BNAM 2018
Baltic-Nordic Acoustics Meeting
15-18 April 2018
Harpa, Reykjavík, Iceland

Long term measurements of highway traffic noise

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Highway E18 in Bærum, the main road into Oslo from the west, is to be changed significantly over the coming years. Part of the purpose of this is to reduce the road's environmental impact, including noise, on its surroundings. Noise from E18 has been calculated, both for todays and the future road situation. However, the noise level has also been measured at 5 different locations along E18. These measurements are the topic of this article.

The measurements at these five locations have been performed continuously over one year, from June 2016 to May 2017, in 1/3-octave bands with 1 min time resolution. Measurements are performed at distances of 25-175 m from the road, with a varying degree of screening.

The main purpose of the measurements has been to supplement and validate the calculations. In addition, the measurement data has been studied in more detail in terms of spectral content and timewise variation, and also in light of hourly resolved traffic monitoring and weather data.

1 Introduction

This paper presents results from measurements of noise along highway E18 in Bærum. The measurements have been performed as part of the planning of a new E18, on behalf of the Norwegian Public Roads Administration (Statens Vegvesen).

2 Measurements

Noise levels have been measured continuously for one year, outdoors at five locations. Time averaged sound levels L_{eq}, both A-weighted and in 1/3 octave bands, have been logged at a time resolution of one minute. Norsonic Nor140s with heated outdoor microphones have been used. A description of the microphone positions is given in Table 1.

Table 1: Microphone positions.

	Distance to E18	Height above ground	Screening towards E18
Boyes vei 2	120 m	4 m	Screened
Sandviksveien 74	50 m	6 m	Partially screened
Oddenveien 7	150 m	2.3 m	Partially screened
Solvikveien 7	75 m	2 m	Screened
Holtet 20	25 m	4 m	Screened

One example of microphone placement, at the address Holtet 20, is shown in Figure 1.

Figure 1: Microphone placement at Holtet 20.

3 Results

Due to the large amount of data, Matlab has been used for the data analysis. In the following, year average values, level variations through the day, week and year and spectral content is presented.

3.1 Year averages

Measured sound levels, averaged over the whole measurement year, are shown in Table 2, along with the calculated levels. The calculations have been executed with the SoundPlan calculation software, in accordance with the nordic prediction method [1].

Table 2: Measured and calculated year average values: L_{den}, L_{Aeq}, L_d, L_e and L_n.

Address	L_{den} [dB]		L_{Aeq} [dB]		L_d [dB]		L_e [dB]		L_n [dB]	
	Meas.	Calc.	Meas.	Calc.	Meas.	Calc.	Meas.	Calc.	Meas.	Calc.
Boyes vei 2	64	66	60	63	62	65	60	62	57	58
Sandviksveien 74	71	71	67	67	69	69	67	66	64	62
Oddenveien 7	65	65	60	62	61	63	60	61	58	57
Solvikveien 7	63	63	59	59	61	61	59	58	55	54
Holtet 20	72	71	67	68	69	69	68	66	64	63

The measured and calculated levels are all within ±3 dB of each other, which is regarded as good compliance.

3.2 Level variations through the day

Noise level L_{Aeq} as a function of the time of day is shown in Figure 2. The figure shows averaged levels through the year, for Monday to Thursday combined, Friday, Saturday and Sunday.

