NERS-analysis extended to include noise levels measured on city courtyards

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One of the goals for the EC financed Integrated Project Quiet City Transport (QCITY), is to provide European city administrations with validated analysis tools and technical noise control solutions for the efficient production of noise action plans. A part of the QCITY project work is to produce complete noise maps and hot-spot analysis for the entire Gothenburg area.
Earlier studies have shown that calculated noise levels from traffic at inner city courtyards are lower compared to actual measurements. Gothenburg city have performed over 700 measurements on city courtyards. The measurements are included in the NERS-analysis to show the influence of the actual courtyard noise levels. The study covers a smaller area in the central part of Gothenburg where the measurements have been made.

1 Introduction

One of the goals for the EC financed Integrated Project Quiet City Transport (QCITY), is to provide European city administrations with analysis tools for an efficient production of noise action plans. According to the EC-directive, 2002/49/EC [1], the action plans should be designed to manage noise issues and effects, including noise reduction if needed. To provide good grounds for any noise action plan, one can make a map of the calculated noise levels throughout the studied city or neighbourhood of particular interest. Using the noise map as input for the action plan can be enough in many cases. But to take the analysis further, we need to account for the influence from number of inhabitants for each building, mean sound insulation and calculated façade levels. These factors can drastically enhance the understanding of the noise situation felt by residents and therefore making the action plan better and more adjusted to the needs of the city.

One of the ways to make such an analysis is to use the Noise Environmental Rating System (NERS) [2]. The end product of such an analysis is a noise score that is specific for each building. The score is derived from the calculated façade level, the mean sound insulation and the number of inhabitants.

It is popular in densely populated areas in Sweden, to use the quiet side of a building as an incitement for allowing higher noise levels at the traffic side. This means that if the sound insulation of the building at the traffic side is good enough the inhabitants can have their windows open or use their balconies on the quiet side, therefore not exposing themselves to noise levels above the recommended level. The bedrooms in these cases should be located at the quiet façade. When using a statement like this, it is important that the noise level at the quiet side is low (<45 dB(A)), not compared to the traffic side, but as a total of all noise sources on the quiet side.

On the noisy side of the building, traffic is most likely to be the dominant noise source. The calculated noise levels at the traffic side often agree quite well when comparing to long term measurements. Looking at the quiet side however, the situation is often more complex. Some prediction methods often fail in calculating a value that corresponds to measurements at inner courtyards. The Nordic prediction method [3] has a tendency to underestimate the noise levels in these situations. The traffic is often not the dominant noise source. Therefore measurements, or refined ways to predict the sound level at the quiet side, can be used to compliment the analysis.

This paper shows a case study from the city of Gothenburg where measurements at inner courtyards are compared to the calculated values from the Nordic prediction method for road traffic noise. The differences in perceived noise environment are shown by extending the NERS-analysis tool to include the quiet side.

2 Case study

The part of Gothenburg, studied in this paper is located between Vasagatan and Parkgatan. These are busy streets with many residential buildings.

Fig.1 The area of Gothenburg studied in this paper.

2.1 Calculation

The model is imported from Gothenburg's GIS software and the calculations performed in CadnaA [4] using the Nordic prediction method [3]. All parameters concerning the road traffic noise sources such as number of vehicles, percentage heavy vehicles, road surface type etc., are given by the city of Gothenburg. The calculations are made assuming that the buildings are totally reflecting with a maximum of two reflections.

Fig.2 The GIS data used for the calculation of noise levels around the buildings. The buildings marked with dark (blue) are the buildings used for the NERS-analysis.

The measurements were made between 7h00-19h00 a week day at 2 meters above ground. Consequently the corresponding *calculations* are made at the same height and with a traffic density representing daytime traffic. The calculated values are coupled to the façades and the highest level for each building as well as the highest level at the quiet side are derived for further analysis.

