barrier, potentially offering improved screening relative to the vertical barrier, as well as increased space for worker access at the track edge. Figure 4 shows examples of different noise barrier profiles.



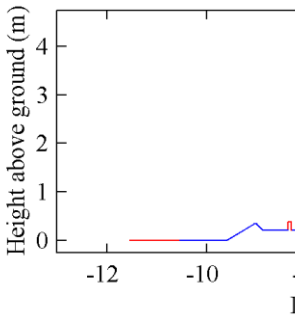
a) Vertical barrier, Germanyy
(Photo: DB AG/Günter Jazbec)

(b) Cantilevered barrier, Hungary (Original source unknown)

(c) Curved barrier
(from Morgan and Watts, 2004)

Figure 4: Examples of different noise barrier profiles

The use of added devices or caps onto the top of a barrier can improve the performance of the barrier. These devices work in various ways, either by increasing the number of diffracting edges, generating sound interference patterns which result in cancellation of some of the sound passing over the top of the barrier, causing the diffracted sound to pass over sound absorptive surfaces or using Helmholtz resonators[2]. The end result is similar to the degree of screening offered by a vertical screen of greater height and therefore offers increased options if barrier height needs to be restricted. Figure 5 shows examples of some of the different types of tops that have been investigated. It is unclear as to whether any of these devices have been adopted in practice.



[2] A Helmholtz resonator is a container (or in this instance, a hollow element on a noise barrier) with a small open neck; the air in the cavity resonates when the air is excited.

(a) Prototype interference device (from Tahara et al., 2010)

(b) Y-shape noise barrier (from Murata et al., 2006)

(c) Curved barrier (from Morgan and Watts, 2004)

Figure 5: Examples of different noise barrier profiles

Research into the use of added devices for use on railway noise barriers, e.g. Tahara et al (2010), Morgan and Watts (2004), Koh et al. (2012), has been largely restricted to computer modelling or scale model experiments, although there have been limited full-scale trials of some designs, e.g. Jung et al. (2006), Murata et al. (2006), Belingard et al. (2012).

Results from the various studies suggest that noise reductions of up to 3 dB(A) greater than the vertical screen alone can be achieved, depending upon the design. An increase of this magnitude is approximately equivalent to increasing the height of a vertical sound absorptive barrier by 1 m.

More recently, work has been reported on the use of sonic crystal noise barriers, which are barriers made up of a series of cylinders that can let light and air through while scattering sound waves. Figure 5 shows an illustration of an installation in the Netherlands on the A2 near Eindhoven. Loughborough University has undertaken much of the work in the UK in this field and based on their research, more than 30 companies, spanning the rail and renewable energy sectors, are engaged in the development of the technology.

Construction: Whilst it is not proposed to discuss different construction methods within this document, it is recognised that ecological requirements will have to be taken into account in the design process. Ecological surveys will need to be performed to establish the types of wildlife in the vicinity and how the presence of barriers might affect their movements.

Figure 1: Railway noise barrier, Germany

(Reproduced with permission of SDG Construction Technology Ltd)

1.4 Indicative performance levels

Based on a summary of pass-by noise levels reco
trains, noise levels for trains travelling at 300 km/
at 25 m from the track (Gautier, Poisson and

further details). At the speeds at which HS2 is expected to operate (360 km/h for initial technologies and trains; HS2 Ltd, n.d.), Gautier et al. report levels of the order of 95-97 dB(A). Assuming that similar train technologies are used, pass-by levels in excess of 90 dB(A) will need to be considered.

For comparative purposes, pass-by noise levels at 25 m from a motorway due to vehicles travelling at or close to the speed limit will be of the order of 75 dB(A) in the absence of any noise mitigation.

Noise barriers provide screening at a local level only, e.g. in the vicinity of where they are installed and not across the network. A 2012 European Commission report (Clausen et al., 2012) suggests typical levels of noise reduction are, on average over a range of different receptor positions, of the order of 10 dB(A) for 2 m high barriers and 15 dB(A) for 3-4 m high barriers; however no information is provided in terms of barrier position or type/design. A report by Oertli and Hübner (2010) suggests reductions of 5-15 dB(A) but does not include any information on the height or type/design of barriers to which this applies. Numerical modelling of different types of railway noise barrier reported by Morgan and Watts (2004) suggests similar levels of performance for sound absorptive noise barriers.