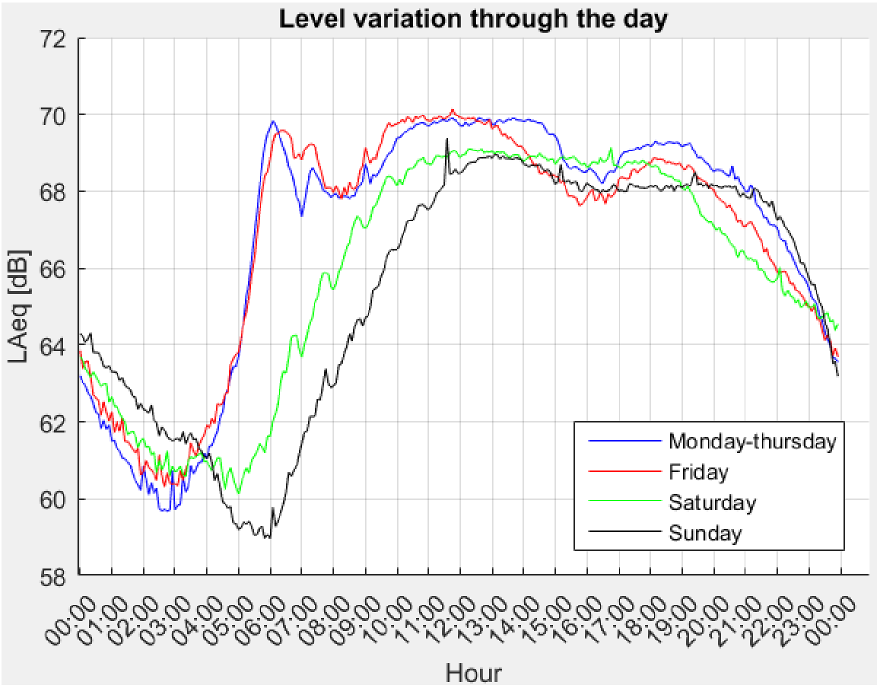

Figure 2: Level variations through the day, for Monday-Thursdays, Fridays, Saturdays and Sundays. These values are averages for the whole year, measured at Holtet 20.

During the work days, the noise level actually drops during the rush hours in the morning and afternoon. Traffic data shows that the amount of traffic increases during rush hours, but queues causes a reduction in speed which makes the total emitted sound level drop. On Fridays, noise level in the afternoon drops more, and earlier. This is because of more, and hence slower, traffic than in the other afternoons.

3.3 Level variations through the week

L_{den} variation through the week, for the five microphone positions, is shown in Figure 3. At each position the L_{den} values are normalized to an arithmetic mean of 0 dB.

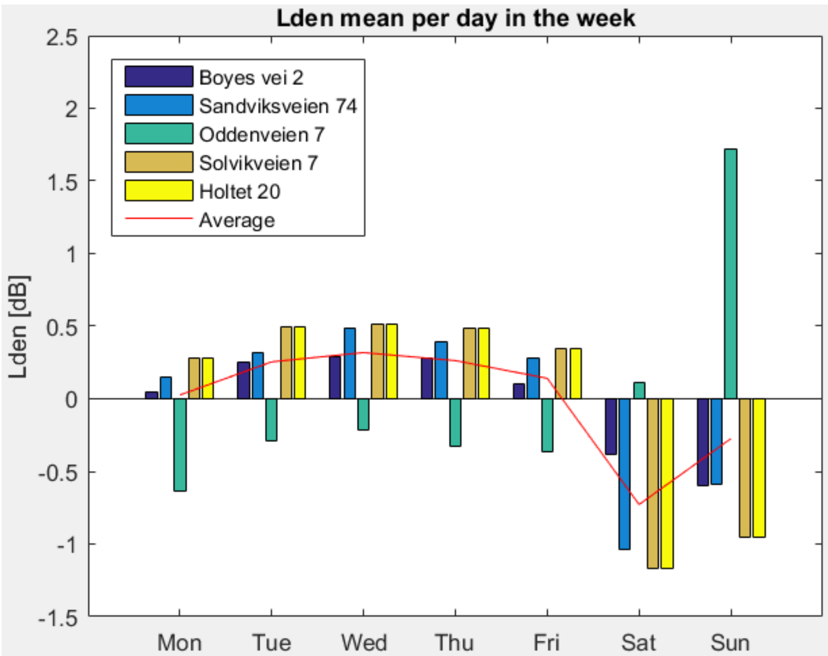

Figure 3: Variation of L_{den} through the week at the different microphone positions, normalized to an arithmetic mean over the week of 0 dB at all positions. The red line shows the arithmetic mean of all positions for each day.

As one would expect, the noise levels are in general a little bit higher during the work days than in the weekend. The difference is about 1 dB, which matches the variations in traffic[1]. Oddenveien 7, however, displays a different pattern. The reason for this has not been studied, but is assumed to be caused by activity close to the microphone or other background noise.

