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Pilot study on the presence of quiet sides in Flanders

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ABSTRACT

It was shown by means of large-scale surveys that the presence of a quiet side near a dwelling could reduce negative noise-related effects for inhabitants. Furthermore, the European Environmental Noise Directive mentions care for silent zones in an urban environment as a possible action plan against noise. A pilot study was set up, which was part of a large and repeated measurement campaign related to the evolution of road traffic noise in Flanders. Simultaneous short-term noise level measurements were performed at the front and back facade of 38 randomly selected dwellings. Temporal and spectral analysis allows categorizing these locations for their ability of providing a quiet side.

Keywords: Quiet side, measurements, sound propagation

1. INTRODUCTION

From large-scale surveys, it was shown that the presence of a quiet side near a dwelling could reduce negative noise-related effects for inhabitants [1]. A possible explanation is that the dwellers have the opportunity to locate their noise-sensitive rooms like e.g. a bedroom at the quiet façade. A nearby and easily accessible quiet courtyard or silent zone can also serve as a refugee from excessive noise levels [2][3]. The attractiveness of such locations is important and influenced to a large extent by the amount of greenery [2][4].

Furthermore, the European Environmental Noise Directive [5] mentions care for silent zones in an urban environment as a possible action plan against noise. The quiet side concept has already found its way to environmental noise policy in e.g. Sweden and the city of Amsterdam.

In this study, the presence of quiet sides in a densely built, densely populated and heavy motorized Western-European region like Flanders (Belgium) is assessed. The measurements described in this paper are part of a larger and repeated study on the evolution of road traffic noise levels at the street facing façade in the years 1996, 2001 and 2009 [6]. In the 2009 measurement campaign simultaneous front and back façade measurements have been carried out as well. The analysis of these measurements (sound pressure level differences, frequency spectra and dynamics) is the subject of this paper.

2. MEASUREMENT METHODOLOGY

2.1 Location selection

Simultaneous front and back façade measurements were performed at 38 locations. This is a subset of the 250 assessment points selected on a population basis for investigating the evolution of road traffic noise levels over 13 years. More information on the spatial sampling approach can be found in Ref. [6]. Measurements were performed during daytime only (between 7:00 h and 19:00 h) at work days. Given the large population density and dwelling density in Flanders, and given the fact that the region under study is highly motorized, the sound environment almost any location is dominated by road traffic noise. The dataset contains mainly measurements at dwellings near minor roads.

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The front-back measurement locations were chosen randomly from these 250 points. The decision to perform such a measurement was mainly based on practical aspects like e.g. an inhabitant of the selected dwelling being home and allowing to perform measurements at the back façade. A priori estimates as for the presence of a quiet side were not made. It is clear that this procedure favored certain dwelling types. Easy access to a garden and thus open building structures resulted in dwellers allowing access more easily; dwellers of apartments in city centers on the other hand were less inclined to give access to a terrace or bedroom at the back.

2.2 Instrumentation

The noise level measurements were performed with a ½" electret microphone (type Bruel & Kjaer 4189) connected to a pre-amplifier (type Bruel & Kjaer 2669C). The logging of the measurements was done with a Svantek 959 device. Two measurement chains have been used and were calibrated daily with a Bruel & Kjaer 124.06 dB pistonphone, producing a pure tone of 251.2 Hz. A 90-mm diameter windscreen (type Bruel & Kjaer UA 0237) was used. The microphone and logger were put on a tripod at 1.5 m above the ground. The clocks of both loggers were manually synchronized on a daily base, leading to a maximum time lag of 1 s. The microphones were placed at a distance of 1 m from the front or back façade.

2.3 Measurement duration

The measurement duration was 20 minutes. The feasibility to acquire a reasonably accurate estimate of longer-term noise levels by extrapolating short-term samples is confirmed by other researchers. In [7], many studies were analyzed leading to the conclusion that a measurement duration between 10 minutes and 1 hour is standard practice. In Ref. [8], it was shown that taking a few 15-minute samples during daytime in a dense urban setting could lead to errors of only 1.5 dBA when extrapolating to L_{den} values (in 90 % of cases of random sampling). Detailed analysis on the uncertainty related to the short-term sampling approach in the current measurement campaign is found in Ref. [6]. One-third octave band levels were measured on a 1-s basis.

