Plants and Environmental Noise Barriers

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Abstract
Since the introduction of more effective and stringent noise legislation across Europe, environmental noise barriers have become ubiquitous features along many road corridors. Barriers to mitigate noise and views of traffic may be located wherever there is development and human activity, along inner city routes, suburban byways and also along more rural routes where villages and recreational areas require protection. It must be recognised that noise barriers are architectural features in their own right and that they should be designed to fit into their local environments. Indeed, if these barriers are not designed for each individual location they are likely to remain alien visual elements and diminish landscape character and landscape quality. The main aspects of good environmental noise barrier design include the appropriate manipulation of elements and materials and most importantly incorporate the use of plants. When designing noise barriers, plants should always be considered as part and parcel of the design. Plants not only help to integrate the barrier into its surroundings, by reducing apparent scale and screening elements, but they can also provide an aesthetic contribution by softening appearance and by providing architectonic form and robust features. A great depth of soil is not a necessary requirement. Plants can indeed form an integral part of noise barrier design in what are termed 'bio-barriers'. The earth mound is the simplest effective environmental noise barrier. Reinforced earth mounds are used where space is limited but a natural looking barrier is required. Bio-barriers may be divided into four generic types: the 'A' frame and vertical, the box wall, woven-willow and stack and crib bio barriers. Many studies have been undertaken to indicate whether plants themselves reduce noise and this appears possible in certain situations.

INTRODUCTION
 When we talk about noise we are interested in its effects on people, as it appears that most other sentient creatures are generally unaffected by a constant and predictable noise source. When discussing the mitigation of traffic noise it is worthwhile considering the terminology we use. In the United Kingdom the broad term Environmental Noise Barrier is used. One of the reasons for doing this is that it stresses the fact that it is the environment we are protecting and that environment includes people. We cannot call them environmental barriers because this can mean all sorts of other things. For example for a geotechnical engineer an environmental barrier is something that may be used in the ground to combat soil erosion or soil contamination. In German, the term used is Lärmschutz, which translates as "noise protection" in English, but this term appears to miss out the key word of environment.

Indeed when we look at the issue of noise we need to go back some 2000 years where it has been recorded that noise was an issue. The Romans were all too familiar with the unwanted noise of wheels on stone streets and issued a decree, which banned the use of chariots on the streets of Rome at night (Kotzen and English 1999). More recently, the introduction of more effective and stringent noise legislation across Europe, has meant that environmental noise barriers have become ubiquitous features along many road corridors (Fig. 1). Barriers to mitigate noise as well as views of traffic are thus located wherever there is development and human activity, along inner city routes, suburban byways and also along more rural routes where villages and recreational areas require...
protection. Noise barriers are architectural features in their own right and they should be designed to fit into their local environments (Fig. 2). Indeed, if these barriers are not designed for each individual location they are likely to remain dull, contrived visual elements and diminish landscape character and landscape quality. They can also be overdesigned thus also becoming overelaborate and unnecessary elements in the landscape (Fig. 3).

Noise is not only an acoustic issue, but it is ‘a landscape issue’ as well (English and Kotzen 1994, Kotzen and English 1999). From a landscape perspective, this means that the visual qualities of any noise barrier should be considered on an equal footing with the noise issue and thus it is important to understand aesthetic considerations when designing these structures.

THE BASICS OF ENVIRONMENTAL BARRIER DESIGN

One of the main principles of noise barrier design is to limit long lengths of barrier of the same form and material. This also is the case with bio barriers, i.e. barriers that incorporate and integrate planting within their forms and structures (Fig. 4). Another principle is that timber barriers should never ever be placed on bridges or overpasses (Fig. 5). Wherever possible barriers on viaducts and bridges should be transparent and as light as possible (Fig. 6). Where traffic needs to be hidden opaque barriers must be used.

There are different options for controlling traffic noise (Fig. 7). The first option is not having barriers at all and using distance as a means of mitigation. The second option, which has both noise and visual benefits, is to use tunnels. The third option is to place the transport corridor within natural cuttings or depressions, or by creating false cuttings with earth mounds. We can also use environmental noise barriers whether they are vertical, cantilevered, and reflective or partially noise absorptive. Noise absorptive surfaces such as porous asphalt or whisper concrete, can be used in areas which do not suffer very hard winters. Insulation of properties through double glazing and other means of ventilation is another possibility. A further option, so called “integrated barriers” utilises other structures such as other utilitarian buildings to mitigate the noise.

There are basically two ways in which barriers reduce noise. They either reflect the noise or they partially absorb noise. Reflective barriers may be constructed out of any dense material, whilst partially absorptive barriers usually have a perforated skin and a chamber behind into which the sound waves enter and get dispersed. Noise barriers should be considered to be items of architecture and if they are not analysed sufficiently then we end up with visual errors. It is thus important to have a morphology, which allows the designer to discuss the barrier in logical terms (Fig. 8). It is also important to get the barrier proportions correct. Barriers, like architecture, which are top or bottom heavy appear awkward and badly designed (Fig. 9). Often, it is necessary to use transparent sections at the top of barriers or to cantilever barriers away from the viewer in order to reduce visual impact (Fig. 10). Finally, barriers can be angled to help reflect noise skywards and help create a more dynamic visual effect (Fig. 11).