1.5 Illustrative costs

The costs presented are for illustrative purposes only since they will be dependent upon a wide range of factors, including the design, materials and height of the barrier as well as the ground conditions at the point of installation.

Figures collated in a 2008 report for UIC (International Union of Railways; Hemsworth, 2008) suggested costs of the order of €1,000/m for a 2m high barrier, €1,350/m for a 3m high barrier and €1,700 for a 4m high barrier.

Indicative costs for the supply and erection of a 1 m length of noise barrier with a height of 3m were reported by Watts and Morgan (2005). Although the costs are now out-of-date, it is considered that the rank ordering of barrier materials is probably still of some relevance. The figures showed that the lowest costs were applicable to timber noise barriers, whilst the highest costs (approximately 3 times greater than for single-leaf, reflective timber barriers) were for transparent, acrylic barriers. Concrete barriers were approximately twice the cost of the timber barriers and aluminium panels were marginally cheaper than the transparent, acrylic barriers.

In terms of cost per decibel reduction, timber barriers appear the most cost effective solution, although they may not be suited for use in close proximity to high-speed rail lines. In terms of whole life costs, over for example a 20 to 30 year period, a more robust barrier may be more cost effective.

1.6 Benefits and disbenefits

The **benefits** of full-height noise barriers can be summarised as follows:

- The design, application and performance of this type of mitigation is well established for use on railways;
- Noise barriers have a small physical footprint compared to other mitigation measures such as earth embankments and in the majority of cases do not require

the use of ground outside of the boundaries of the railway;

- They can be used alone or in combination with other mitigation measures such as earth embankments.

The **disbenefits** of full-height noise barriers can be summarised as follows:

- In order to potentially provide screening of aerodynamic noise sources on the top of the trains, noise barriers will have to be at least 4 m high;
- Potential adverse visual impacts for residents (although the view can be preferable to the direct view of a railway line) and light loss. However, with careful design and the selection of appropriate materials such impacts can be reduced; for example, in some countries within mainland Europe, e.g. Germany and the Netherlands, it is not uncommon for noise barriers to be made a distinct design feature of a highway;
- Safety, in terms of restricted/prohibited emergency escape from the track. However, with careful design, e.g. the inclusion of access gates at regular intervals along the barrier length, such impacts can be reduced;
- Vandalism and maintenance. With careful design, e.g. the selection of materials that are both vandal proof and durable, such impacts can be reduced;
- There may be effects on the movement of wildlife which will have to be taken into account during the design process.

1.7 Suitability for use on HS2

Full-height noise barriers can be used in a wide variety of locations. Whilst the primary application for HS2 will be on open ground for screening residential dwellings where the line is running at grade and there are no natural/artificially created landforms such as earth berms or cuttings. They may also potentially be implemented as a supplementary measure on top of earth berms (but typically with a height less than 1.0m) or as one of a combination of measures on viaducts (Ch 26+000 – 29+500; Ch 50+500 – 51+100; Ch 52+500 – 53+100; Ch 64+350-65+250); this is discussed further on Factsheets 05 and 06 respectively.

It is also noted that there are a number of instances where road infrastructure is likely to cross the proposed route (Ch 48+800; Ch 57+800; Ch 67+600; Ch: 71+600), rail infrastructure is likely to cross the route (Ch 80+200) and where there will be bridge crossings by Rights of Way. It is foreseen that noise mitigation measures may be required at these locations; as such, the use of noise barriers is likely to be the most appropriate option.

- For mitigation on road bridges, it is expected that conventional road traffic noise barriers will most likely be suitable as frequently used on highways, although wind loading due to air turbulence effects from passing HS2 trains might require additional design constraints;
- For mitigation on rail bridges, the performance design requirements will be less restrictive than for HS2 due to the significantly lower operating speeds, however as noted above, increased wind loading requirements due to the passage of HS2 trains may also have to be taken into account in the design;
- Bridge crossings by Rights of Way may require noise mitigation to be included to shield pedestrians and other users from the high noise levels that will be

experienced due to the passage of HS2 trains. Screening may also be required to minimise potential turbulence effects on the users of the bridges and for security reasons. Barrier materials might therefore be used as bridge parapets and any additional structures might serve as fixings for cladding materials. Depending upon the dimensions of the bridge and the height of any screening, the use of transparent materials may be beneficial.

1.8 References

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