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IMPROVING THE IN-SITU DETERMINATION OF THE INTRINSIC CHARACTERISTICS OF NOISE BARRIERS

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The acoustic performance of noise barriers is mainly determined by the insulation and the absorption of the noise barrier. Traditionally, these properties are determined using laboratory measurement methods. In recent years, in-situ methods have been developed and standardized. Our research focusses on application and improvement of these methods.

One of the main problems during the in-situ measurements is the influence of the background noise. This can significantly influence the measured values. During the measurements, the operator can select which measurements are influenced by the background noise and which are not. But this might differ from operator to operator thereby increasing the uncertainty in the resulting value. We are developing a method that uses the coherence function as indicator for the influence of background noise.

The in-situ measurement uses a sound source with limited angles of incidence. However, traffic passes by the noise barrier and is further away from the noise barrier than the sound source is during the in-situ measurements. We conducted experiments to simulate this passing sound source and compare the results of these measurements with the results of the absorption measurements in-situ.

Keywords: Noise barriers, sound reflection, measurements

1. Introduction

Noise barriers are often used as a noise mitigation measure. The reduction and the sound level behind the noise barrier depends on the acoustic properties of the noise barrier, the position of the source, the noise barrier and the receiver, the dimensions of the noise barrier, the local conditions and the weather conditions.

Noise barriers can effectively prevent the propagation of noise from the source to the receiver as the function as obstacles between the noise source and the receiver. When a sound wave reaches the noise barrier three phenomena occur:

- Transmission: The sound wave reaching the exposed side of the noise barrier partly transmits through the noise barrier. The amount of transmitted energy is determined by the insulation of the noise barrier.

- Reflection: The sound wave partly reflects on the noise barrier. The amount of reflected sound can be altered by changing the absorption of the noise barrier.
- Diffraction: Part of the sound wave travels over the noise barrier and diffracts on top of the edge and then propagates to the receiver.

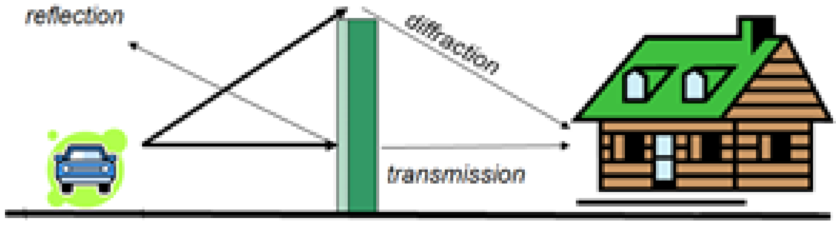

Figure 1: Reflection, transmission and diffraction at a noise barrier

The current paper mainly focusses on the reflecting properties of a noise barrier.

2. Quantification

Traditionally, the sound absorption and the airborne sound insulation characteristics of noise barriers have been determined in the reverberant rooms. The standards EN 1793-1:1997 [1] and EN 1793-2:1997 [2] describe the measurement method for the sound absorption and airborne sound insulation respectively.

In 2012, EN 1793-6: 2012 [5] was made available, describing a measurement method for in-situ determination of the airborne sound insulation. This made it possible to restrict the application of EN 1793-2:2012 to noise reducing devices used under diffuse sound field conditions.

Since March 2016, EN 1793-5: 2016 [4] is publicly available. EN 1793-6:2016 describes the test method to determine the acoustic absorption of the noise barrier in-situ. This completes the set of in-situ determination of the intrinsic characteristics of noise barriers. In near future, the use of the current EN 1793-2:2012 can be restricted as well to intended use to under diffuse sound field conditions only.

This will mean that the old tests inside the reverberant rooms will no longer be considered applicable for the assessment of noise barriers along roads under direct field, non-reverberant conditions.

We conducted a research programme to the application of the in-situ determination of the acoustic absorption, mainly focussing on two topics.

