



Whisstone, a sound diffractor: does it really affect traffic noise?

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Summary

In the Netherlands there is a great demand for noise reducing measures to fulfill the noise legislation and to reduce the annoyance of traffic noise. Silent pavements and noise barriers are well-known, but are there other alternative or additional measures? The company 4Silence developed a sound diffracting element (Whisstone); a concrete element with cavities that is placed alongside the road at the same level as the road surface. The diffracting element deflects tyre-road 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. In theory, this acoustic phenomenon can be very effective, but does it work in practice? For a theoretical description and the results of model based research, see the accompanying paper of Y.H. Wijnant. Experiments have been done on different types of Whisstone diffracting elements in combination with several road surface types. In 2012 and 2013 this innovation was constructed at two sites along a secondary road. This paper shows the approach of the measurements and the results. The Whisstone elements seem to be an interesting innovation which can increase noise reduction up to 4 dB.

1. Introduction

1.1. Background

In the past few years the developments in traffic noise reduction are mostly focused on developing silent pavements and noise barriers. These measures are commonly used to reduce traffic noise. Next to silent pavements and noise barriers there is a need for other measures to reduce traffic noise. A new measure to reduce traffic noise are the Whisstone diffracting elements.

1.2. Whisstone

The Whisstone diffracting elements are concrete elements with cavities. These elements are placed alongside of the road. Due to resonance in the cavities the sound waves are deflected in an upward direction. This results in a noise reduction behind the Whisstone elements.

A theoretical description and the results of model based research are described in an accompanying paper of Y.H. Wijnant [1].

2. Experiments

To investigate the effect of the Whisstone elements on traffic noise, measurements have been conducted on different variants of the Whisstone elements. In 2013 and 2014 measurements were conducted at the N413 near Soesterberg (province of Utrecht, the Netherlands) and N314 near Hummelo (province of Gelderland, the Netherlands). At these locations the effect of different variants of the Whisstone elements could be measured in a situation with normal traffic. Based on the results of measurements and of the models the Whisstone elements have been further developed and optimized.

In June 2014 measurements were conducted at the N314 near Hummelo on two specific variants of the Whisstone elements. In figure 1 and figure 2 photos of the two variants are shown.



Figure 1. Whisstone diffracting elements variant 1 (section 1)



Figure 2. Whisstone diffracting elements variant 2 (section 2)

3. Measurement set-up

The measurements were done at the N314 near Hummelo. This is a provincial road with a maximum speed of 80 km/h. The road surface is a thin surface layer.

To measure the noise reducing effect of the Whisstone, the diffracting elements were placed alongside of the road over a length of hundred meters each. Next to these road sections a similar section without Whisstone elements was defined. This section was used as a reference section.

At all sections, measurements were conducted more or less similar to the Statistical Pass-By (SPB) - Method [2]. For this experiment extra microphone positions were added to the SPB-method. The microphones were placed at 7.5 meter and 15 meter out of the center of the driving lane at four heights.

At a distance of 7.5 meters at a height 1.2m, 2m, 3m and 5 m, and at a distance of 15 meter at a height of 1.5m, 3m 3.75m and 4.5m.

In figure 3 a photo and schematic overview of the measurement set-up is shown.

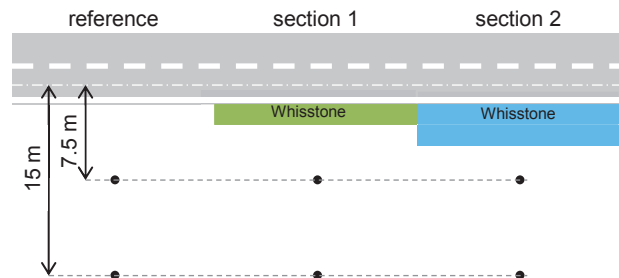


Figure 3. Measurement set-up

During the measurements the sound levels of a passing vehicle were measured at all three measurement sections and all microphone positions. Also the speed of the vehicle was measured. If the vehicle speed between the test section and the reference section differed more than 5 km/h the measurement was discarded.

The acoustic properties of the road surface of the different measurements sections was checked with a Close Proximity (CPX) measurement [3]. It was found that there was no significant difference between the sound emission of the different test sections. In figure 4 a typical pass-by of a passenger car is shown.

