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The effect of openings on the insertion loss of a noise barrier

Summary

The effect of holes and gaps under noise barriers has been measured at three sites in Finland. The sound pressure levels behind the barriers were measured in a situation with openings in the barrier, and the results were compared with a situation with no openings. All measurements at one site were carried out during the same day in order to minimise the effect of weather.

It seems that a gap may be allowed between a noise barrier and ground surface without significant effect on the insertion loss in many situations, even though the effect of a gap would be dramatic on the insulation measured according EN 1793-2.

Measurements

The sound pressure levels were measured in the reference point above the noise barriers and in one or several points behind the noise barrier. All measurements were carried out in third-octave bands in the frequency range of 20 Hz-10 kHz. Normally, two two-channel real-time analysers were used in order to make simultaneous measurements in four microphone positions. The duration of each measurement was 5 minutes, and all measurements were carried out two or four times. The traffic volume was observed during each measurement. When analysing the results those (opening/no opening) comparisons were preferred in which the distribution of the traffic on the width of the road and the percentage of heavy vehicles were close to each other. The variation in the traffic volume was taken into consideration by using the reference microphone above the noise barrier.

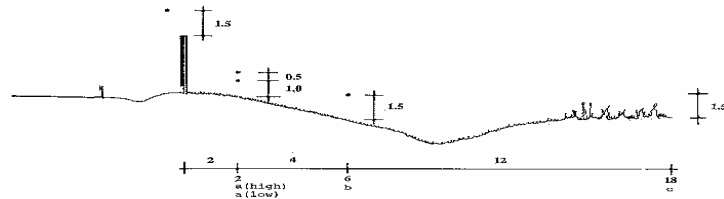
Wind, guard-rails and other noise sources in the environment (tree leaves, children, reflection from houses) may have effected the results. Some results were deleted due to major interruption caused by an aeroplane or because of big differences in the road traffic. There was no road traffic in the vicinity on the protected side of the noise barrier.

Hämeenlinna

The noise barrier is located in Hämeenlinna on the west side of motorway Vt 3 (2 + 2 lanes and a ramp beginning at the measured cross-section, speed limit 100 km/h). There is a park behind the barrier and a school behind the park. The weather was dry, half cloudy, temperature 12...15°C, gusty wind 0...8 m/s 45° towards the road, date September 11, 1997.

Hämeenlinna

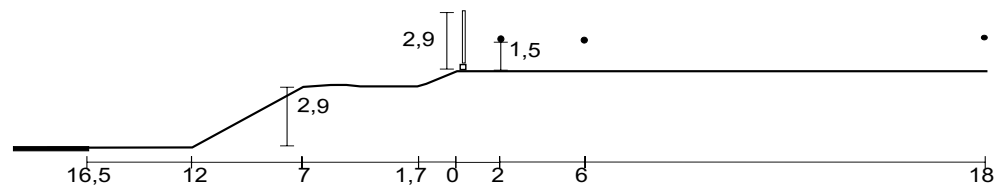
The barrier consists of elements made of perforated and non-perforated steel plate and filled with mineral wool ($DL_R > 25$ dB). At the ground level there is a 4 mm thick corrugated steel plate with rubber seals at the joints. In the case of '3 holes' three 4 m long corrugated steel plates were removed from the ground level in order to get, on the average, 0.4 m high openings at the measured cross-section and 26 m north and south from it. In the case of 'gap: 0,4 m x 60 m' the gap was made longer. In the case of 'gap 0,2 m x 60 m' the upper part of the gap was filled with boards. The total length of the barrier is 290 m and height 3.0...3.5 m.



Pakila

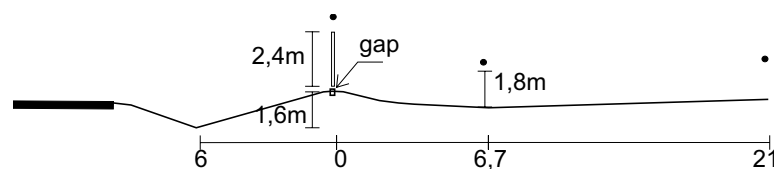
The noise barrier is located in Pakila in Helsinki on the north side of Ring II (2 + 2 lanes, speeds from 63 to 76 km/h). There is a garden behind the noise barrier. The sky was clear, light wind 0...2 m/s with no specific direction, temperature 20...22°C, date June 27, 1997.

The barrier is made of overlapping wooden boards with a 21 mm plywood plate ($DL_R = c. 27$ dB), and with a horizontal concrete beam in the lower part. During the measurement 'gap: 0.15 m' there was a gap between the ground surface the concrete beam. In the case of 'no gap' the gap was filled with crushed stone. The length of the gap covered the total 80 m length of the barrier.



Lusi

The noise barrier is located in Lusi near Heinola on the east side of main road Vt 4 (2 lanes). There are houses behind the noise barrier. The sky was clear, light wind 0...1 m/s with no specific direction, temperature 20...22°C, date August 29, 1996.



