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Whisswall, a sound diffractor on a low height noise barrier: experimental testing.

Wout Schwanen
M+P consulting engineers, Vught, the Netherlands.

Ysbrand Wijnant
4Silence, Enschede, the Netherlands

Nils Yntema
ProRail, Utrecht, the Netherlands

Summary

In the Netherlands there is a great demand for noise reducing measures to fulfill noise legislation and to reduce annoyance of traffic noise. The company 4Silence developed a sound diffracting element on a low height noise barrier (Whisswall). The sound diffracting element is a metal element with cavities that is placed alongside the railway track. The diffracting element deflects the noise in an upward direction, creating a zone of noise reduction behind the element. It can therefore act as a complement to existing noise-reducing measures and can be optimized for maximum noise reduction.

A test setup has been achieved along the railway track in the Netherlands and sound measurements have been conducted. This paper shows the approach of the measurements and the results. The Whisswall is a promising sound reducing measure that can achieve a significant noise reduction.

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1. Introduction

In the recent years the focus to reduce the noise from railway traffic has mainly been focused on rail dampers and rail roughness control on one side and noise barriers on the other side. Although noise barriers are a common noise measure, they can lead to complaints or objections as they don't fit well into the surroundings. There is thus a need for new noise measures. A new noise measure to reduce the noise of railway traffic is the Whisswall.

2. Whisswall

The Whisswall is a low height noise barrier with a diffracting element on top. The sound diffracting element is a, in this case, metal element with cavities. The diffracting element deflects the noise in an upward direction. This creates an extra noise reduction in the zone behind the noise barrier, but also creates a noise increase at higher heights. So, the total noise reduction is a combination of the effect of the noise barrier and the diffracting element.

The sound diffracting element was originally designed to reduce tyre-road noise and to be placed in the ground next to the road [1], [2].

3. Current research

ProRail, the Dutch infrastructure manager, and 4Silence, have started a pilot study to test the Whisswall. The pilot study consists of two stages:

- Phase 1: Research programme
- Phase 2: Implementation stage.

Within the research programme sound measurements are conducted to determine the noise reduction of the Whisswall. The second stage focusses on the implementation of the Whisswall in the legislation, like the Dutch calculation scheme [3], so the Whisswall can be used as a noise reducing measure.

This paper presents the results of the sound measurements that M+P performed to determine the noise reduction of the Whisswall.

Figure 1. The Whisswall at the test location in the Netherlands.

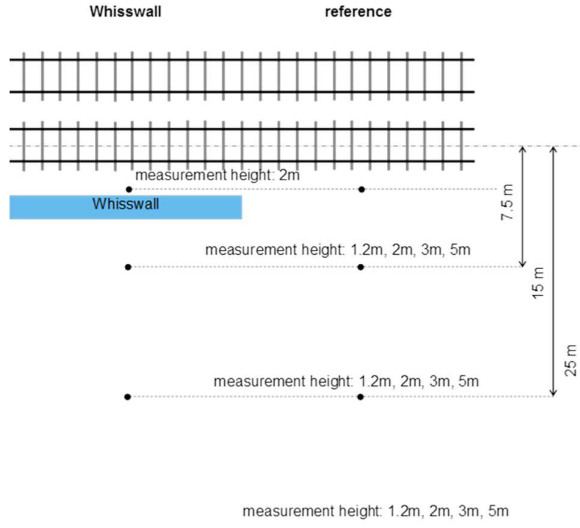

Figure 2. Schematic representation of the measurement setup

4. Test location

The Whisswall was placed along the railway track in the Netherlands over a length of 100 meters. It has a height of 1.10 meter above the upper surface of the rail. The front side of the Whisswall is at 4.77 meter from the center line of the track. The total width of the construction is 1.08 meter. A picture of the Whisswall is given in Figure 1.

Next to the Whisswall there was a section without any noise measure. This section was used as a reference section.

The railway track in both sections is the same. It consists of ballasted track with concrete sleepers. At both sections we measured the track decay rate and the rail roughness. The results of these measurements show that the track decay rate and the rail roughness at both sections is comparable and no correction to compensate for differences in noise emission is needed.

5. Measurement method

To determine the noise reduction of the Whisswall we performed pass-by measurements. Microphones were placed at three distances from the center of the track at 7.5m, 15m and 25 m from the nearest track; one set along a reference section (no diffracting element) and one set behind the diffracting elements. Four heights were used: 1,2m, 3m, 4m and 5m. In addition, we placed reference microphones close to the track. A schematic representation of the measurement setup is shown in Figure 2. Note that measurements were done for trains on two tracks; the nearest and farthest track.

During each pass-by we recorded the A-weighted sound level in third octave bands, the vehicle speed, the vehicle type and the number of cars. From this we calculate the equivalent sound level over the time that the train is in front of the microphone. Per train pass-by, this results in an equivalent sound level, both in third octave levels and total sound level, for each microphone position, together with the vehicle speed at the reference section and at the section with the Whisswall.
The difference in speed between the two sections was never more than 2 km/h. Therefore, no emission correction for the speed difference was applied.