3. RESULTS AND DISCUSSION

3.1 Analysis of the sound field at the front and back façade

Three typical cases can be distinguished when comparing simultaneous front and back façade sound fields.

In a first case (see Fig. 1), the front façade is characterized by much higher noise levels than the back facade. Both the front and back façade share the same dominant source, present at the street-facing front façade. Such locations are characterized by small level differences in the low frequency range. Shielding by the building results in much lower sound pressure levels at high frequencies at the back façade. It is further noticed that the dynamics at the front and back of the building are different. At the front façade, peaks are much more pronounced and the distribution of levels is wide. At the back façade, on the other hand, the variation of levels over time is much more limited and peaks are less pronounced. This is consistent with measurements and simulations reported in Ref. [9]. Integration of noise levels over 3-s periods has been performed before plotting the time series (as shown in Fig. 1) to account for possible errors as regards clock synchronization between the two logging units.

In a second case (see Fig. 2), the front and back façade are very similar as concerns levels and sound frequency spectrum. Such situations typically occur when the dominant traffic noise source is not the road in front of the house but a larger road at some distance. The buildings could be oriented in such a way that both façades receive the same noise. A typical case is a dwelling with length axis normal to the dominant road. Other examples are found in residential areas constituting of detached houses, where sound from a busy road at some distance reflects on facades of adjacent buildings and diffracts around them. The sound fields at both façades have similar dynamics and fluctuate less than the noise level at the front façade of the dwellings in case 1.

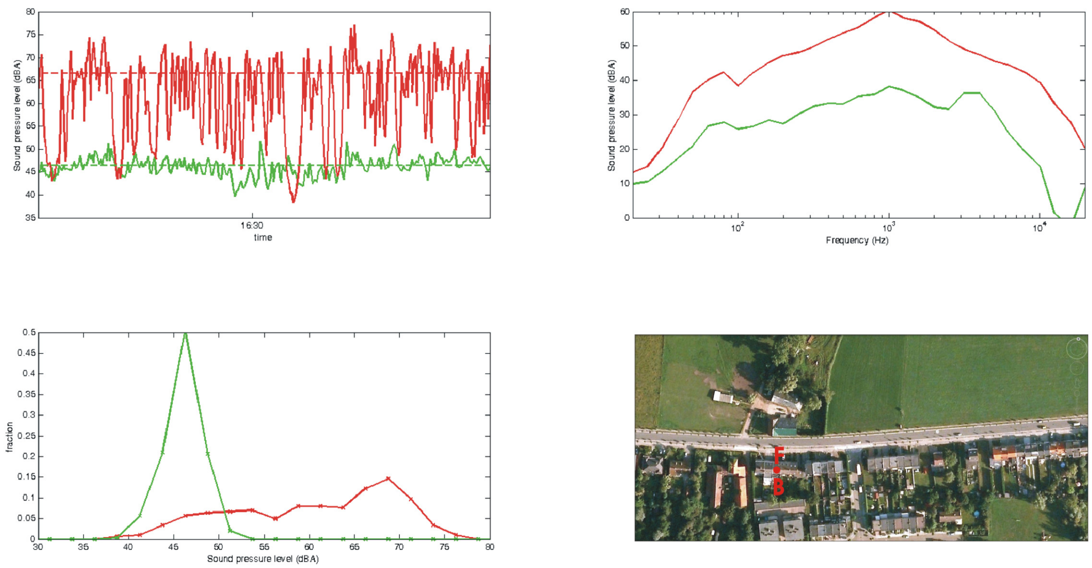

Figure 1 – Case with a clear identifiable quiet façade. The total sound pressure level over time (integrated over 3-s periods, *upper left*, the dashed lines are the equivalent levels over the sample period), the equivalent sound frequency spectrum (*upper right*), the total sound level distribution (*lower left*) and an orthophoto (*lower right*) of the measurement location (F=front façade, B=back façade) are shown. The red lines indicate the front façade measurements, the green lines the back façade measurements.

