Acoustic Effect of Drainage Gaps in Noise Barriers

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Summary

The design and construction of noise barriers has to meet acoustical requirements. However, with respect to structural requirements, it is sometimes necessary to leave gaps in the structure. Especially drainage gaps at the bottom of noise barriers are frequently applied. These gaps may influence the acoustic performance of the barrier.

Research on the acoustic effect of these drainage gaps has been done, but mostly by modelling and calculating techniques. In this research measurements have been performed on a series of noise barriers with drainage gaps. The acoustic insertion loss of these barriers (before and after closing the drainage gaps) was measured. The results of the measurements are compared to calculated values of the insertion loss.

The results of the measurements and calculations show that for large drainage gaps (up to 20 cm) there is a significant effect on the insertion loss. However, this effect is limited to maximum 1 dB. This meets the requirements in GCW2012 [1]. For smaller gap sizes, the effect on the insertion loss is smaller. The largest effects on insertion loss occur on low positions (close to the gap).

1. Introduction

The design and construction of noise barriers has to meet acoustical requirements. However, with respect to structural requirements, it is sometimes necessary to leave gaps in the structure. Especially drainage gaps at the bottom of noise barriers are frequently applied. These gaps may influence the acoustic performance of the barrier.

Research on the acoustic effect of these drainage gaps has been done, but mostly by modelling and calculating techniques [2]-[4]. Validation of this research by measurements in the field has never been done. In this research measurements have been performed on a series of noise barriers with drainage gaps. The effect of closing the draining gaps on the acoustic insertion loss of these barriers (before and after closing the drainage gaps) has been measured. The results of the measurements are compared to calculated values of the insertion loss.

2. Measurement Locations

To determine the effect of drainage gaps on the acoustic performance of noise barriers a series of measurements on noise barriers have been performed. In total six noise barriers with drainage gaps were selected, all along highways in the Netherlands. In one case the measurements were repeated after the drainage gap was excavated to a greater depth of 20 cm. Therefore, the results of measurements on seven situations are analyzed in this project. The location and description of the measured noise barriers are summarized in table I.

3. Measurement Set-Up

The basic idea to determine the acoustic effect of the drainage gaps is by measuring the sound levels in two situations: the original (with the drainage gaps open) and after closing the drainage gaps. The results from these two situations can be used to determine the effect of the drainage gap on the acoustic performance of the barrier.

Table I. Overview of measurement locations and noise barriers

Location	*Material and height [m]*	*Height drainage gap [cm]*	*Remarks*
A20 Schiedam I	Concrete, 7.0 m	10-15	-
A20 Schiedam II	Concrete, 7.0 m	20	Excavated to 20 cm
A2 Veldhoven	Transparent PMMA, 8.0 m	12	'sharp' gap
A2 Nieuwegein	Concrete, 4.0 m	8-15	'sharp' gap
A12 Maarn I	Concrete, 4.0 m	5-10	Partially grown
A12 Maarn II	Concrete, 4.0 m	5-7	Partially grown
A12 Gouda	Transparent PMMA, 6.5 m	8-12	Partially grown

The noise levels behind the barrier are determined by the energetic summation of the following contributions:

- L_{diffr}: contribution of diffraction of sound at the top of the barrier;
- L_{gap}: contribution of sound propagating through the drainage gap;
- L_{trans}: contribution of sound transmitted through the barrier.

The total sound level behind the barrier becomes:

$$L_p = L_{diffr} \oplus L_{gap} \oplus L_{trans} \quad (1)$$

In the analysis the assumption is made that the transmission of sound through the barriers is neglectible ($L_{trans} << L_p$ and $L_p \approx L_{diffr}$)

Figure 2. Example of drainage gap under noise barrier (A2 Nieuwegein)