3.4 Level variations through the year

L_{den} variation through the year, for the five microphone positions, is shown in Figure 4. At each position the L_{den} values are normalized to an arithmetic mean of 0 dB. For each month, noise levels are averaged over 28 consecutive days rather than the entire month, to ensure an equal number of each weekday in all months.

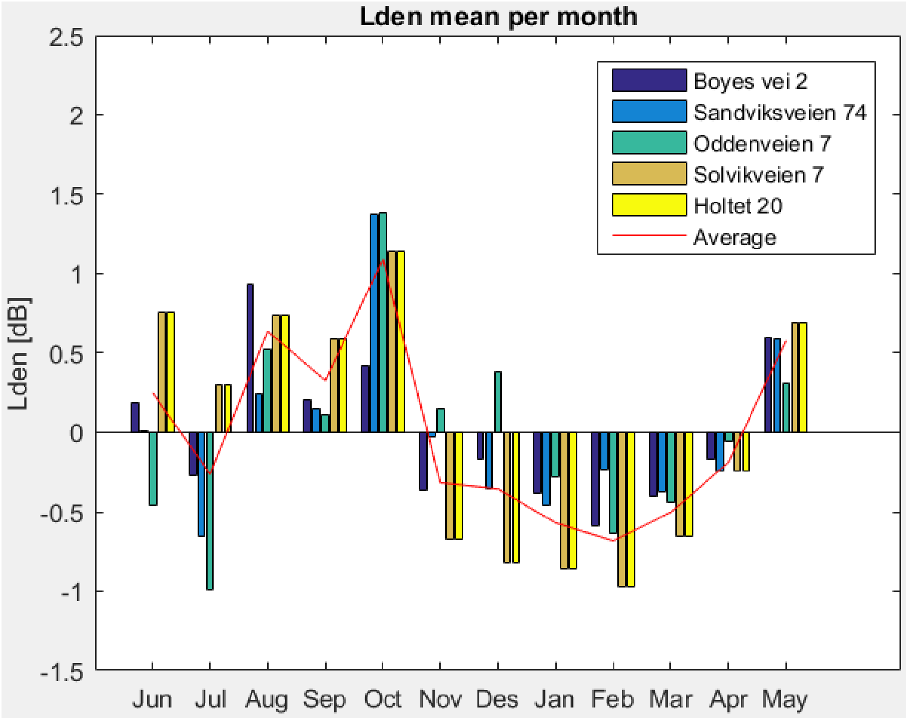

Figure 4: Variation of L_{den} through the year at the different microphone positions, normalized to an arithmetic mean over the year of 0 dB at all positions. The red line shows the arithmetic mean of all positions for each month.

Noise levels seem to be lower during the summer vacation in July, and in the winter. The reduced levels in the winter is perhaps surprising, both because of the use of studded winter tyres and as the road surface is presumably wet more of the time during winter.

However, winter tyres might on average emit less noise than summer tyres. According to VTIs report *Effects of winter tyres – state of the art* [1], emitted noise from studded and non-studded winter tyres differ from summer tyres by +2 and -1 dB, respectively, at 80 km/h. With a distribution of 13 % - 87 % of studded – non-studded tyres in the Oslo region, this gives a winter tyre noise level approximately 0.5 dB lower than summer tyre noise level.

Snow on the ground might also increase the ground absorption.

[1] Countings of traffic show an average of about 88 000 cars per day, with 95 000 at work days and 70 000 at weekends.

3.5 Spectral content

Figure 5 shows the A-weighted spectral content in 1/3-octave bands at the five microphone positions from midday traffic on dry tarmac[2]. Also shown in the figure are the reference spectra of motorway noise, given in Handbook 47 [3], with and without screening. These reference spectra are used in Norway when calculating indoors noise levels based on single-value outdoor noise levels. The levels are normalized to L_{Aeq} = 0 dB.