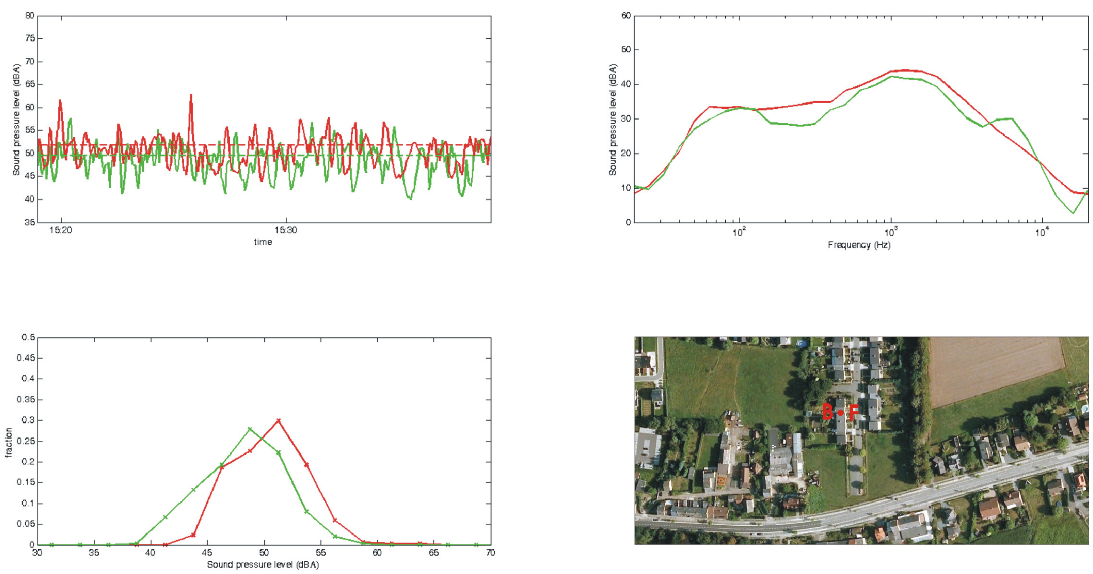

Figure 2 – See caption of Fig. 1, for a case in absence of a quiet façade.

As a third case, one can mention situations where the sound fields at the back and front façade are not linked. At these locations, the sound field at both façades shows different dynamics, and the frequency spectrum can be different. Examples are e.g. a local road which is dominant at the front façade, but that does not contribute to the back façade (e.g. because of a large degree of shielding provided by the building). At the back façade, another source like a nearby road or a highway at some distance can become the dominant noise source.

It is clear that the in the first case it is most likely to observe the desired “quiet façade” effect. This case is therefore most interesting from the perspective of urban planning taking care of noise issues. Levels are much lower at the back façade, and noise events (passing cars) will be less noticed which is clearly beneficial from the viewpoint of limiting noise annoyance and sleep disturbance. A possible drawback is the higher (relative) importance of low frequencies [9]. In the second case, quiet side benefits are absent.

In the third case, the benefit of a quiet side could still be present provided that the contribution from other sources at the back façade remains low enough. It is however the hardest situation to assess in noise mapping and urban planning since all distant sources have to be accounted for accurately. Moreover, very local disturbances can also be important.

3.2 Overall assessment

The 38 dwellings where measurements were performed at both the front and back façade can be clustered based on the resemblance to the prototypical cases discussed in Section 3.1. This clustering is done manually based on the temporal fluctuations and level distributions at the one hand, and on the knowledge of the local situation at the other hand. In Fig. 3, a scatter plot between front and back façade total A-weighted equivalent level during the measurement period is shown. "Case 1" situations occur quite often (in 16 of the 38 observations) and mostly have high front façade levels and a significantly lower level at the back façade. "Case 2" situations are also quite common (13/38). Fortunately, this situation which is unlikely to give any quiet side benefit occurs mainly at low levels where noise annoyance is expected to be limited. Note that in this situation sometimes the A-weighted equivalent level at the back façade is still 5dBA lower, but the temporal changes and level distributions are very similar. Finally situations categorized as "case 3" (9/38) are scattered around in the center of the plot (with one exception). Since these situations are the hardest to predict, it is fortunate that they represent a minority.

