Computer modelling and site investigations of noise barriers with complementary noise reduction element

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Summary
Based on the experiences of the past few years, it was proved that the maximal noise reduction achievable with noise barriers is 13-15 dB. Over the last year, to reduce the increased noise caused by the increased traffic, various complementary elements have been installed on top of noise barriers. The suitable complementary can be chosen according to given geometric and geodetic conditions. In order to apply this, the acoustic impacts of each particular element have to be known. In order to increase the acoustic efficiency of noise barriers, several investigations have been conducted in order to shed light on the connection between the shape of the noise barriers and the amount of the achievable insertion loss. Computer modelling as well as site measurements have been conducted to assess the noise reduction impacts of noise barriers of different shapes and to compare the noise reduction impacts of different possibilities.

1. Introduction, Preliminaries

1978, the first model experiments were performed regarding achievable size of insertion loss with noise barrier of different shapes and different closure [1,2]. It was found that the absorbing effect of the upper edge leads to an increase of insertion loss. Japanese company (Nitto Boseki Co Ltd) utilized the results of the model experiments for the first time [3].

1996 – 97, in Hungary, we already have dealt with the noise reduction effect of reduction element mounted on a noise barrier. We examined the effect of a mounted tube at both site "laboratory" and at real site.

In Hungary, we examine insertion loss of noise barriers using a simplified method. The authoritative insertion loss [4] means the difference between noise level formed with the presence or without the presence of a noise reducing facility at the same point. This means that the authoritative insertion loss is the average value of insertion losses measured 1 m, 5 m and 10 m behind the wall at 1.5 m height.

During the outdoor laboratory examination [5] we compared the walls of a 6 m long

- 0.4 m high barrier element of same structure
- TUBOSIDER reduction tube of 0.4 m diameter

built on the top of a 8 m long, 3 m high Schober noise barrier. Comparing the barriers we found that the difference of the insertion loss in this specific configuration is 4 dB. This means that a greater noise reduction can be achieved with a barrier with a reduction tube placed close to the source than with a straight barrier of same height.

The first site examination was carried out along a railway line [5]. 4.5 m high, completely absorbing Schober type of noise barrier was built along this section. Along the critical section, a 207 m long TUBOSIDER sound absorbing reduction element was placed on top of the 4.5 m high noise barrier. During the examinations it was found that due to the effect of the tube, depending on the location of the immission point, the noise load is reduced by 5.2 dB-7.7 dB.

2. Computer modelling of barriers of various configurations in order to illustrate the noise reduction

2.1. Examinations

Results of previous examinations were established on the basis of small sample experiments and site examinations. With today's technology, similar examinations can be conducted by computer modelling using programs with proper accuracy. We examined the noise reduction effect of the barriers of various configurations along main roads and motorways with the help of SoundPLAN computer program. Separately, we have examined the effects of barriers with absorbing surface and reflective surface.

During the examinations we examined the following barrier configurations:

I. Noise barriers with 3 m effective height:

- Straight noise barriers
- Barrier with T profile (with a deflection of 0.5 m)
- Barrier leaned by 30°
- Noise barrier with cross-section C
- 0.5 m high „reduction element” on top of a 2.5 m high barrier
- 2.5 m straight with 0.71 m long incurvation leaned by 45°,
- waveform noise barrier
- 2.1 m high noise barrier with curved elements on top

Figure 1. Noise barriers of various configurations of examination I.