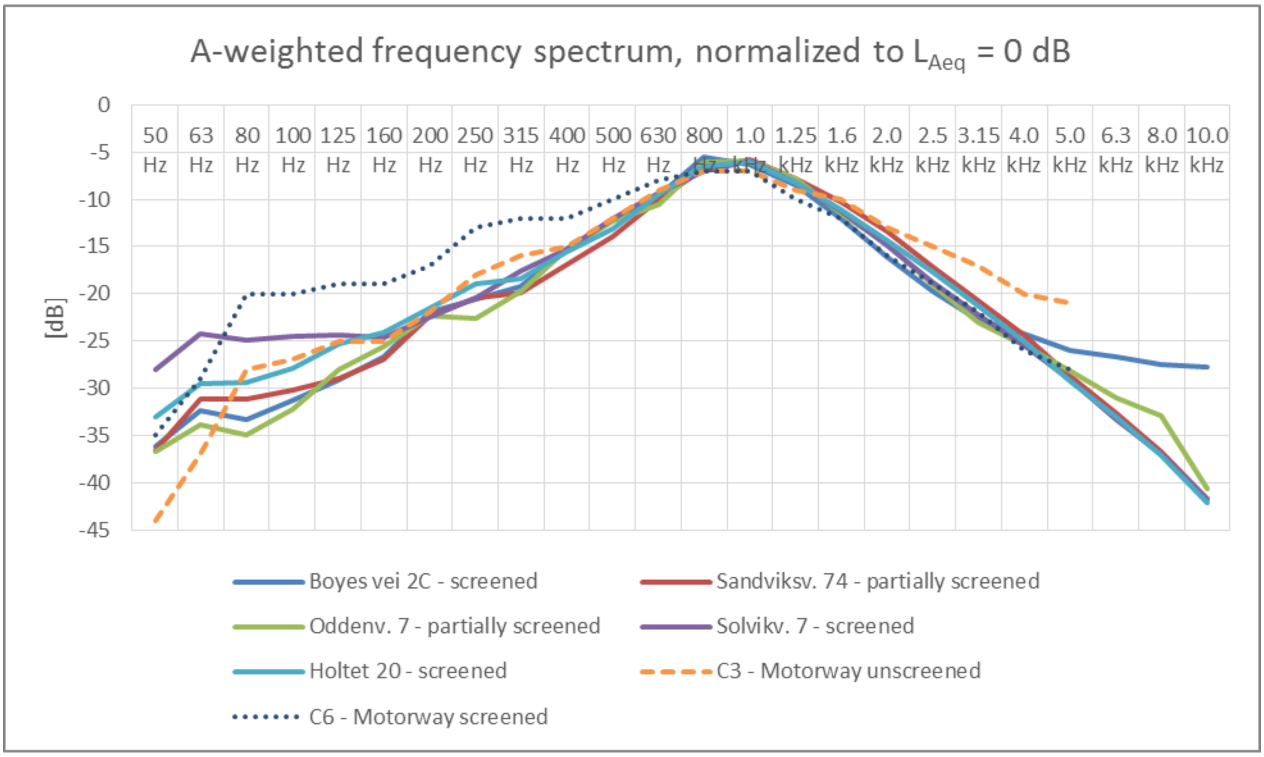

Figure 5: Spectral distribution, normalized to L_{Aeq} = 0 dB. The levels shown are averages over the period of 12-13 o'clock, Monday to Thursday, on days with no rain until 13 o'clock.

Compared to the reference spectra, for screened motorway in particular, the measured spectra have significantly less energy in the range of 80-500 Hz and more in the range of 50-63 Hz. The cavity resonance of ordinary double- or triple-glazed windows is typically within the 80-500 Hz range, while the cavity resonance of light double walls might around 50-63 Hz or lower. When calculating indoor noise levels using the reference spectra one might therefore underestimate the windows' sound insulation and overestimate the walls' sound insulation.

3.6 Wet and dry tarmac

Figure 6 shows the difference in measured noise level with wet and dry tarmac. Ingoing data in this plot is average noise levels for the period 12-13 o'clock Mondays to Thursdays. A day is considered wet if there has been registered rain or snow in this hour, and considered dry only if there has been no rain or snow from 0 to 13 o'clock. Days with rain before 12, but not between 12 and 13, are therefore not included in the plot.

[2] Averaged over the period 12-13 every Monday to Thursday, on days with no rain or snow until 1 o'clock in the afternoon.