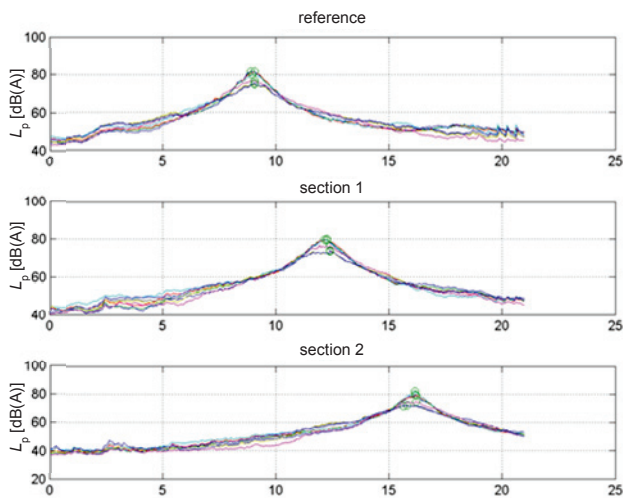


Figure 4. Example of a measurement of one passenger car for the 3 sections (L_p versus time)

4. Results

4.1. Effect for light motor vehicles

At every microphone position the difference in sound levels between the test section and the reference section was calculated. This difference in sound levels gives the effect of the Whisstone elements for that particular microphone position.

In figure 5 and figure 6 the effect of the Whisstone elements is shown for the eight microphone positions. The error bars show the 95% confidence interval of all measured vehicles.

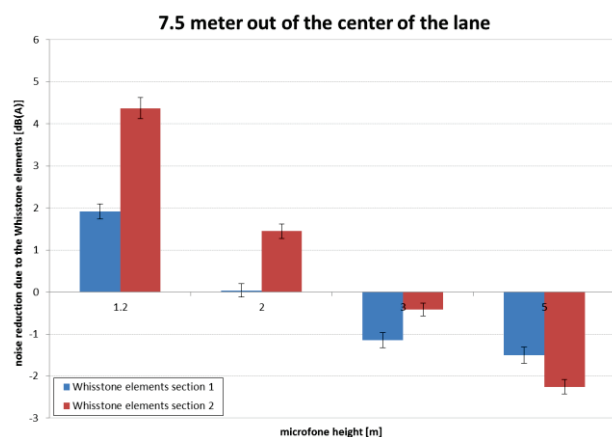


Figure 5. The effect of the Whisstone elements at 7,5 meter out of the center of the driving lane

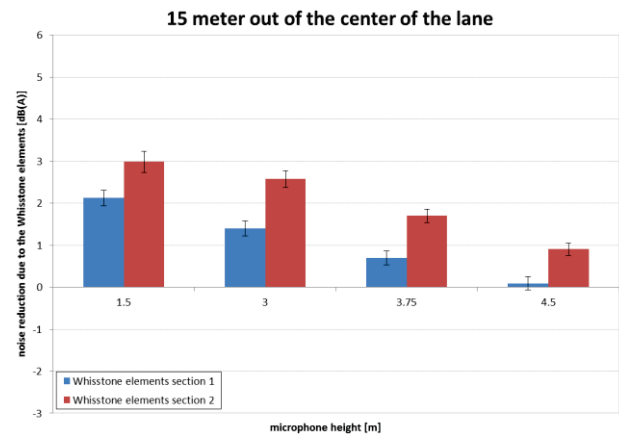


Figure 6. The effect of the Whisstone elements at 15 meter out of the center of the driving lane

Based on figure 5 and figure 6 we can conclude that the effect of the Whisstone elements is consistent with the expectations that the Whisstone elements deflect the soundwaves in an upward direction. The largest reductions are found at the lower microphone positions. At the higher microphone positions the sound levels increase. The different variants of Whisstone elements show different effects. The Whisstone elements at section 2 show a higher noise reduction than the Whisstone elements at section 1. The elements at section 2 show a noise reducing effect up to 4 dB depending on the microphone position.

The overall reduction of the Whisstone elements depend on the emission spectrum of the traffic (and the road surface) because the reduction of the elements depend on the frequency. Figure 7 shows the average immission spectrum for the different test sections at 15 meters out of the center of the driving lane at a height of 3 meters.

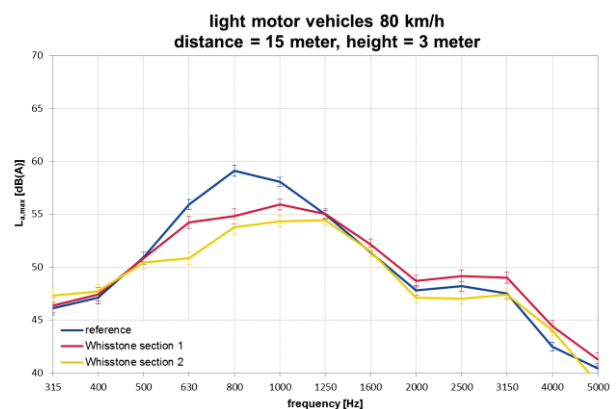


Figure 7. Average sound spectra for light motor vehicles with 80 km/h at a distance of 15 meter and height of 3 meter

The largest effect of the Whisstone elements is found in the frequency range from 630 to 1000 Hz. At the other microphone positions the effect is found in the same frequency range. In figure 8 and figure 9 the spectral effect of the Whisstone elements is shown for all the microphone positions. The figures demonstrate that the effect of the Whisstone elements at section 2 is more broadband, which results in an overall larger effect.