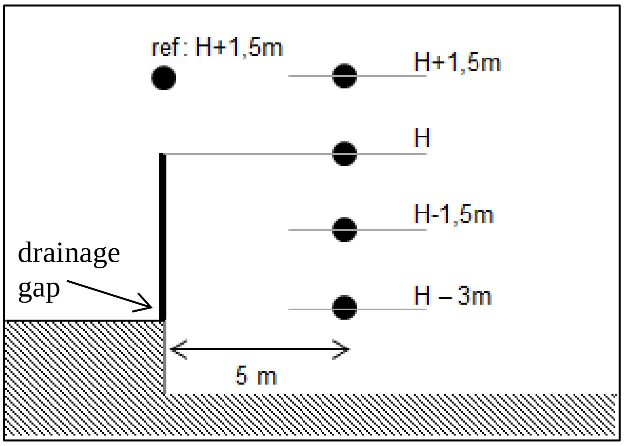

Figure 1. Schematic overview of measurement positions

3.1 Insertion Loss

The insertion loss is measured according to ISO 10847 [5]. Since it is not possible to measure the situation without the noise barrier it is only possible to determine the effect of closing the gaps on the insertion loss. Absolute values of the insertion loss according to ISO 10847 cannot be measured.

The measurements are performed on standardized positions behind the noise barriers. These are chosen at 5.0 m distance behind the barrier and at heights relative to the top of the noise barriers (from the top of the barrier in steps of 1.5 m). A reference position is chosen 1.5 m above the top of the barrier. A schematic overview of the measurement setup is shown in figure 1.

The effect on the insertion loss of closing the drainage gap (ΔD_{IL}) is according to ISO 10847 given by:

$$\Delta D_{IL,barrier} = (L_{ref,B} - L_{ref,A}) - (L_B - L_A) \qquad (2)$$

with

$L_{ref,X}$: sound level on reference position;
L_X: sound level on measurement position;
A: situation with drainage gap closed;
B: situation with drainage gap open.

ΔD_{IL} is computed in both overall levels and in third octave bands.

The measurement locations are chosen in such a way that influence of disturbance noise and reflections are as small as possible. In the analysis of the measurement results an extra check on these items is performed. Data influenced by disturbance noise or reflections is eliminated from the analysis.

The sound levels are measured during approximately 30 minutes in each situation. This is long enough to determine a stable L_{Aeq} level on the measurement positions.

An example of the measured sound levels and the marked disturbance noise is shown in figure 3.

- The location with the biggest drainage gap (A20 Schiedam) shows the largest effect. The maximum effect is approximately 1.0 dB on overall level.
- The location with the smaller gaps (and partially grown) show no significant effects.
- The biggest effect occurs on the measurement positions close to the drainage gaps. At higher positions the effect is not significant.

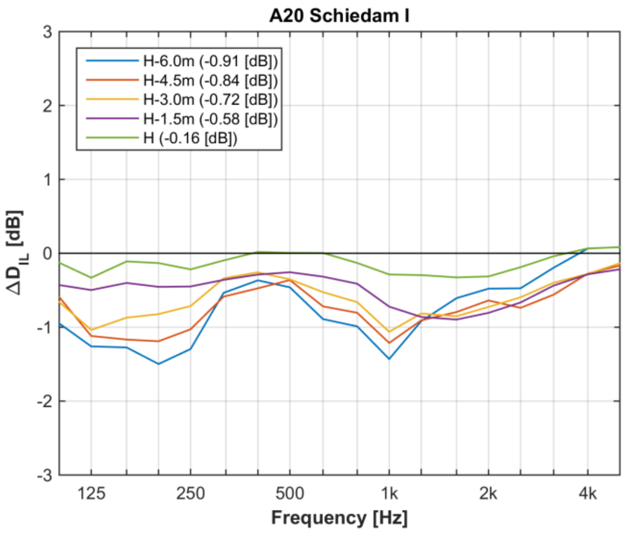

Figure 4. Example of measured effect on insertion loss, location A20 Schiedam I

4. Results

4.1 Effect on insertion loss

The effect on the insertion loss is calculated in third octave bands and on the overall levels. A typical result of this analysis is shown in figure 4. The main results for the results on all the locations are the following:

- The locations with a so called 'sharp' drainage gap show a limited effect of closing the drainage gap. On overall level the effect is max. 0.7 dB. Looking at the spectral results there are some larger effects, but not in the relevant frequency bands;

4.2 Comparison with model computations

To check the accuracy of the measurements a check of the results with computed insertion loss values has been performed. According to the Dutch standard calculation method for traffic noise (SRM2) models of the measurement positions are made. On the measurement position the expected sound levels were calculated, and the expected insertion loss on these positions were derived. As a result, it became possible to compare the measured insertion loss with the computed insertion losses. The results are shown in figure 5.

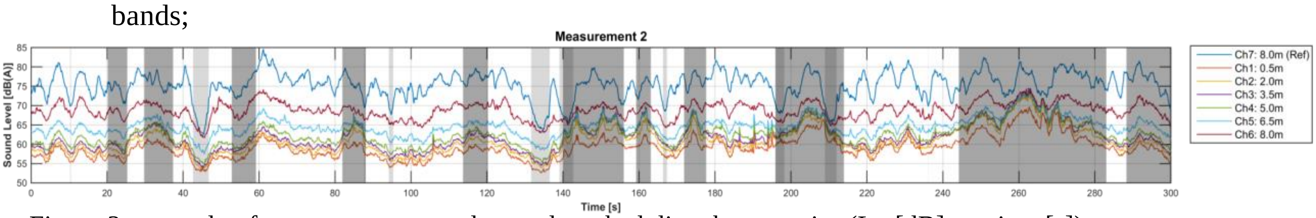

Figure 3: example of raw measurement data and marked disturbance noise (L_A [dB] vs. time [s])

From this figure it can be concluded that for the positions with a high insertion loss (low positions behind high barriers) the measured insertion loss is lower than expected. On the other hand, for positions with low insertion losses (high positions, low barriers) the measured insertion loss is more than expected.

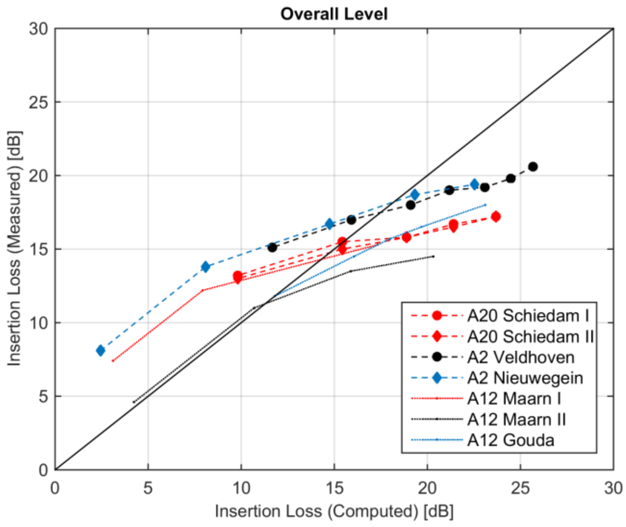

Figure 5. Insertion loss, measured vs. computed

4.3 Effect in relation to measurement position and gap size

The largest effects on the insertion loss occur at the lower measurement positions (figure 6). That means: close to the drainage gap. On higher positions the effect becomes non-significant. In some cases a result is shown for positions 'below' the drainage gap. In these cases the barrier is placed on top of a slope. These ground slopes may block the sound from the drainage gap to these measurement positions. From this figure the influence of gap size becomes also clear. The noise barriers with the biggest drainage gap show the biggest effect on insertion loss. The locations with relatively small, or partially grown gaps, show no significant effects.

5. Legislation

In the Netherlands there are regulations for the maximum allowed size of drainage gaps in noise barriers. These rules are summarized in the 'Guidelines for Noise Barriers along roads', GCW2012 [1]).