II. Configurations on top of the noise barrier: we examined further configurations on barriers (3m high barrier with various noise barrier configurations built on top) leaned on top (curved):

- 0.5 m long incurvation leaned by 30°
- 1.0 m long incurvation leaned by 30°
- 0.5 m long incurvation leaned by 45°
- 1.0 m long incurvation leaned by 45°
- building a 0.5 m high reduction element on top

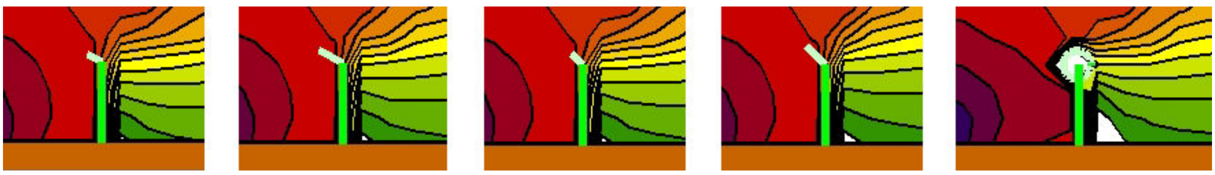

Figure 2. Noise barriers of various configurations of examination II.

We performed calculations on the side that should be protected, at different distances from the impact of the noise barriers. We considered as noise source the main road and the motorway of a given traffic. The noise emission of main road and motorway is an average value ($L_{Aeqn(25\ m)}$=58 dB, $L_{Aeqe(25\ m)}$=66 dB for night-time). The calculation is not suited for an absolute comparison, just for a relative comparison. The distinction of main road and motorway is important to illustrate the different effect on shielding resulting from the width of traffic lanes. The noise load was examined before a three-storey building.

To compare the effects of the barriers to each other, we used as initial value the noise load measured behind the 3 m high straight noise barrier. Negative values result greater, plus values result smaller noise attenuation (the noise load differences in front of the building were taken into account). The result of the calculation is shown in table 1.

	Barrier Type	ΔL_{Aeq} (dB)					
		Along Main Road			Along Motorway		
		1st floor	2nd floor	3rd floor	1st floor	2nd floor	3rd floor
I.	Straight	0,0	0,0	0,0	0,0	0,0	0,0
	T-Profile	-0,2	-0,3	-0,4	-0,2	-0,2	-0,1
	Leaned	+0,8	+1,2	+1,6	+0,4	+0,6	+0,4
	C-Profile	0,0	0,0	0,0	-0,1	0,0	0,0
	With Reduction Element	-0,1	-0,1	-0,2	-0,1	-0,1	-0,1
	Leaned on top	-0,3	-0,3	-0,4	-0,2	-0,2	-0,1
	Wave	0,0	0,0	0,0	-0,1	-0,1	0,0
	Curved on top	-0,3	-0,4	-0,5	-0,1	-0,1	-0,1
II.	30°, 0.5 m	-0,6	-0,8	-1,0	-0,7	-0,8	-2,0
	30°, 1.0 m	-1,1	-1,4	-1,8	-1,3	-1,5	-2,4
	45°, 0.5 m	-0,7	-0,9	-1,1	-0,9	-1,0	-2,1
	45°, 1.0 m	-1,3	-1,6	-2,0	-1,7	-2,0	-2,6
	0.5 m Reduction Element	-0,9	-1,1	-1,3	-1,2	-1,3	-2,2

Table 1. Comparing the noise load of the building 50 m from the road axis

To compare the results, we primarily used the results of the upper floor, because the differences are more visible there.

Along both road types, the following order can be determined among the three-meter high noise barriers:

1. curved on top
2. leaned on top
3. T-Profile
4. with reduction element
5. straight
6. C- Profile
7. waved

Among the leaned elements built on top of three-meter high straight noise barriers, the change of the inclination angle does not cause subjectively noticeable change (+0,2 dB noise reduction by 45°). However, next to the main road, the longer 1.0 m elements decrease the noise load by 0.8-0.9 dB compared to the 0.5 m element. Building the reduction element on top of the noise barrier can result similar noise attenuation than the extension by 0.5 m, regardless of inclination angle.

Along the motorway, these differences are smaller. The change of the inclination angle causes a difference of 0.1-0.2 dB, while the difference of smaller and longer element causes a difference of 0.4-0.5 dB, in contrary to the difference of the noise load at middle floor, where these are 0.3 - 0.5 dB, and 0.7 - 1.0 dB.