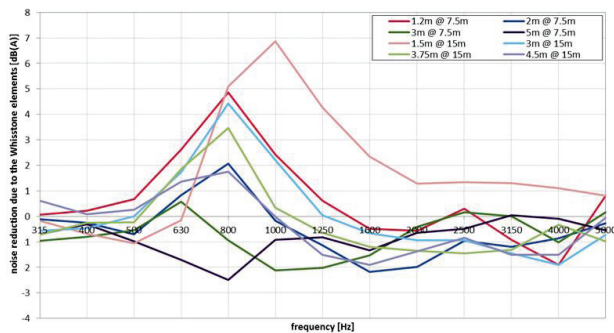


Figure 8. Effect spectra of the Whisstone elements at section 1

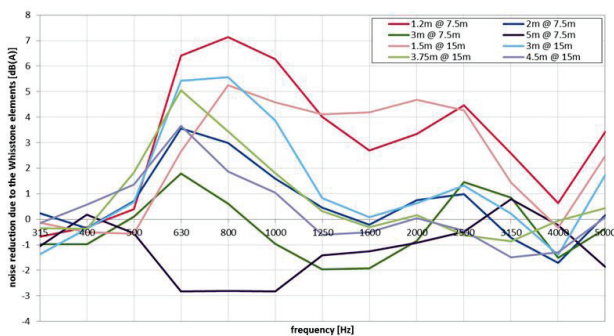


Figure 9. Effect spectra of the Whisstone elements at section 2

The maximum effect of the Whisstone elements at section 1 is found at the frequency of 800 Hz. For the Whisstone elements at section 2 the largest effect is found at the frequency of 630 Hz.

To optimize the Whisstone elements the spectral effect can be changed and tuned for a specific situation. This depends on the road surface, vehicle speed and percentile of heavy motor vehicles. The Whisstone elements could further be optimized by making the effect more broadband.

4.2. Effect for heavy motor vehicles

Also measurements were conducted on heavy vehicles. Because the number of heavy vehicles was limited, the accuracy of the effect for heavy vehicles is less than for passenger cars. The measurements do however show that a sound reducing effect can also be expected for heavy motor vehicles, as is shown in figure 10 and figure 11.

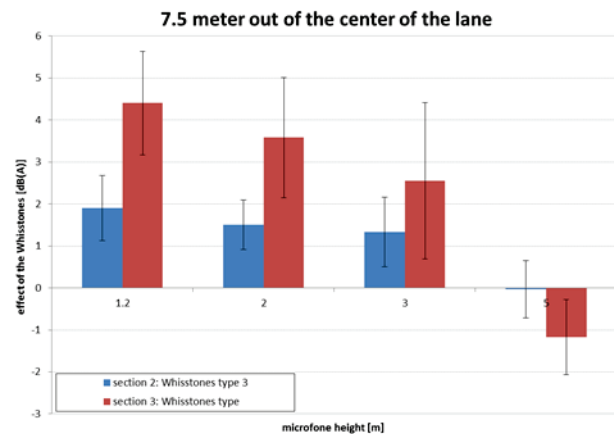


Figure 10. The effect of the Whisstone elements for heavy motor vehicles at 7,5 meter distance of the driving lane

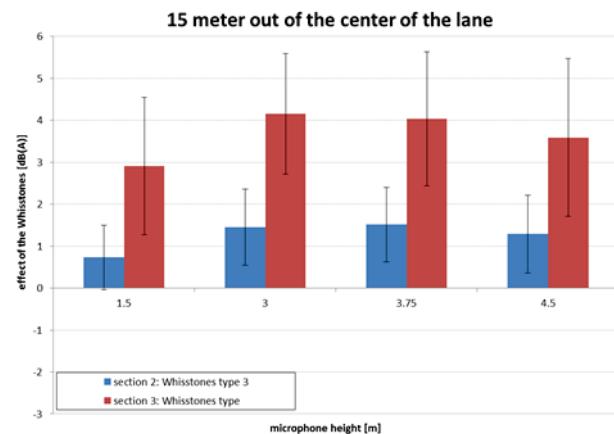


Figure 11. The effect of the Whisstone elements for heavy motor vehicles at 15 meter distance of center of the driving lane

An effect for heavy motor vehicles up to 4 dB can be achieved. The maximum effect for heavy motor vehicles is found at 800 Hz for both variants of Whisstone elements.

