Railway noise mitigation factsheet 05: Cuttings and earth berms

1.1 Overview

In certain locations, the best option for the mitigation of railway noise may be to place the railway line low relative to the surrounding terrain (in a shallow cutting, the sides of which would be at a shallow angle to the horizontal), or to sink the line into a deep cutting (the sides of which would be at a steep angle) so that the sides can shield sensitive areas from railway noise (European Commission, 2002). Depending upon the terrain, the sides of the cutting may be acoustically hard, e.g. rock, or more acoustically absorptive, e.g. earth.

In some instances, it may be preferable to construct a cutting and then use cut-and-cover techniques enclose it, transforming it into a so-called 'green' tunnel; such tunnels are addressed in Factsheet 04, 'Tunnels'.

Earth berms can also be to reduce railway noise as an alternative to conventional noise barriers, although not necessarily to the same effect. Earth berms on both sides of the line can effectively be considered as placing the line in a cutting, although the effects on radiated sound will differ on reaching the tops of the berms, as there will be a reduced ground absorption effect relative to cuttings.

1.2 Mitigation modes

Cuttings: Placing the sound source in a cutting will obstruct the direct transmission of sound between the source and receiver. However, studies of sound in and around railway cuttings (Heutschi, 2008) found that noise levels can be dominated by multiple reflections between the sides of the cutting and passing rolling stock and between the sides of the cutting themselves. This is a particular issue when the walls of the cutting are acoustically hard.

Earth berms: Earth berms also obstruct the direct transmission of sound between the source and receiver; however the slopes of berms are more often considerably shallower than cuttings. As the slope of the berm decreases (becomes flatter), there is a greater likelihood both of sound being reflected/scattered towards the top of the berm and the generation of surface waves which propagate along the berm surface, and over the top of the berm, thereby reducing the screening effects. The screening performance can therefore be improved by steepening the front (source facing) slope.

Berms with highly absorptive surfaces suppress reflected and scattered sound waves as well as providing additional sound absorption benefits in terms of the sound passing over the soft top surface of the berm (British Columbia Ministry of Transportation and Highways, 1997). The screening performance of berms can also be enhanced when using low-height noise barriers on the tops of the berms (e.g. British Columbia Ministry of Transportation and Highways, 1997; Watts, 1999).

1.3 Design

Cuttings: The depth of the railway cutting does not greatly affect the noise reduction. This is because the improved screening provided by the increased depth of cut is offset by the increase in reflected noise from the opposite side of the cut area (European Commission, 2002).

Improvements in the screening of noise from cuttings can potentially be achieved in a number of different ways:

- Through the use of absorbent side surfaces or sloping the reflecting side of the cutting, where space is not an issue. Stone gabbions with sound absorptive cores (as discussed in Factsheet 02: Full-height noise barriers) could potentially act as both the retaining wall of the cutting and as an absorptive surface;
- The combined use of cuttings and noise barriers ;
- The combined used of cuttings and earth berms. This potentially has additional benefits; for example, planners in Denmark have discussed placing highways in a cutting and then using the surplus soil and material to establish embankments along

the highway (Bendtsen, 2010).

Earth berms: The level of screening provided by earth berms depends on the height and slope combination implemented. For berms with 3m high tops and a 20° slope, the volume of material required to construct the berm rises with the square of the height.

Earth berms can be built from a range of earthen materials such as soil, stone, rock and rubble (Fleming *et al*, 2004). They are generally constructed with side slopes of 2:1 (2m horizontal to 1m vertical) although they can be as steep as $1^{1}/_{2}$:1 depending on site-specific factors. It is important to note that the sloping sides of the berm must be gradual enough to ensure the stability of the structure (Fleming *et al*, 2004).

The top of the earth berm can be designed with minimal width or with a wide plateau. A wider plateau on the top of the berm requires more space, but can be used for the placement of additional mitigation features such as noise barriers, which can further enhance the acoustical performance of the earth berm (Fleming *et al*, 2004).