- The representativity of the in-situ measurement of the acoustical absorption. When a car drives along the noise barrier, the angle of incidence of the sound source changes and this might influence the absorbing properties of the noise barrier. We use the Sonocat [6] to measure the absorption of a noise barrier under different angles of incidence and compare the results of those measurements to the results of in-situ measurements according to EN 1793:5
- When performing in-situ measurements background noise might play a role. EN 1793:6 demands a good signal to noise ratio. In our experience this might not be sufficient and it is on the measurement operator to judge if a measurement is valid or not. This might lead to different opinions and thus to extra variation in the measurement result. An objective measure to check whether the measurement is valid or not is thus needed. We propose to use the coherence function for this purpose.

3. Measurement methods

3.1 In situ measurement of the acoustical absorption

An artificial sound source and a square nine microphone array are used. The array is placed between the sound source and the object under test. The sound source emits sound waves that travel through the microphone array to the object under testing, on which the waves reflect. The microphones receive the direct sound wave from sound source to object under test and the indirect sound wave. A free field measurement with the same source and microphone setup is subtracted from the previous measurement to isolate the reflected component. To subtract both measurements from each other the signal converted into impulse responses. The ratio of acoustic power of the direct and reflected components is used to calculate the sound reflection index RI. From the sound reflection index the single-number rating DL_{RI} can be derived to indicate the performance of the product.

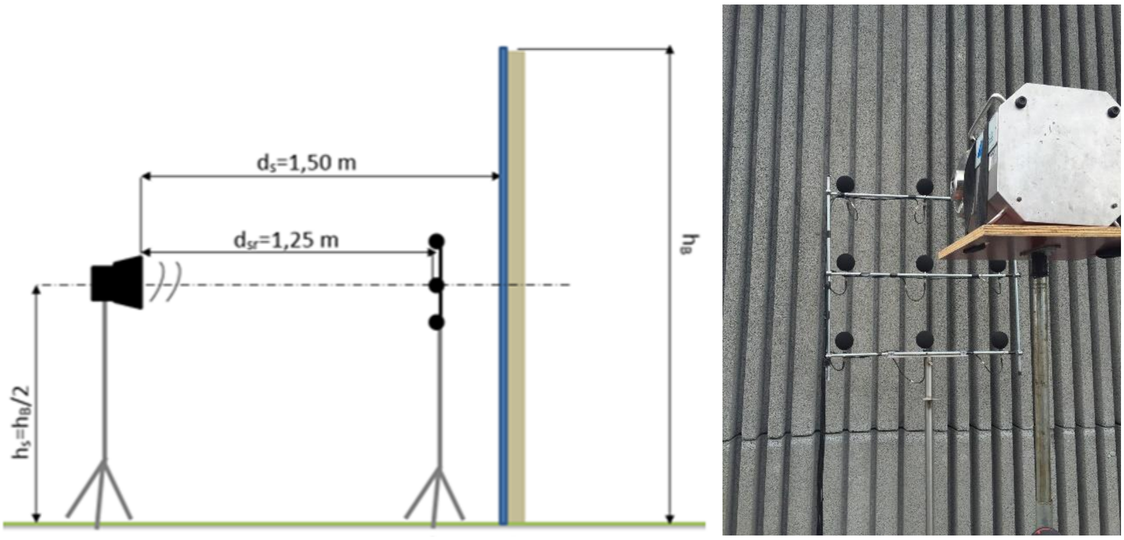

Figure 2: Left: Schematic representation of in-situ measurement to determine the reflection index. Right: Measurement setup for in-situ determination of the reflection index

3.2 Sonocat measurement device

The Sonocat measurement device (Figure **3**) can measure the acoustical absorption coefficient of a material or surface in a-priori sound field. It uses so called local plane wave methods to measure acoustical absorption. The absorption coefficient is calculated based on a measurement of the acoustic pressure in eight points, using MEMS microphones, in the vicinity of the absorbing surface. For an extensive description of the working principle of the Sonocat measurement device, the reader is referred to reference [7].