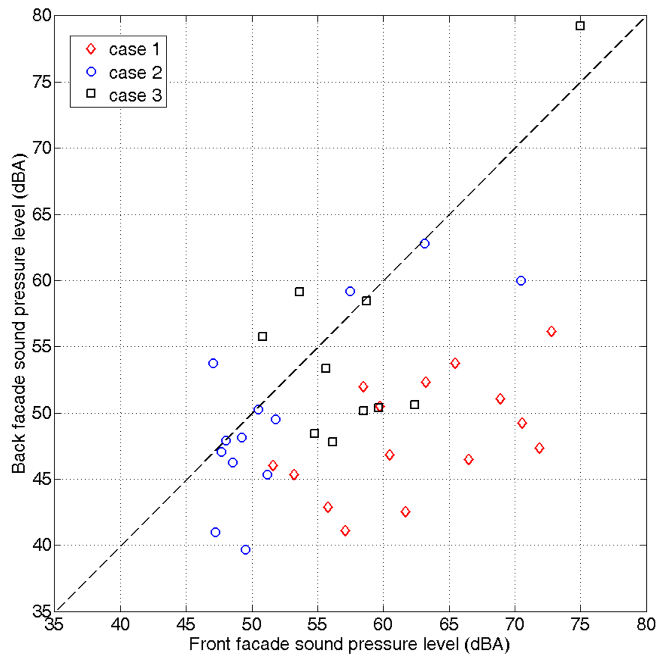

Figure 3 – Scatter plot between front and back façade total A-weighted equivalent levels, clustered based on the resemblance to the situations sketched in Section 3.1.

The same data is shown in a more condensed way in Fig. 4. It gives an idea of the prevalence of quiet sides in Flanders, based on the limited sample. The difference in total A-weighted equivalent level between the front and back façade is shown in the histogram, using class widths of 5 dBA. At 5 of the 38 locations, the front (street-facing) façade is characterized by lower levels (negative values). The median on this data is near 7.1 dBA; 29% of the level differences are between 5 and 10 dBA. 34% of the locations have a back façade that is more than 10 dBA quieter than the front façade.

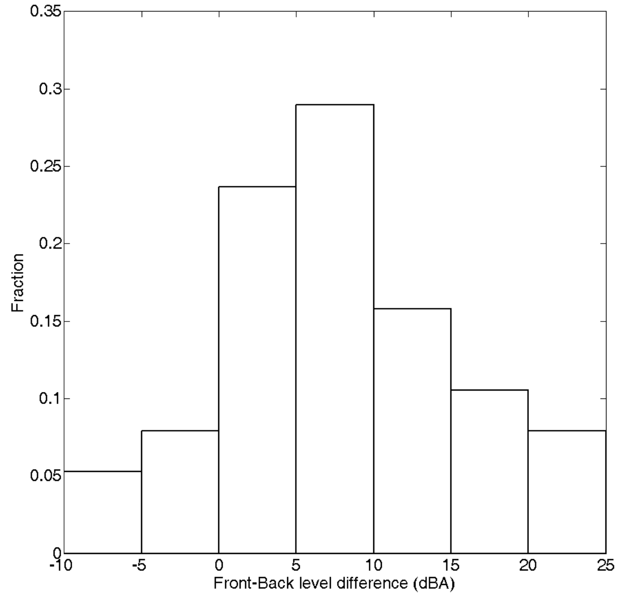

Figure 4 – Histogram of front-back level difference at the 38 measurement locations.

The noise annoyance criterion described in [1] takes into account the quiet side benefit. Based on the large scale survey conducted (in Sweden), it was concluded that the $L_{Aeq,24h}$ at the most exposed façade should not exceed 60 dBA, while at the quiet façade the level should not exceed 45 dBA. When obeying this criterion, 80% of the population will not be annoyed by road traffic noise, and negative health-related noise effects are not expected. Based on the limited sample here, this condition is only fulfilled at 10% of the locations.

Some caveats are however needed on the above cited values, given the extrapolation from short-term sampling to 24-hour equivalent levels, the limited number of locations considered, and the absence of rectification on typical building geometry/orientation in the region under study.

4. CONCLUSIONS

This pilot study shows that providing quiet sides has not been an aspect that city planners have considered in the Flanders region (in the past). This means that there is quite some potential to apply this concept to help reducing road traffic noise related problems.

This study also confirmed the expected large difference in traffic noise dynamics between highly exposed and shielded façades, at least in a majority of the observations. It should be investigated whether the reduced dynamics at the quiet side contribute to the reduction in negative noise related effects. If so, indicators other than equivalent A-weighted sound pressure level differences between most and least exposed façades should be envisaged while deciding on the existence of a quiet side. This pilot study only proves that there are large differences when it comes to dynamics of the noise at the most exposed and the shielded façade in situations where quiet side effects could be of importance, not whether they actually contribute.

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