The barrier is made of overlapping single wooden boards ($DL_R = c. 15$ dB). At the ground level there is a horizontal concrete beam. During the measurements the barrier elements were lifted 0.12 m from the concrete beam. In the case of 'no gap' the gap was filled with wooden

Table 1. Increase in the A-weighted sound levels due to gaps in Hämeenlinna, Pakila and Lusi, and due to slits in Espoo.

Hämeenlinna Gaps: barrier // ground surface	A m ²	Distance from the barrier (and the height from the ground surface)		
		2 m (1.5 m) 2 m (1.0 m)	6 m (1.5 m)	18 m (1.5 m)
no gaps	0	0 0	0	0
3 holes: 0.4 m x 3.8 m	5	0.7 2.3	-0.2	-0.8
gap: 0.2 m x 60 m	12	0.5 1.2	0.1	-0.5
gap:0.4 m x 60 m	23	2.0 3.1	1.3	0.5

Pakila Gap: barrier / / ground surface		Distance from the barrier (and the height from the ground surface)		
		2 m (1.5 m)	2 m (1.5 m)	18 m (1.5 m)
no gaps	0	0	0	0
gap: 0.15 x 80 m	12	0.1...0.4	0.4	-0.1...0

Lusi Gap: concrete beam // element		Distance from the barrier (and the height from the ground surface)		
			6,7 m(1.8 m)	21 m (1.8 m)
no gaps	0		0	0
2 holes: 0.1 x 0.1	.02		-0.1	-0.3
5 holes: 0.1 x 0.1	.05		0.1	-0.4
gap: 0.06 x 40 m	2.4		- 0.6	-0.7
gap:0.12 x 40 m	23		-0.3	0.6
no gaps, height reduced 0.12 m			-0.2	-0.1

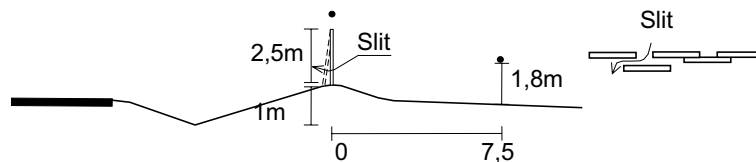
Espoo		Distance from the barrier (and the height)		
			7.5 m(1.8 m)	
no slits			0	
vertical slits 0..0.1			2.3	

boards fixed horizontally. In the cases of '2 or 5 holes' holes were made in the boards. In the case of '0.06 m gap' half of the boards were removed and in the case of '0.12 m gap' all horizontal boards all were removed. This modification covered a 40 m long section of the noise barrier. In the case of 'no gaps: height of the barrier reduced by 0.12 m' the elements were lowered back in their original location. The total length of the barrier is 72 m.

Espoo

The noise barrier is located in Espoo on the east side of Ring I (2 + 2 lanes). The total length of the barrier is 225 m. There is a street and houses behind the noise barrier. The sky was almost clear, light wind 0...3 m/s, temperature 10...15°C, date September 18, 1996.

The barrier is made of overlapping single wooden boards ($DL_R = c.15$ dB). In the case of 'vertical slits' every third board of the barrier was detached in a way that caused a 100 mm wide slit at the lower end, but the width of the slit was 0 at the top. The barrier was handled this way at a length of 28 m near the measured cross-section.



Conclusions

It seems that a 0.4 m high gap between the barrier and a soft ground surface has only a small effect (0.5 dB), on the insertion loss measured further behind the barrier when considering A-weighted sound levels. Very close, less than 10 m, to the barrier the effect may be higher (3 dB).

In a case with a smaller gap, 0.2 m, the effect is only a half of the values mentioned above.

These results have been measured at sites where the ground level near the barrier is at the same level or at a higher level than the road. If the opening is located below the level of the road surface the effect of the opening is supposed to be even smaller.

These results have been measured at sites where there is soft ground near the barrier. In Hämeenlinna and Pakila the grass was rather high. The results may not be similar in a case of hard soil, such as asphalt, or in the case of a bridge.