A total of 46 pass-bys were recorded: 22 on the first track and 24 on the second track. On the first track only passenger trains, three different types, were measured. On the second track we measured 22 passenger trains and 2 single locomotives. An overview of the measured train types is given in Table 1.

Table 1. Number of train types during the measurements.

	first track	second track
VIRM 6	11	9
VIRM 4	4	6
GTW 2/6	7	7
other	0	2
total	22	24

The speed of the measured trains was between 110 and 133 km/h except for the 2 locomotives, which passed at a speed around 85 km/h.

6. Measurement results

Figure 3 shows the A-weighted sound level during the pass-by of a train on the nearest track at the Whisswall section and at the reference section at 15m distance and 3m height. The effect of the Whisswall on the sound level is clearly visible. During the pass-by of the train, the sound level at the section with the Whisswall is lower than the sound level at the reference section.

The resulting equivalent sound spectra are shown in Figure 4. We observe a broad band noise reduction for the Whisswall.

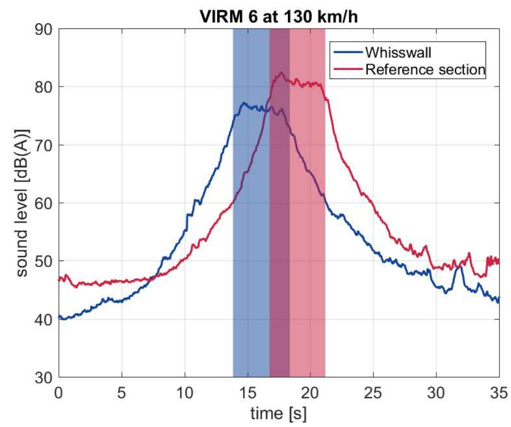

Figure 3. Sound level during a pass-by at the Whisswall (blue line) and the reference section (red line). The blue and red area indicate the time that the train was in front of the microphone. The results are measured at 15meter at 3meter height

7. Analysis

The noise reduction of the Whisswall is determined by taking the difference between the equivalent sound level at the reference section and the section with the Whisswall. The average noise reduction is obtained by calculating the average difference over all pass-bys. This results in 24 noise reductions: 3 microphone distances, 4 microphone heights and 2 tracks. These are displayed in Figure 5. The blue bars are the results for the nearest track, the yellow bars are the results for the farthest track. The error bars indicate the value for the standard deviation.

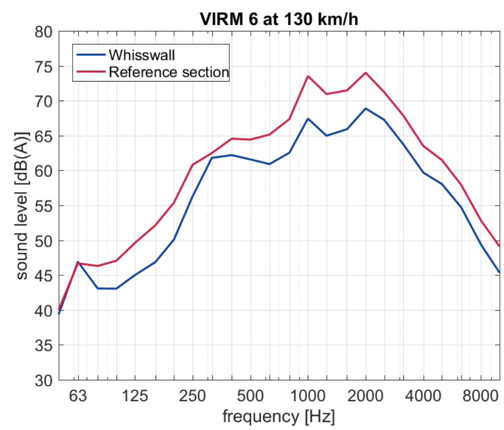

Figure 4. Equivalent sound level in third octave bands during a pass-by at the Whisswall (blue line) and the reference section (red line). The results are measured at 15meter at 3meter height

7.1. Noise reduction

The highest noise reduction is achieved at the lowest microphone height and the shortest distance from the Whisswall. The noise reduction at this

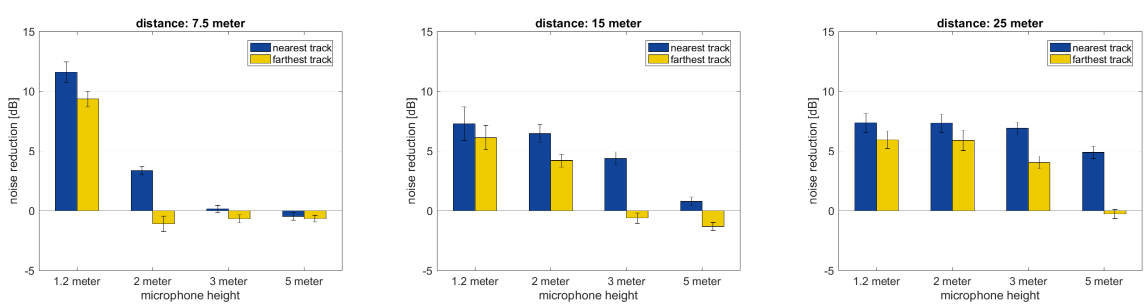

Figure 5. Average noise reduction measured for the Whisswall per microphone height and distance. The error bars indicate the standard deviation.

