The effect of close proximity, low height barriers on railway noise

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Summary

In order to control railway noise in the Netherlands, there is a need to expand the standard set of noise reducing measures. An idea from the old box is to construct small barriers at a very close distance from the track. Issues with regard to safety and maintainability of the track have always been a serious obstacle for building these objects. To overcome these restraints mini barriers were constructed as a pilot project in Hilversum. As part of the evaluation process, the noise reduction of the close proximity barriers was established by measurements. The results were compared with calculations according to the Dutch calculation scheme for conventional barriers.

The research shows that the measured overall noise reduction corresponds well to the calculations. Although more work has to be done, it is expected that only minor changes have to be implemented in noise legislation.

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1. Introduction

Conventional noise barriers are frequently used to limit railway noise. In the Netherlands these barriers are located at typically 4.8 meters from the nearest track. To achieve a sufficiently strong noise-reducing effect, high barriers are often needed. Many residents and urban planners believe that high objects don't fit in the surroundings. A possible compromise is to construct small barriers at a very short distance from the track. However, in the Netherlands it is not permitted to apply close proximity barriers concerning safety and maintainability issues. In addition the Dutch calculation scheme has not been validated for barriers at a distance smaller than 4.5 meters from the track.

2. Railway noise mitigation in Hilversum

In 2016 the Municipality of Hilversum and ProRail, the Dutch infrastructure manager, have established a mitigation program for rail traffic noise for the Hilversum - Baarn railway line. As part of the mitigation program, tuned rail dampers as well as conventional noise barriers will be installed. As a pilot close proximity barriers ("mini barriers") with a height of 0.76 meter and distance of 1.75 meters from the track are constructed as well. These barriers are built with a special exemption from the standard design regulations.

3. Scope of the research

To evaluate the pilot, the noise reduction of the close proximity barriers was established by measurements. The effect of the close proximity barriers in combination with rail dampers was also determined. The measurements were done according to the Dutch standard [1]. Results were compared with calculations in accordance with the Dutch calculation scheme for conventional screens [2].

If measurements and calculations match, the existing scheme can be used to calculate the effect of close proximity screens. In that case mini barriers can be used as a noise measure with minor changes of legislation, provided that safety and maintainability are guaranteed.

This paper describes the results of noise measurements in Hilversum and calculations according to the Dutch calculation scheme.


Figure 1. Close proximity barrier in Hilversum

4. Close proximity barriers

The railway in Hilversum consists of two adjacent ballasted tracks with concrete sleepers. The mini barriers, applied in the summer of 2017, have a concrete structure with a sound absorbing surface at the railway side. They were placed along both sides of the track over a length of approximately 200 meters. The height of the barriers is 0.76 meter above top of the rail (ATR). The barriers are located at 1.75 meters from the center line of the nearest track. The elements are of the Eco Silence type, supplied by Strukton Prefab Beton. Figure 1 presents a picture of the test location with barriers.

5. Measurement method

The noise reduction of the barriers was determined by performing pass-by measurements in a cross section with (B) and without (A) a barrier. At both sections microphones were installed at a height of 1.2, 2.0, 3.0, 4.0, 5.0 and 6.0 meter ATR. The horizontal distance between all microphones except one and the center line of the nearest track was 7.5 meter. To reduce interference with the embankment along the track, the lowest microphone was placed at 5.0 meter from the track.

The exact same microphone setup was used in cross sections C and D, where S&V tuned rail dampers were installed. Section C has a mini barrier, whereas section D serves as a reference for C. The locations of the measurement sections, barriers and rail dampers are shown in Figure 2.

For each train pass-by, the A-weighted sound pressure level in 1/3-octave bands was measured. The equivalent sound pressure level was calculated over the pass-by time of the train from buffer to buffer. The velocity of the train at all sections was derived from pass-by times and the length of the vehicles.