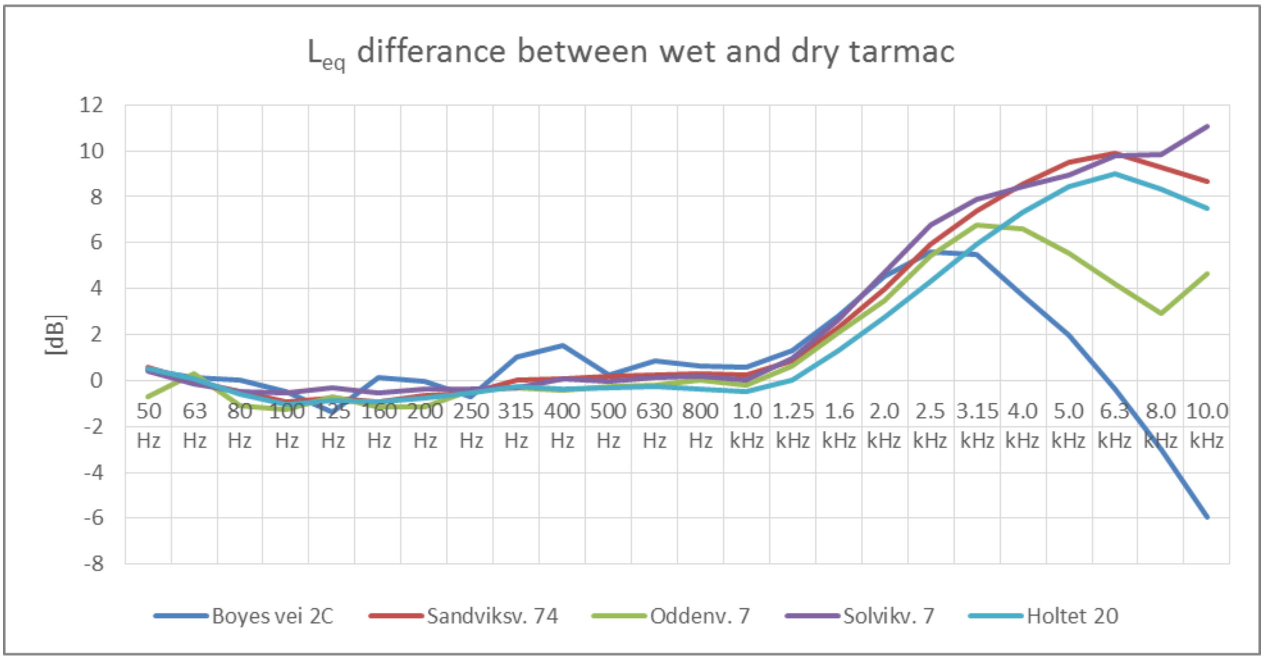

Figure 6: Difference in average noise level with wet and dry tarmac. Positive values mean higher noise level with wet tarmac.

The plot shows minimal differences up to 1 kHz, and up to 10 dB difference in the high frequencies. The reason for the negative difference at the highest frequencies at Boyes vei 2C, meaning higher sound level with dry tarmac, is not known, but assumed to be background noise.

The total L_{Aeq} values are about 1 dB higher in the wet than in the dry.

4 Summary

Measurements of noise from E18 have shown the following:

There is good compliance between measured and calculated noise levels, with all deviations being within 3 dB.

The standard calculation method for indoor noise from road traffic in Norway is likely to overestimate noise in the region of 80-500 Hz, and underestimate noise below 80 Hz. This may lead to buildings being built with unnecessarily expensive windows but with insufficient walls.

The sound levels drop by about 1 dB at weekends compared to work days, and by about 1 dB in the winter compared to summer.

References

[1] TemaNord 1996:525 Road Traffic Noise – Nordic Prediction Method, 1996

[2] M. Gustafsson et al., *Effects of winter tyres – state of the art*, VTI Report 543, 2006 (Swedish)

[3] A. Homb and S. Hveem, *Isolering mot utendørs støy – Beregningsmetode og datasamling*, Byggforsk Håndbok 47, 1999 (Norwegian)