4.3. Effect at larger distance of the source

To investigate the effect of the Whisstone elements at a larger distance of the source, passing vehicles on the opposite driving lane were measured. The distance between the Whisstone elements and the center of the driving lane was in this case larger than four meters. The results are shown in figure 12 and figure 13.

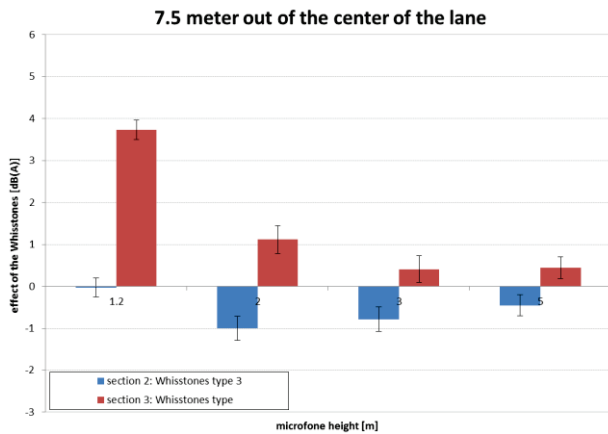


Figure 12. The effect of the Whisstone elements at larger distance of the source (traffic on lane of opposite direction)

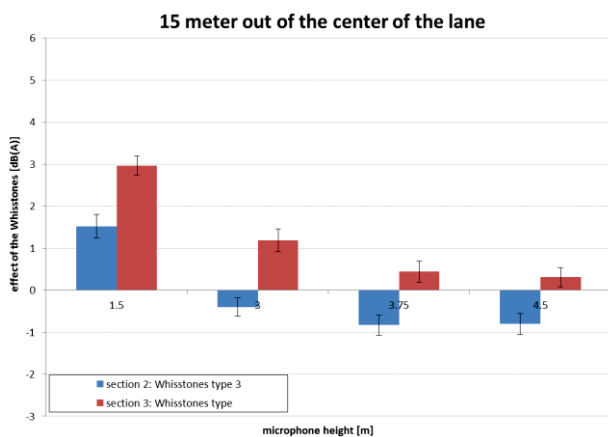


Figure 13. The effect of the Whisstone elements at larger distance of the source (traffic on lane of opposite direction)

Comparing the measurement results, the effect of the Whisstone elements is larger when it is placed close to the source, but there is still a significant effect when the Whisstone elements are placed at a larger distance from the source.

5. Conclusions

Based on measurements the effect of the Whisstone diffracting elements is examined for light and heavy motor vehicles. The following conclusions can be made. The results match with the expectations that the Whisstone elements deflect the sound waves in an upward direction. Close to the road there is an increase of the sound levels at a higher measurement height. At a larger distance from the road, the sound levels decrease at lower measurement positions.

The different variants of the Whisstone elements show different effects in noise reduction. The noise reduction of the Whisstone elements also depends of the position of the receiver. At a distance of 7.5 meter out of the center of the driving lane there is a sound reduction at a height of 1.2 and 2 meters. At a distance of 15 meters there is a sound reduction at all measured heights. With the Whisstone elements from section 2 sound reductions up to 4 dB can be achieved. The measurements show that there is also a significant effect for heavy motor vehicles. At a larger distance from the source the Whisstone elements can still have a significant reduction.

The results presented in this paper are typical for the two tested variants of the Whisstone elements. Different experiments with other variants of the Whisstone elements show spread in results. Based on the results of the different measurement campaigns it is expected that the Whisstone elements can further be optimized.

We conclude that the Whisstone elements can be a useful supplement to the existing noise measures and can also be used in combination with silent pavements. In that situation the effect of both measures can be added.

Acknowledgement

We would like to acknowledge the province of Gelderland and Utrecht which made it possible to do experiments with the Whisstone diffracting elements and to run a measurement campaign in a situation with normal traffic.

References

- [1] Y.H. Wijnant, J. Hooghwerff: A model for diffracting elements to reduce traffic, Proc. Euronoise 2015
- [2] ISO 11819-1, “Acoustics – Method for measuring the influence of road surfaces on traffic noise – Part 1: The Statistical Pass-By method”, 24th of May 1996
- [3] ISO 11819-2, “Acoustics – Measurement of the influence of road surfaces on traffic noise – Part 2: The Close-Proximity (CPX) Method”, 12th of March 2011