The noise reduction of the barriers has been established by comparing the noise levels in section A (reference) with B (barrier) and D (reference) with C (barrier). Measurement data were compensated for differences in train speed at the measurement sections. In case of a deviation of more than 20% of the speed in the reference section, the passage was excluded from analysis. Most of the pass-bys failed the criterium for speed difference.

Additionally, corrections were applied for differences in track properties at the rail sections. This was done with data of rail roughness and track decay rate at section A, B, C and D derived from measurements that were done prior to pass-by measurement. Pass-by measurements were done for the nearest and the farthest track. However, the track properties have not been established for the farthest track. Therefore only the results for the nearest track are presented in this paper.

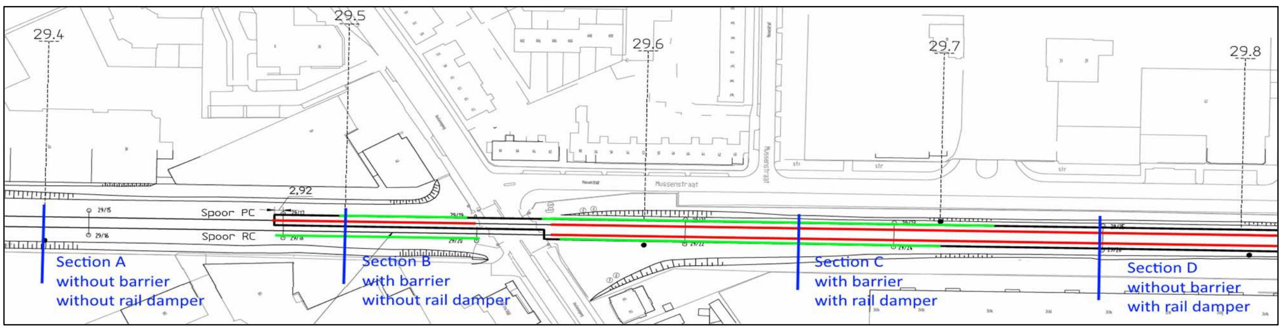

Figure 2. Plot plan of the test location; mini-barriers are indicated with a green line, rail dampers with a red line

The data set contains 22 passenger trains passing by on the nearest track. The train types are ICM (16) and SLT (6). The train speed ranged from 50 to 100 km/h. During pass-by measurements the wind speed was 3 Bft and the wind direction was NE. These atmospheric conditions are considered to be as "favorable".

6. Calculation method

The measurement setup was modelled according to the Dutch calculation scheme for railway noise. The mini barriers were schematized as screening objects with the geometry as built in Hilversum. We ignored the fact that regulations do not allow for screens close to the track. The heights of noise sources representing the train are typically 0.0 and 0.5 meter ATR. For each train passage that was recorded, the noise reduction of the barrier was calculated at receiver points representing all 24 microphone positions used during measurements. The calculations take into account the type of train, the vehicle speed and the presence or absence of rail dampers.

To get an idea of the noise reduction the calculation model predicts, contour lines were also plotted. Figure 3 shows the calculated noise reduction for an ICM type passenger train travelling at 80 km/h. The isolines at the right hand side of the figure represent the anticipated noise reduction for trains passing at the track close to the barrier.

7. Results of the research

Figure 4 shows the measured and calculated overall noise reduction at all microphone positions for the track without rail dampers. The scatter points represent the measured values and the lines the calculated reductions. Figure 5 presents similar data for the track provided with rail dampers. We observe a clear dependency between noise reduction and receiver height in both measured and calculated data. At a distance of 5 meter and height of 1.2 meter ATR the measured noise reduction is 6 to 10 dB. The noise reduction at a distance of 7.5 meter and height of 6.0 meter ATR is up to 4 dB.