Figure 3: Sonocat measurement probe

4. Influence of angle of incidence

4.1 Experimental setup

We designed an experiment to test the setup for the absorption measurement. A first step in this setup was to measure the acoustical absorption of absorbing foam to prove correct working of the measurement setup. This experiment consisted of two parts:

- Measuring the reflection index with the setup as described in EN 1793-5 so by using a square array with nine microphones (picture on the right-hand side of Figure **4**);
- Measuring the reflection with the Sonocat for different distances between the source and the screen and different heights for the source (picture on the left-hand side of Figure **4**). The distances correspond to typical distances between the noise barrier and passing traffic.

The second step is to determine the reflection for different angles of incidence. We varied the angle of incidence between -45 and +45^{0} in steps of 15^{0}.

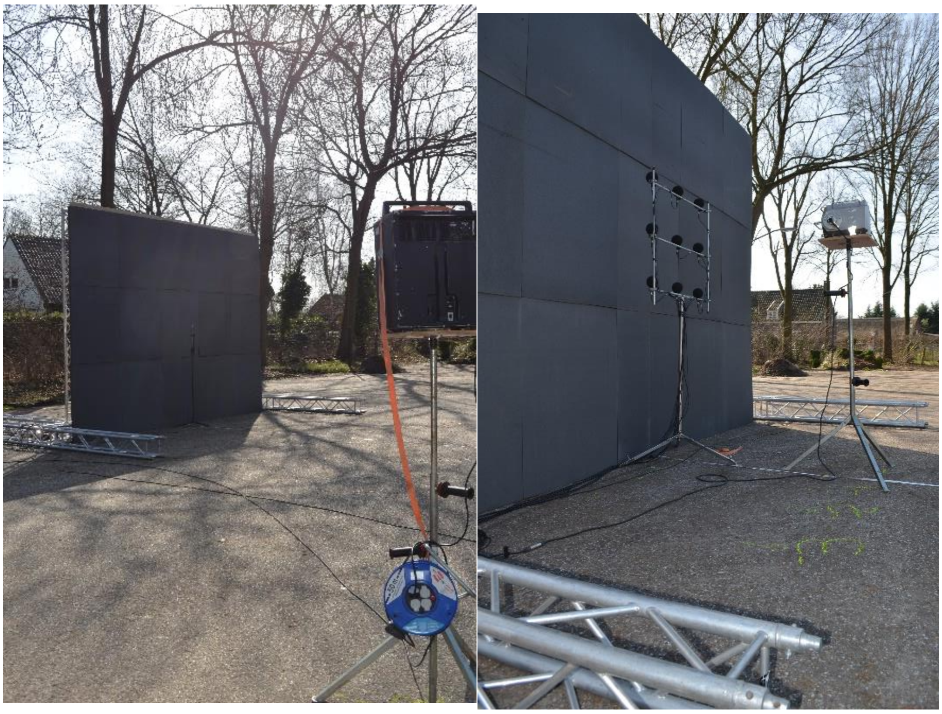

Figure 4: Test Setup with the Sonocat (left) and in-situ measurement according to EN 1793-5 (right)

4.2 Results

Figure **5** shows the results for the measurements under normal incidence. The blue line shows the reflection index according to EN 1793-5. The red line and the yellow line show the results for the measurement with the Sonocat device for different distances between the sound source and the noise barrier. The Sonocat determines the absorption coefficient but for comparability reasons we calculated the reflection coefficient. We observe a reasonable agreement between the results of both measurement methods. For certain frequencies, the difference between the results for the sonocat and the EN 1793-5 measurement is a bit more. Part of the difference can be explained that the Sonocat was relatively far away from the noise barrier. It was positioned at 25cm from the surface of the noise barrier. Ideally, it would have neem positioned closer to the surface. Additional measurements will be performed in near future to estimate the effect of this distance. Secondly, a window is used in the measurements according to EN 1792-5 to eliminate the effect of reflection. Such a window is not included in the analysis of the Sonocat measurements.