In case of the main road, elements built on top of three-meter high straight barriers – due to various configurations – can cause further noise reduction of 1.0-2.0 dB at the upper floors (at the bottom floor 0.6-1.3 dB, at the middle floor 0.8-1.6 dB).

In case of the motorway, leaned elements built on top of the noise barrier can result a noise reduction of 0.7-1.7 dB at the bottom floor, noise reduction of 0.8-1.9 dB at the middle floor and noise reduction of 2.0-2.6 dB at the upper floor. Building a reduction element on top of the noise barrier results similar noise attenuation as the noise barrier with 0.5 m long incurvation leaned by 45° on top.

2.2. Findings

Comparing the calculations the followings can be stated:

1. The acoustic efficiency of the existing noise barriers of corresponding load capacity can be increased with a noise configuration element built on top. At the same effective height, the noise barrier impact of a noise barrier with noise configuration element built on top is greater than the impact of a straight noise barrier.

2. Comparing the calculations can be stated that the 0.5 m long incurvation leaned by 45°

configuration on top of the noise barrier has the same impact as the noise barrier with reduction element built on top in noise attenuation point of view.

Greater noise protection can be achieved by extending the configuration up to 1.0 meter. This solution results an additional noise reduction of 0.2-0.7 dB next to motorways, 0.5-1.0 dB the next to main roads at distant buildings. At closer buildings, using longer configuration, the noise attenuation impact is 0.6 - 1.6 dB greater than with a reduction element built on top.

At the protection of the 3rd floor of higher buildings, the 0.5 m long configuration built on top of a noise barrier is a little bit better (0.3 dB) than the noise barrier with a reduction element built on top.

3. Comparing the noise attenuation of the straight barrier and the noise barrier of same effective height, leaned on top can be stated that the noise barrier built with a configuration on top has a more favourable impact by 0.1-0.2 dB along motorways and by 0.3-0.5 dB along main roads than at distant buildings. This implies that the effective height of a noise barrier with a configuration on top can be smaller than a straight barrier. The difference between the two barrier types continues to grow at closer buildings along main roads: the barrier leaned on top decrease the noise level by additional 0.4-0.8 dB.

4. Geometric and geodetic conditions significantly influence the increase in noise reduction achievable with reduction element, configuration on top. Therefore, before each attachment, calculations shall be carried out to determine the value of the achievable noise reduction.

3. Site Examinations

3.1. Examinations

2 m high noise barrier with glued glass was built along a Hungarian motorway. CALMA TEC PIN reduction element was placed on top of this barrier. During the examinations, based on standard MSZ 13-121-2 we measured the noise before and after the placement of a reduction element.

The result is: the impact of the reduction element on the insertion loss is 3,8 dB.

Along another section of the motorway, a 0.5 m high DAK reduction element (0.5 m long incurvation leaned by 45°) was placed on a 3.5 m high noise barriers of

- DAKusztik with normal steel panel and
- THERAFA 6. type.

3.2. Findings

During the measurements was stated that

1. The impact of the reduction barrier element on the insertion loss is 3.1- 3.2 dB.
2. The acoustic efficiency of the existing noise barriers of corresponding load capacity can be increased with a noise configuration element built on top. At the same effective height, the noise barrier impact of a noise barrier with noise configuration element built on top is greater than the impact of a straight noise barrier.
3. As a result of the measurements can be stated that a noise barrier with a 0.5 m long incurvation leaned by 45° on top has the same impact as a noise barrier with a reduction pipe element built on top, in noise attenuation point of view.
4. Greater noise protection can be achieved by extending the configuration up to 1.0 meter.

4. Conclusions

It should be noted that geometric and geodetic conditions significantly influence the achievable noise reduction with reduction element, configuration curved on top. Therefore, before each attachment, calculations shall be carried out to determine the value of the achievable noise reduction.

The results of the measurements and calculations provided identical results for the noise reduction impact of each complementary element.

Henceforward, we conduct comparative examinations in accordance with standards EN 1793-4,5,6.

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