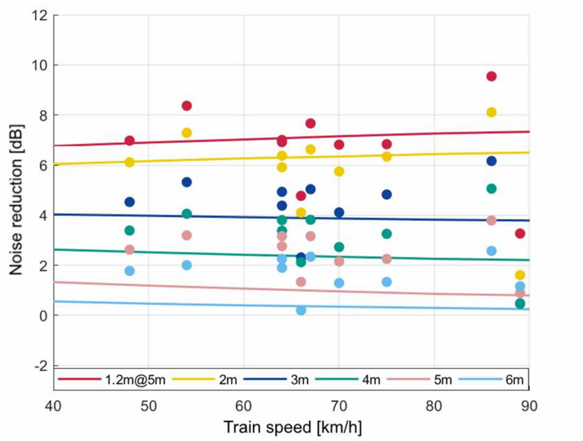

Figure 4. Results for the track without rail dampers

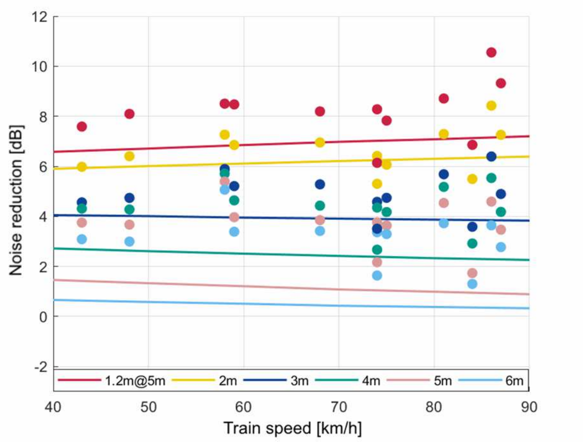

Figure 5. Results for the track with rail dampers

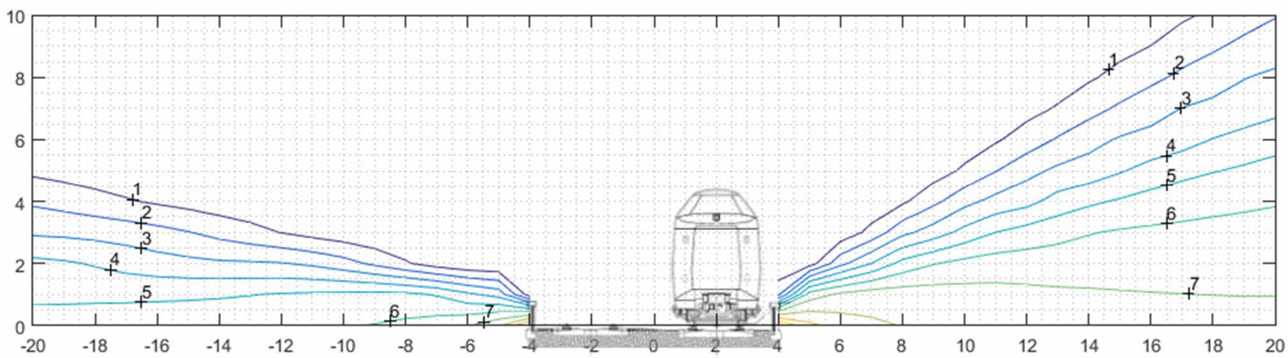

Figure 3. Calculated noise reduction of the barrier for a ICM train, travelling at 80 km/h; X-axis: horizontal distance to the center line of the railway; Y-axis: vertical distance to top of rail

Table 1 presents the average difference between calculated and measured noise reduction. Negative numbers indicate the measured reduction is higher than accounted for by the calculation scheme.

Table 1. Average difference between calculated and measured reduction in dB. St. dev. between brackets

height	with dampers	without dampers
1.2 m @5.0m	0.3 (1.8)	-1.5 (1.1)
2.0 m	0.5 (1.8)	-0.6 (0.8)
3.0 m	-0.3 (1.6)	-1.1 (0.8)
4.0 m	-0.8 (1.2)	-2.0 (0.8)
5.0 m	-1.5 (0.9)	-2.7 (0.9)
6.0 m	-1.3 (0.7)	-2.7 (0.9)

From table 1 we learn that the calculation scheme is conservative for the effect of close proximity barriers on noise propagation. This particularly applies to the highest assessment points. For these points the measured noise reduction is substantial, whereas the calculated effect is almost negligible. A possible explanation for this is that the noise source was modelled at the center line of the track. In reality, noise is emitted by wheels and rail at 0.72 meter from the center line. The most relevant sources are therefore closer to the barrier, which results in higher noise reduction.