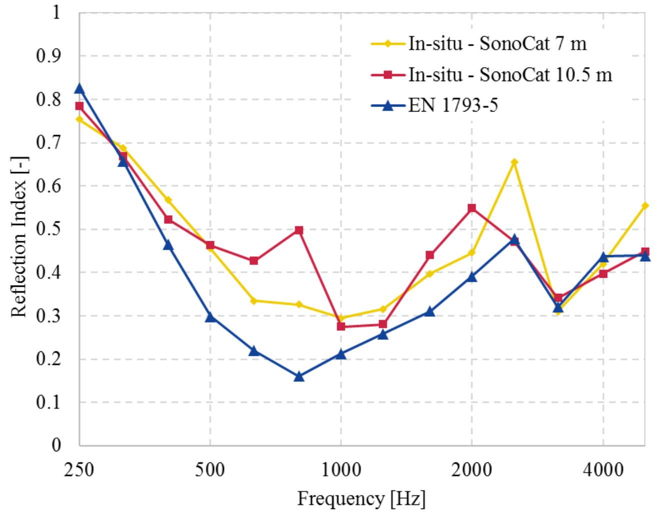

Figure 5: Reflection index measured with the Sonocat at different distances between source and noise barrier and measured according to EN 1793-5

Figure **6** shows the reflection for different angles of incidence. Again, we notice a reasonable agreement between the results of the Sonocat measurements and measurement according to 1793-5. The reflection does not change significantly for the different angles of incident, except for the peak around 1600 Hz. This peak vanishes as the angel of incident increases.

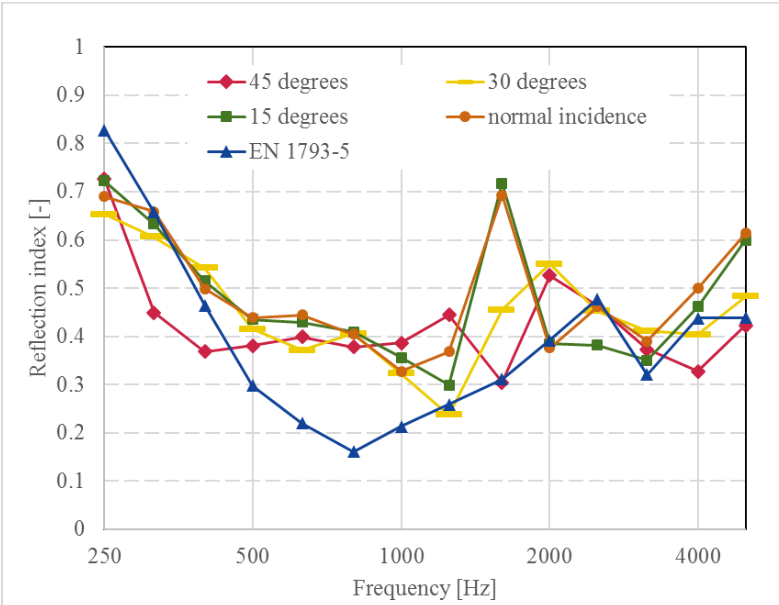

Figure 6: Reflection index for different angles of incidence

5. Influence of back ground noise

During the measurements, the operator can select which measurements are influenced by the background noise and which are not. But this might differ from operator to operator thereby increasing the uncertainty in the resulting values. A commonly used parameter to describe the quality of the measurement result is the coherence function, which also has been used to improve the determination of the absorption coefficient for highly reflective road surfaces [0].