1.4 Indicative performance levels

Cuttings: No indicative levels on the noise reduction from railway cuttings have been identified other than limited scale model experiments reported by Heutschi (2008). These considered a 64m long cutting and receiver positions up to 15m away from the cutting with heights from 2-6m above the outlying ground; three different cutting widths (4, 8 [two tracks] and 16m [4 tracks]), two different cutting heights (4 and 8m) and two angles of cutting wall (0° and 10° from vertical) were considered. The presence of the cutting itself was found to increase noise levels. Looking at the effects of using sound absorptive treatments on the cutting walls relative to reflective cutting walls, noise levels could be reduced by between 4 and 12 dB(A) depending upon the receiver by using absorptive materials in the 4m wide cutting; as would be expected, the largest differences were found for narrow deep cuttings with vertical walls; the effects of the absorptive materials were reduced as the cutting width increased.

Earth berms: The level of screening provided by earth berms depends on the height and slope combination implemented. In guidelines produced by the British Columbia Ministry of Transportation and Highways (1997) on the use of berms for controlling highway noise, it is noted that earth berms provide approximately 2 dB(A) less than noise barrier of the same height and in the same position (it is assumed this is with respect to the position of the front top edge of the berm and barrier) due to sound waves being reflected or scattered towards the top of the berm or surface waves propagating over the crest of the berm. Berms with highly sound absorptive surfaces will perform 4-5 dB(A) better than berms with normal grassy surfaces.

Due to the large footprint of the berm, if the foot of a noise barrier were moved to the same position as the front foot of the berm, the loss in berm screening performance relative to the barrier would be increased.

Various studies for the mitigation of road traffic noise have reported that the screening effects of earth berms can be enhanced through the use of low-height barriers on the tops of the berm. British Columbia Ministry of Transportation and Highways (1997) reported that for the various configurations evaluated using scale model experiments, the largest noise reduction, 10.2 dB(A), was achieved from a 3m high, 3:1 sloped berm with a 1m wall on top, although no information is presented on the source and receiver positions. Similarly, numerical model investigations reported by Watts (1999) found that a 2.5m high berm with multiple 0.5m high noise barriers on the top at 0.5 m centres improved screening by a significant amount compared to an earth berm of the same overall height; the 2.5m high berm with the barriers was also observed to provide similar or greater screening than a 5m high berm without barriers.

1.5 Illustrative costs

No generalised cost information is presented for the use of cuttings and earth berms as noise mitigation measures due to the significant number of different factors, e.g. location, terrain profile relative to the proposed vertical alignment of the railway, ground type, ease of access for construction, etc. that would need to be taken into consideration.

1.6 Benefits and disbenefits

The **benefits** of cuttings and earth berms can be summarised as follows:

- The low placement of a railway line in a cutting maximises the ground attenuation caused by acoustically soft natural soils;
- Earth berms require little maintenance and have an added advantage over noise barriers of not being subject to graffiti;
- Berms are more aesthetically pleasing than large noise barriers and can be integrated into the natural environment;

The **disbenefits** of cuttings and earth berms can be summarised as follows:

- The screening performance of a railway line cutting can be affected by reflections in the opposite wall; therefore absorption must be used for optimum performance;
- Earth berms require a large amount of space and cannot be built as near to the noise sources as conventional noise barriers;
- Earth berms can interrupt natural drainage patterns and potentially cause elevated flooding of adjacent lands or roadways;
- Earth berms have been applied for highways, but there are few examples documented for railways. There are suggestions that earthwork berms may not be the most effective barrier for high-speed rail because of the large amounts of kinetic energy associated with a vehicle travelling above 200mph (Parsons Brinckerhoff, 2008).

1.7 Suitability for use on HS2

The proposed route for HS2 includes 4 deep cuttings ((i) Ch 44+800-46+200; (ii) Ch 47+350-50+500; (iii) Ch 84+900-86+800; (iv) Ch 93+100-95+300). Based on the vertical cross-sections, the depth of these cuttings ranges from approximately 5-20m depending upon position, but typically appears to be of the order of 10m.

None of the cuttings are in close proximity to densely populated areas, although cutting (iv) appears to be approximately 250m from the village of Turweston. However there are isolated properties in very close proximity to some of the cuttings where the depth of the cutting is in excess of 10m (the precise nature of these properties (residential or outbuildings) cannot be determined from the maps. Consideration should therefore be given as to whether sound-absorptive measures should be incorporated at these locations.

The use of earth berms as an alternative to conventional noise barriers along those sections of the route where noise mitigation is required but the line is not in either tunnels or cuttings would depend upon the potential height of the berm and the space available.

1.8 References

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