We also observe a difference between the sections with and without rail dampers. We assume that these differences are within measurement accuracy.

8. Third octave bands

Figure 6 and 7 show the measured spectral noise reduction in 1/3 octave bands and the calculated spectral values. At midrange frequency (250 Hz to 1 kHz) measurement data corresponds well to calculated data. However, in the high frequency range (2-8 kHz), we measured a relevant noise reduction at high positions (4.0, 5.0 and 6.0 m), while the model predicts a negligible effect. Furthermore in the measurement data a reduced effect occurs at 500 Hz. This is caused by ground reflections. The Dutch calculation scheme is not suitable for calculating these kind of effects.

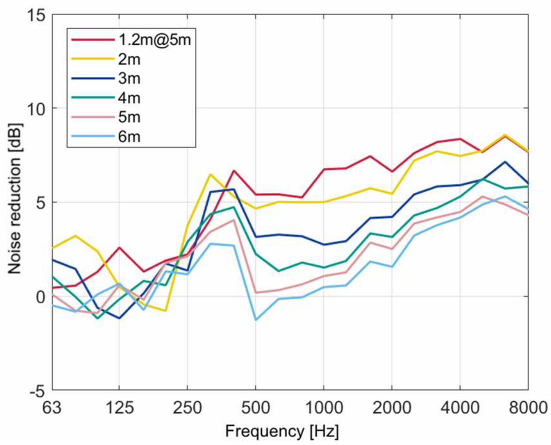

Figure 6. Measured noise reduction in 1/3 octaves

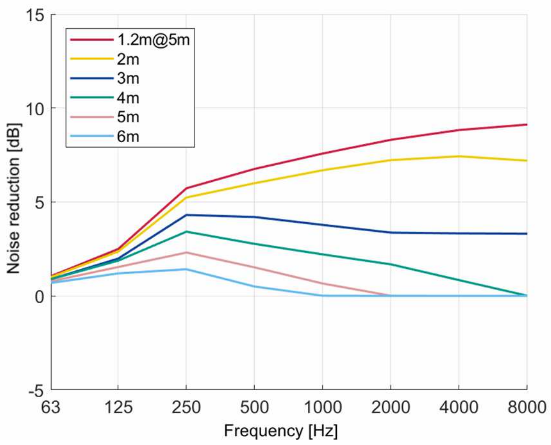

Figure 7. Calculated noise reduction in 1/3 octaves

9. Conclusions and recommendations

This paper has given an overview of the results of noise measurements to determine the noise reduction of close proximity, low noise barriers. Experimental data has been compared with calculations according to the Dutch calculation scheme. Its shows that the measured overall noise reduction corresponds well to the calculations.
From the results, we learn that the spectral results do not match as well as the total noise reduction. This raises the question of how measurements compare to the calculation scheme at greater distances than 7.5 meters. Because of local conditions in Hilversum, measurements could only be done at short distance from the track.

During measurement only one cargo train passed the test location. Therefore, the screening effect of the mini barrier on cargo train noise could not be established. Another aspect that could not be researched in detail is the effect of the barrier on trains passing on the farthest track. Measurements indicate that the calculation scheme also works for the farthest track. But since rail roughness and track decay rate of that track have not been established, these finding can't be considered as robust.

It is recommended to do additional research on the effect on noise from cargo trains, from the farthest track and at greater distances from the track.

References

[1] CROW-stuurgroep Reken en Meetvoorschriften, Technische Regeling Emissiemeetmethoden Railverkeer 2006, CROW, 21 december 2006.

[2] Bijlage IV behorende bij hoofdstuk 4 van het Reken- en Meetvoorschrift Geluid 2012, Staatscourant 202 nr. 11810, Den Haag, 27 juni 2012.