5.1 Experimental setup

An experiment was conducted to determine the influence of background noise on the resulting reflection index and the coherence function. We performed three measurements on a noise barrier

- Ideal situation without any significant background noise;
- The situation in which we added broad band noise during the measurement;
- The situation where we added impulse noise during the measurement,

5.2 Results

The figure below shows the results of the different measurements. The left diagram shows the reflection index. The three measurements yield comparable results though we notice a that in most third octave bands the reflection index is a bit lower for the measurements with background noise. The corresponding values for the coherence function for the centre microphone are given in the right diagram. For the ‘ideal measurement’, without background noise the value for the coherence function is close to 1 in each third octave band. The value for the coherence function drops when background noise is added.

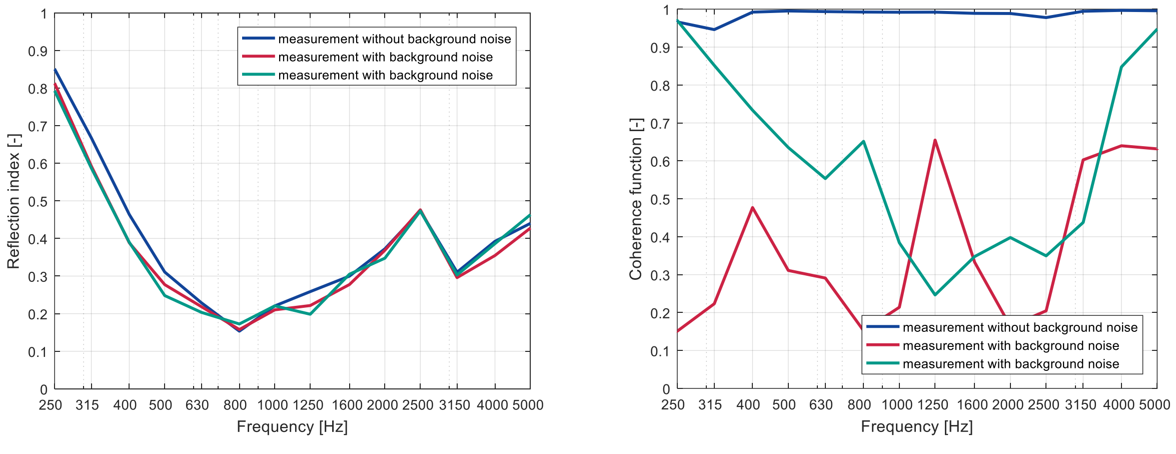

Figure 7: Left: reflection index of noise barrier measured with and without background noise.
Right: corresponding coherence function per third octave band for the centre microphone in the array

The effect on the DL_{RI} is in the order of 0.2 dB and after rounding to the nearest integer this value is 4 or 5 dB respectively. Hence. the accuracy of the measurement results can be increased when using the coherence function as indication whether the measurement is disturbed by background noise. A next step is to implement the coherence function as indicator for the quality of the measurement in the analysis software. We also will look into the possibility to use the coherence function as indicator for determining the airborne sound insulation in-situ.

6. Conclusions and recommendations

The current research focussed on the in-situ determination of the absorbing properties of noise barriers. We conducted experiments on an artificial noise barrier consisting of a wooden panel with absorbing material glued to it. The current research has two major goals:

To determine how the absorbing properties changes for different angles of incident and how this corresponds to the in-situ determination of the reflection according to EN 1793-5. For this purpose, we used the Sonocat measurement device. It shows that the reflection does not change significantly when changing the angle of incident and that the in-situ measurement method can describe this well. We still observe a difference though between the results of the Sonocat and the in-situ measurements, which might be caused by the position of the Sonocat relative to the noise barrier. Further research is needed to find out if this is indeed causing the difference or that there is another reason for the differences observed.

To develop a method that can determine whether the measurement is influenced by background noise. For this purpose, we use the coherence function. The first results show that the value for the coherence function decreases significantly when background noise is added during the measurements. So, using the coherence function is a good way of doing that. Further development of this method is needed with the goal to have a value for the coherence function as limit value. This technique looks promising and can in future also be applied for the measurement of the sound insulation.

REFERENCES

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