PLANTING AND BARRIERS

Earth Mounds

When one is designing a cutting, a false cutting or earth mounding, the planting should form part of the strategy not only to stabilise slopes but also to help integrate the mound into the landscape. Unless one is trying to create some kind of visual dynamic, the character of the planting should help to better integrate the mound into the landscape or townscape as well as potentially having some ecological and wildlife benefit. In the United Kingdom and elsewhere in Europe, planting can significantly increase biodiversity and wildlife content (Fig. 12).

Planting should be considered as an essential part of barrier design. Firstly, *Parthenocissus quinqufolia* and other vertically oriented plantings do not require a large amount of space: 300 mm may be adequate for climbers and a meter or less for other
woody plants. The planting to the left of the train in Figure 12 is planted in a trough, which is considerably less than a meter wide. This planting helps to soften the appearance of the barrier and break up the scale. With large-scale barriers, planting is extremely important both within the immediate vicinity of the barrier as well as further afield (Fig. 2). With sequential planting, where planting is used immediately behind the barrier and then in a sequence, at distances away from the barrier, barriers can become almost invisible in the landscape (Fig. 13). We can see how important planting behind the working face of the barrier is for people viewing the barrier for the protected side but it is also important when viewing the barrier from the road side where the apparent scale of the barrier can be diminished (Fig. 14). Planting is an important element even when using transparent barriers as it helps to add some nature and softening to the road corridor. Light and shade provided by planting is also important (Fig. 15).

Bio Barriers

Bio barriers, e.g. barriers, which are designed, to specifically incorporate planting within their structures, are used specifically where there is too little space to incorporate planted earth mounds (Fig. 16). A 4 meter high bio barrier can be positioned in a space 2.5 metres wide, whilst a 4 meter mound requires a space of at least 14 metres. There are a number of these types of bio-barrier, usually up to about 4 metres in height, many of which are used in Switzerland and in Holland. In the first instance, the box frame bio barrier has been used quite extensively and successfully (Figures 4 and 17). Similarly, the A frame barrier which uses corten steel plates and associated willow, alder and other planting has been successful (Figure 17). There is also a vertical system used in Holland, which relies on timber struts to support it (Figure 17). The one reported problem with both the vertical and the A frame barrier is that plant stems that are tied onto the frames may chaff against the metal and over time their may be losses. Metal stack bio barriers, which are usually constructed of steel framework and planters, also work well (Figure 17). Using a simple method of stacking large concrete drainage pipes can also be effective if planted and maintained appropriately. Another bio barrier is the willow - wall (Figure 17). Many of these barriers have failed because it was thought that the horizontal willow canes would root and provide structural stability. But this did not happen and some barriers have collapsed but additional support has been provided with timber stakes. Finally there are the concrete and timber stacking and crib systems, which can be used in more domestic situations as well as within larger schemes (Figure 18). These are usually successful but planting establishment and maintenance is critical to the visual effect because viewing the blocks or the cribs is not always visually pleasing, but once planting is established the effect can be very pleasing (Figure 19).

Literature Cited


Figures

Fig. 1. Bold and successful noise mitigation on an existing viaduct built by Mussolini in Genoa, Italy.

Fig. 2. Although extremely large, this barrier has been successfully visually integrated into the landscape near Bellinzona, Switzerland. This will become more apparent as the planting matures. However, a transparent top section would lessen its visual impact.

Fig. 3. A contrived and visually inappropriate barrier in the Netherlands with inappropriately tall columns and baubles adjacent to an oak woodland and housing beyond.

Fig. 4. A timber and box type bio barrier in the Netherlands illustrating a change of material, which helps to minimise visual boredom.
Fig. 5. Opaque timber barriers across viaducts and bridges may hide the traffic but are visually abhorrent.

Fig. 6. The barrier on the Aare viaduct near Bern, Switzerland, changes from transparent to opaque where visual intrusion becomes an issue. This is apparent to the left of the image.
Fig. 7. Noise mitigation options.
Fig. 8. Barrier morphology.

Fig. 9. Barrier proportions: when the top of a barrier is of a different material a more aesthetic appearance is usually achieved if it is 20-30% of the vertical barrier height.
Fig. 10. Reducing apparent barrier heights.

Fig. 11. Angled barriers and spatial effects.
Fig. 12. Native tree and shrub planting as part of a barrier design helps to increase visual and ecological character alongside a road and rail corridor near Hamburg.

Fig. 13. Planting incorporated within the barrier planter and adjacent trees help to integrate the barrier into the landscape.

Fig. 14. The visual character of the barrier is relieved by the barrier design as well as by the large scale tree planting behind which makes it appear smaller.

Fig. 15. Planting behind a transparent noise barrier provides a ‘natural’ and more acceptable character for the barrier.

Fig. 16. Comparative land-take-for a 4 metre high earth mound and a 4 metre high bio-barrier.
Fig. 17. Bio-barrier sections.
Fig. 18. Crib and stacking systems.

Fig. 19. A fully vegetated concrete crib system provides a large verdant screen alongside a motorway in Switzerland.