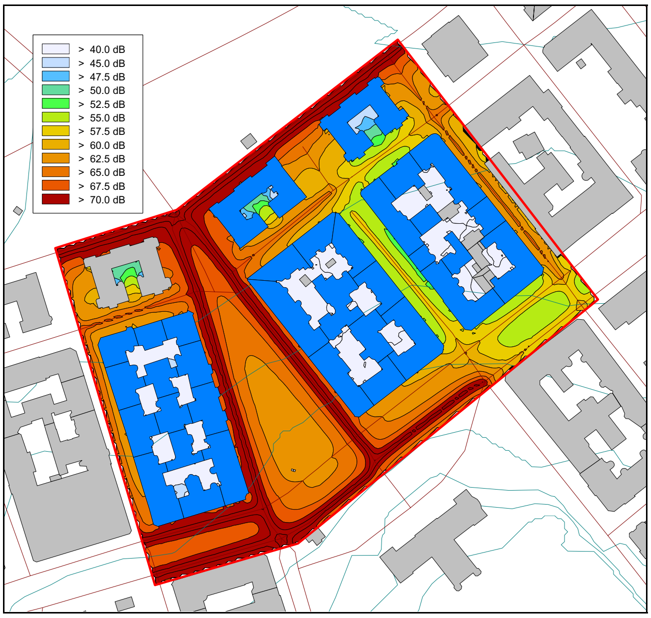

Fig.3 Calculated noise levels using the Nordic prediction method. The calculation is made at 2 meters above ground and with a maximum of two reflections.

2.2 Measurements

The city of Gothenburg have carried out over 700 measurements on city courtyards and other places around the city centre. The measurements are snapshots of the actual noise levels. The measurements were delivered as a list containing x- and y-coordinates as well as measurement date, time and a subjective note of what sources contributed to the measured levels.

The area chosen in this study contains 14 measurements, all made on courtyards and with the subjective note stating that the dominant noise source is fans mounted at the courtyard facades.

Fig.4 The figure displays the measured values delivered by the city of Gothenburg. All levels in dB(A).

The practice of placing the fans on the quiet courtyards instead of the noisy traffic side in Sweden is for the appearance of the buildings street façade. In absence of updated policies, both restaurants and shops alike will continue to place noise equipment on the courtyard side.

As the use of air conditioning in Sweden increase this problem will grow. The people that expect their courtyards to be screened and quiet from traffic noise will note that the courtyard is no longer a quiet area due to installed noisy equipment. Other countries in Europe have adopted a policy of prohibit the placement of noisy equipment at the courtyards, seeing to the interests of the building's residents.

Currently, noise from road traffic, rail traffic, aircraft and industry is handled separately by Swedish authorities. Consequently the recommended levels are stated separately. As an example the noise from road traffic may create the need for a quiet façade. The building can be built to accommodate such a solution (quiet façade <45 dB(A)), but when looking at the rail traffic noise the quiet side will receive a level above the required 45 dB(A), hence making the quiet side useless.

Fig.5 The figure displays the difference between measured values delivered by the city of Gothenburg and the levels calculated with the Nordic prediction model. All sound levels in dB(A).

When measured results are compared to the calculations, the difference is clear. The differences between the calculated traffic noise and the measured total noise is as large as 9 dB(A) in some cases. The Nordic prediction method may have difficulties calculating an accurate level at courtyards but the conclusion is that the actual dominant source at the courtyards is not traffic. When classifying the courtyard as the quiet side all noise sources must be considered.

3 NERS-analysis

3.1 Extending the NERS-analysis to include the quiet façade

Looking at the differences between the calculated and the measured noise levels alone might be enough to convince city administrations that noise levels on city courtyards will become a problem to the residents.

Making a normal NERS-analysis over the area studied in this paper would not show the effect of a quiet façade. To be able to show the effect, the NERS-analysis can be extended to include the noise levels at the quiet façade or bedroom façade in addition to the most exposed façade. This means that it has been assumed that all apartments in this study have access to both the traffic and quiet side, with the bedroom located on the quiet side.

The NERS-analysis is based on a noise score function [2] which depends on the number of inhabitants for the analyzed dwelling, the highest level coupled to the dwelling and the mean sound insulation of the façade. The last parameter is omitted in this paper as the analysis covers only outside noise levels.

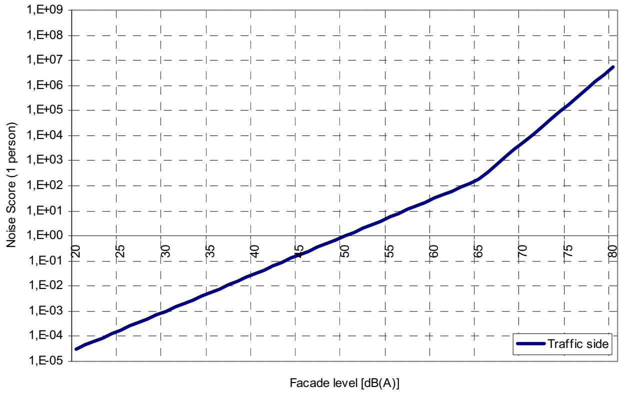

Fig.6 Graph of the noise score function.

The noise score function also takes into account the increase in noise related illnesses expected above 65 dB(A).