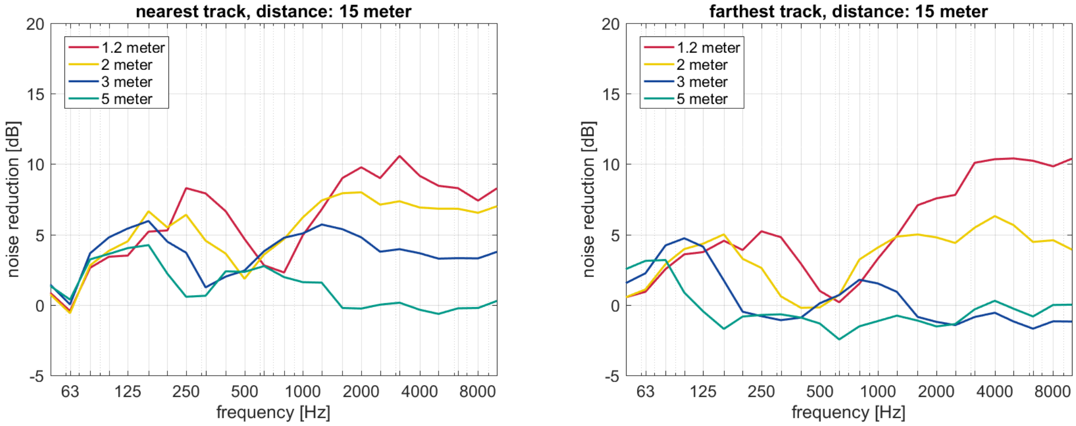

Figure 6. Noise reduction per third octave band. The left figure shows the results for the first track, the right figure shows the noise reduction for the second track.

distance becomes less with increasing microphone height. At 5meter height there even is a minor increase in the noise level. As the microphone distance increases we also observe a noise reduction at the microphones at the higher positions. At 25meter distance we observe a noise reduction of 4 to 7 dB at all heights for trains at the nearest track.

Based upon these results we can conclude that the effect of the Whisswall is consistent with theory. The diffracting element on top deflects the soundwaves in an upward direction. The largest noise reductions are thus found on the lower microphone positions while for the higher positions a small increase of the noise levels is found.

The results for the farthest track show a similar behaviour. The largest reductions are found on the lower microphone positions. When comparing the results, the noise reduction of the Whisswall is seen to be larger when it is placed closer to the sound source, but still a significant reduction is obtained when the Whisswall is placed further away from the track.

7.2. Third octave bands

Figure 6 shows the noise reduction in third octave bands for the Whisswall at 15 meters distance from the nearest track. The left diagram shows the results for the nearest track, the right diagram shows the results for the farthest track. For the lower microphone positions, we observe a broad band noise reduction up to 10 dB in certain frequency bands. As the microphone height increases the noise reduction decreases in most frequency bands. For the results at the farthest track we observe a broad band increase of the noise at 5 meters which is in line with the working principle of the diffracting element

The Whisswall is tuned to be effective in certain frequencies. The reduction for these frequencies is measured at the lowest microphone heights. For higher microphones, this noise reduction shifts to a lower frequency.

7.3. Influence of train types

Figure 7 shows the noise reduction at 15 meters distance at 2 meters height. It depicts the average noise reduction over all trains but also depicts the noise reduction per train type. The VIRM 6, VIRM 4 and GTW 2/6 are all disc braked passenger trains

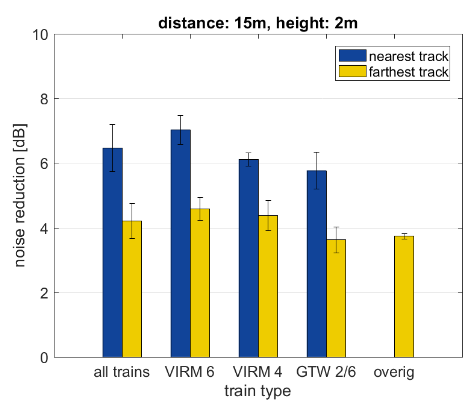

Figure 7. Noise reduction for the Whisswall per train type.

(vehicle category 8 according to the Dutch calculation scheme). The differences in noise reduction between the three train types is less than 1.5 dB for the nearest track and less than 2 dB for the farthest track.

Unfortunately, it was not possible to other types of passenger trains and freight trains since they were not operating on the test track during the measurements. However, there is no indication that the Whisswall would not work for other train types, where the main noise source is rolling noise. Only for aerodynamic sources at higher heights, for instance at high speed trains, the Whisswall might be less effective due to its limited height.

8. Conclusions and recommendations

This paper has given an overview of the results of the pass-by testing of the Whisswall, a new innovative noise measure based on diffraction of noise. The results show that the Whisswall can achieve a significant noise reduction. For higher heights, we observe an increase of the noise levels. This corresponds to the expected working principle of the diffracting element where the noise is diverted into an upward direction.

The total noise reduction is a combination of the effect of the noise barrier and the diffracting element on top of it. However, we cannot tell from the current testing which part of the noise reduction is caused by the noise barrier and which part is caused by the diffracting element. Additional testing without the diffracting element or with the element covered can reveal that.

The next step is that the Whisswall should be implemented in the Dutch calculation scheme. Currently we are investigating with all organizations and authorities involved which steps are needed to achieve that goal.

The noise reduction could only be established for disc-braked material. It would be interesting to test the Whisswall for other vehicle categories as well. However, we do not believe that the noise reduction of the Whisswall will be different as long as the noise sources are not located higher than the height of the Whisswall.

References

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