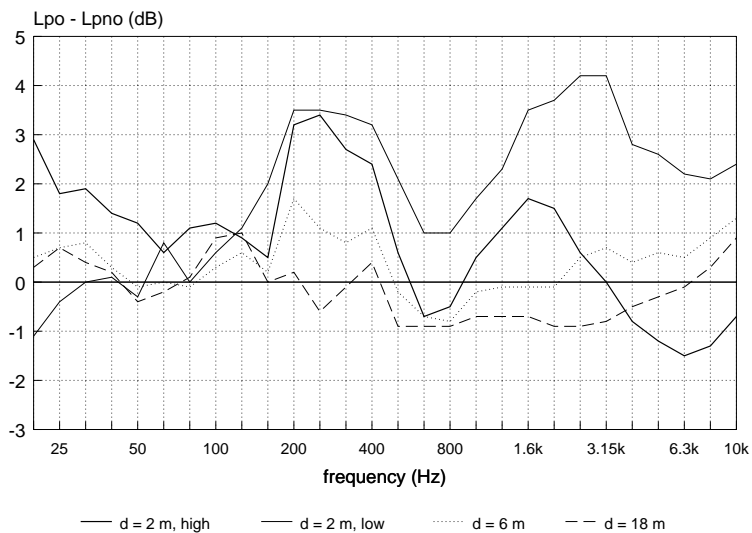
Benefits from gaps

Even though the effect is small one should avoid openings in noise barriers. However, in some cases this kind of openings may be practical. The frost action may heave the ground surface by 50...150 mm every winter if no countermeasures are used. If we may allow a gap between the barrier and the ground surface no expensive measures against frost heave are needed. In some cases this kind of opening may be used to provide drainage.

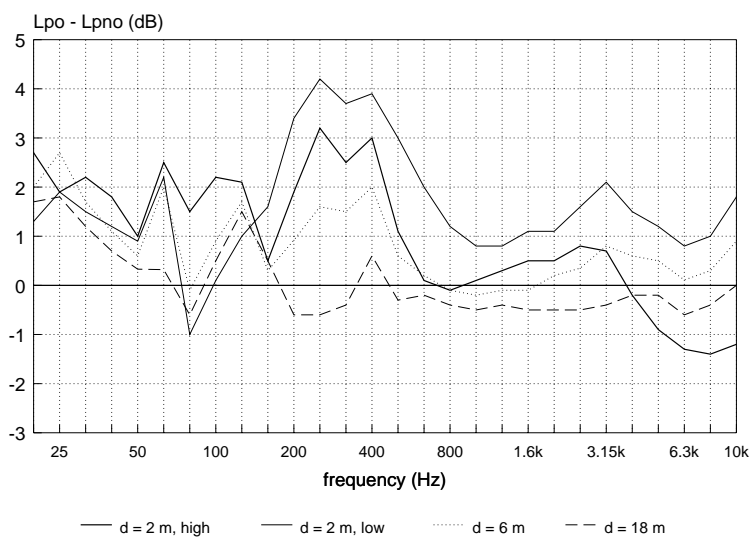
On the other hand, people living behind the barrier may suspect that the barrier is not effective.

Results in Hämeenlinna

3 holes: 0,4 m x 3,8 m



gap: 0,2 m x 60 m



gap: 0,4 m x 60 m

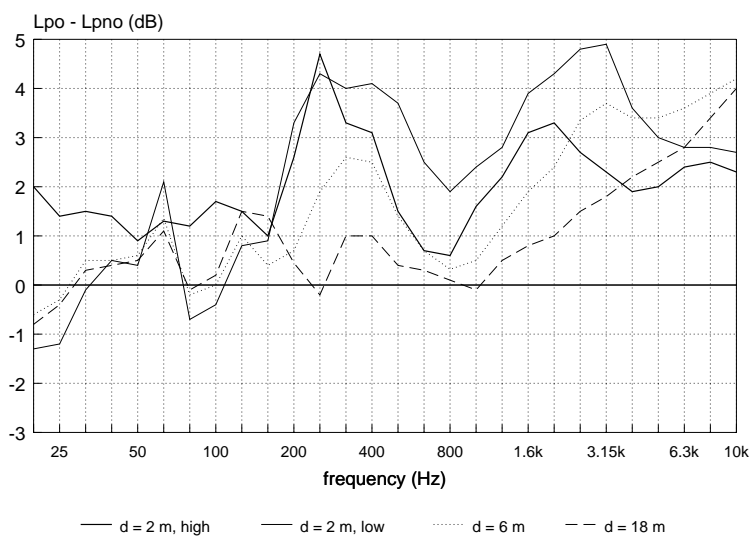


Figure 1. Sound pressure levels, compared with the case 'no gaps' in Hämeenlinna.

EN 1793-2

When measuring the sound insulation in a laboratory according to EN 1793-2 the effect of this kind of gaps would be dramatic. What should be the requirement for the DL_R , if the gap is allowed? Normally one should test the noise barrier without a gap, because it will be used without the gap in most cases. The gap may only be build when specified by the purchaser. In those cases one should rather estimate if the sound levels will be within the limits in the areas where people stay, than to try to test the sound insulation.

Previous numbers:

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5. Break-away lighting columns, current practice in Finland in 1996.
6. Break-away lighting columns, current practice in Finland in 1997.

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Acoustics fax int + 358 9 456 4709

Reports:

Raimo Eurasto:

The Effect of Slits and Openings on the Insertion Loss of Noise Barriers
(in Lusi and Espoo);

The Effect of an Opening on the Insertion Loss of a Noise Barrier in
Pakila, RTE113356/97

The Effect of an Opening on the Insertion Loss of a Noise Barrier (in
Hämeenlinna), RTE11447/97

Reports are available in VTT in English.