The extension of the NERS-analysis to include the quiet side (bedroom side) means that, instead of calculating a noise score for the whole building using only the highest calculated level, the highest calculated level on the bedroom side is also included. Adding the two noise scores generates the total noise score for the dwelling as a whole. For a building without a quiet side, the noise score on the most exposed façade as well as the noise score for the bedroom side should be summed to give the total noise score for that building.

This gives city planers a chance to include quiet sides in their NERS-analysis along with buildings that does not have (or need) a quiet façade.

For the buildings where the benefits of a quiet side have been used to allow higher traffic side levels, it is proposed that the noise score on the quiet façade is compared to the officially authorized or expected level.

In Gothenburg the highest permissible level from road traffic is 55 dB(A) as an 24-hour equivalent. If the level exceeds 55 dB(A) on the traffic side the other side of the building should have an 24-hour equivalent noise level less than 45 dB(A) [5]. Therefore the noise score function has been shifted for the quiet side so that 55 dB(A) at the traffic side generates the same noise score as 45 dB(A) at the quiet side.

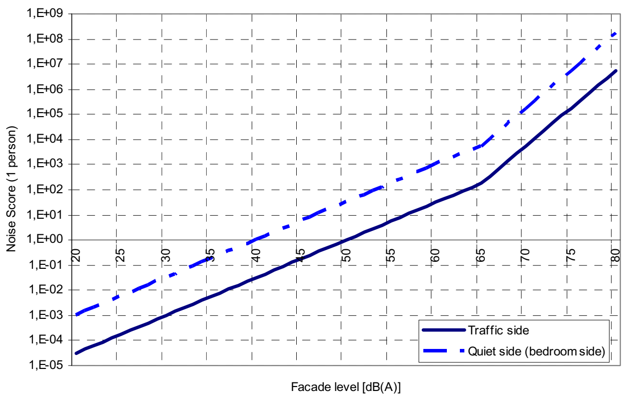

Fig.7 Graph of the noise score function and the function describing the shifted curve to include the expected levels at the quiet (bedroom) side.

Shifting the noise score function for the levels on the "quiet façade", the contribution to the total noise score is as large as the traffic side compared to the recommended levels.

3.2 Gothenburg case study

In the Gothenburg case study all buildings are in need of a quiet façade. The façade levels on the traffic side ranges between 55 and 72 dB(A). For this study only the daytime levels have been used, because of the measurements, but it can still be used as an example to show the effect of shifting the noise score function.

First a NERS-analysis is made using only the highest level of each dwelling.

Fig.8 NERS-analysis of the buildings studied in this paper. The first analysis includes only the highest noise level of each building. The higher the noise score, the worse is the acoustical environment.

The next analysis is made incorporating the quiet side of each building. The contribution by the quiet side is much smaller than the noise score calculated for the traffic side, hence the effect is barely detectable.

By shifting the noise score function according to the method presented in Fig. 7, an extended NERS-analysis can be made. This makes the contribution from the quiet side larger and therefore detectable in the hot-spot map.

Fig.9 The figure shows the results from a NERS-analysis including the quiet side. The noise score on the quiet sides have been calculated using the shifted noise score function. The effect is most clear at the buildings inside the courtyards.

Shifting the noise score function also allows for a higher overall noise score, thus enhancing the effect of changes to the levels of the quiet side. As an example the measured levels on the inner courtyards can be used for the NERS-analysis.

Fig.10 The figure shows the results from a NERS-analysis including measured levels on the quiet side. The noise score on the quiet sides have been calculated using the criteria shifted noise score function. The building to the far right shows the most predominant effect.

4 Conclusion

Most important objective when creating a noise action plan is to first provide help for those who are in most need for noise relief. The availability of a tool that in a quick and easy way can pinpoint where noise problems and complaints most likely will occur is great help for city administrations. The noise reduction budget can now be spent in priority order where it is most needed.

Extending the NERS-analysis to include quiet or bedroom facades makes the action plan work easier. Extending the NERS-analysis adds new dimensions to the problem of mapping not only sound levels but in extension, noise problems. In some cases more hot-spots are likely to be identified by the use of extended NERS-analysis. But with the increased analysis efficiency some of the problems may be seen already at the planning stage and could therefore be avoided before they appear as complaints from residents.

The differences between the calculated and the measured levels also underline the importance of measurements, as a complement to calculations. In the case shown here it is clear that measurements, or other ways to find the total noise levels at the city courtyards, could be used as a complimentary step before using a quiet side to allow higher noise levels at the traffic side. It is therefore important that city administrations promptly issue noise limits that will eliminate installation of noise equipment at city courtyards. Doing so would be a real improvement of the current policies to the benefit for many residents in European cities.

Acknowledgments

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