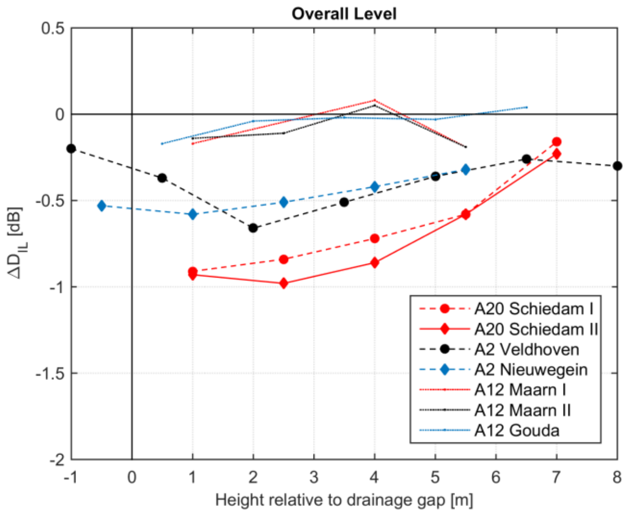

Figure 6. Effect on insertion loss vs.measurement position (and gap size).

In this document it is stated that the influence of drainage gaps on the insertion loss shall not exceed 1 dB. For practical purposes this is implemented by allowing a maximum height of the drainage gap of 20 cm. The results from this research confirm these requirements.

6. Conclusions

The effect of closing drainage gaps in sound barriers has been measured. It can be concluded that:

- For noise barriers with relatively small drainage gaps (<8cm) or with (partially) grown drainage gaps the effect on the insertion loss is non-significant;
- For noise barriers with drainage gaps between 8 – 15 cm, the effect is significant, but limited to approximately 0.5-0.7 dB;
- For noise barriers with big drainage gaps (15-20 cm) the effect on the insertion loss is maximum 1 dB;
- The largest effect occur on low positions (close to the gap);
- The results of the measurements in this research confirm the requirements from the Dutch Guidelines for Noise Barriers along roads.

7. References

[1] "Richtlijnen geluidbeperkende constructies langs wegen (GCW-2012)", CROW publicatie 298, march 2012;

[2] "Schaalmodelonderzoek naar de invloed van spleten onder geluidschermen op de afscherming", TNO/TPD report 623.106, 28-04- 1987;

[3] "Schaalmodelonderzoek naar de invloed van spleten onder schermen op de afscherming – deel 1: heranalyse", TNO/TPD report 924.011, 10 -05-1989;

[4] "Schaalmodelonderzoek naar de invloed van spleten onder schermen op de afscherming – deel 2: metingen aan weg in ophoging", TNO/TPD report 924.011/2, 28 maart 1990;

[5] ISO 10847, "Acoustics -- In-situ determination of insertion loss of outdoor noise barriers of all types", 1997/2013;

[6] M+P.RGPO.14.08.1, "Akoestisch Effect Afwateringsspleten geluidschermen, Measurement report 1: N2 Veldhoven", 30-03-2015;

[7] M+P.RGPO.14.08.2 , "Akoestisch Effect Afwateringsspleten geluidschermen, Measurement report 2: A4/A20 Schiedam", 27-03-2015;

[8] M+P.RGPO.14.08.3 , "Akoestisch Effect Afwateringsspleten geluidschermen, Measurement report 3: A12 Maarn I", 31-03-2015;

[9] M+P.RGPO.14.08.4 , "Akoestisch Effect Afwateringsspleten geluidschermen, Measurement report 4 : A12 Maarn II", 31-03-2015;

[10] M+P.RGPO.14.08.5 , "Akoestisch Effect Afwateringsspleten geluidschermen, Measurement report 5: A12 Gouda", 30-03-2015;

[11] M+P.RGPO.14.08.6 , "Akoestisch Effect Afwateringsspleten geluidschermen, Measurement report 6: A2 Nieuwegein", 30-03-2015;

[12] M+P.RGPO.14.08.9 , "Akoestisch Effect Afwateringsspleten geluidschermen,Report", 13-03-2015;