TOWARDS AN EMPIRICAL MODEL FOR SOUND INSULATION AGAINST TRAM NOISE

Sigmund Olafsen

Brekke & Strand akustikk as

Hovfaret 17, 0275 Oslo, Norway
so@bs-akustikk.no

ABSTRACT

The paper will give a progress report of an empirical model for calculation of indoor tram noise. There are two main challenges for empirical models. The most important one of these challenges is to build a sufficiently large database. Another main challenge is to find the right compromise between model complexity and available data.

The most important parameters that determine the spectrum shape and the overall outdoor levels, are as follows:

1. Type of tram
2. Speed of tram past the immission point
3. Condition of the rails

The paper builds on field immission measurements of tram noise from several locations in Oslo.

The prediction of the outdoor level will be mostly dependent on the noise source.

The prediction of the indoor level is done using a database for façade insulation already presented for use in models for indoor road traffic noise level.

The achievable accuracy of the indoor level calculation is thus mainly dependent on the accuracy of the noise source description. The paper will give preliminary guidelines for indoor level evaluation

1. INTRODUCTION

The concept of empirical models for the prediction of indoor noise from outdoor sources is well established for road traffic noise [1],[2],[3]. But the tram is a very different type of noise source. Our first task will be to establish a way to describe the tram as a noise source. The graphs presented are taken from maximal levels, the measurements of sound energy during the passage gives slightly less pronounced peak spectra. It's important for the city of Oslo to increase the number of residents in downtown areas. Thus the task of securing acceptable indoor levels in residences in the streets along the tram lines is very important.

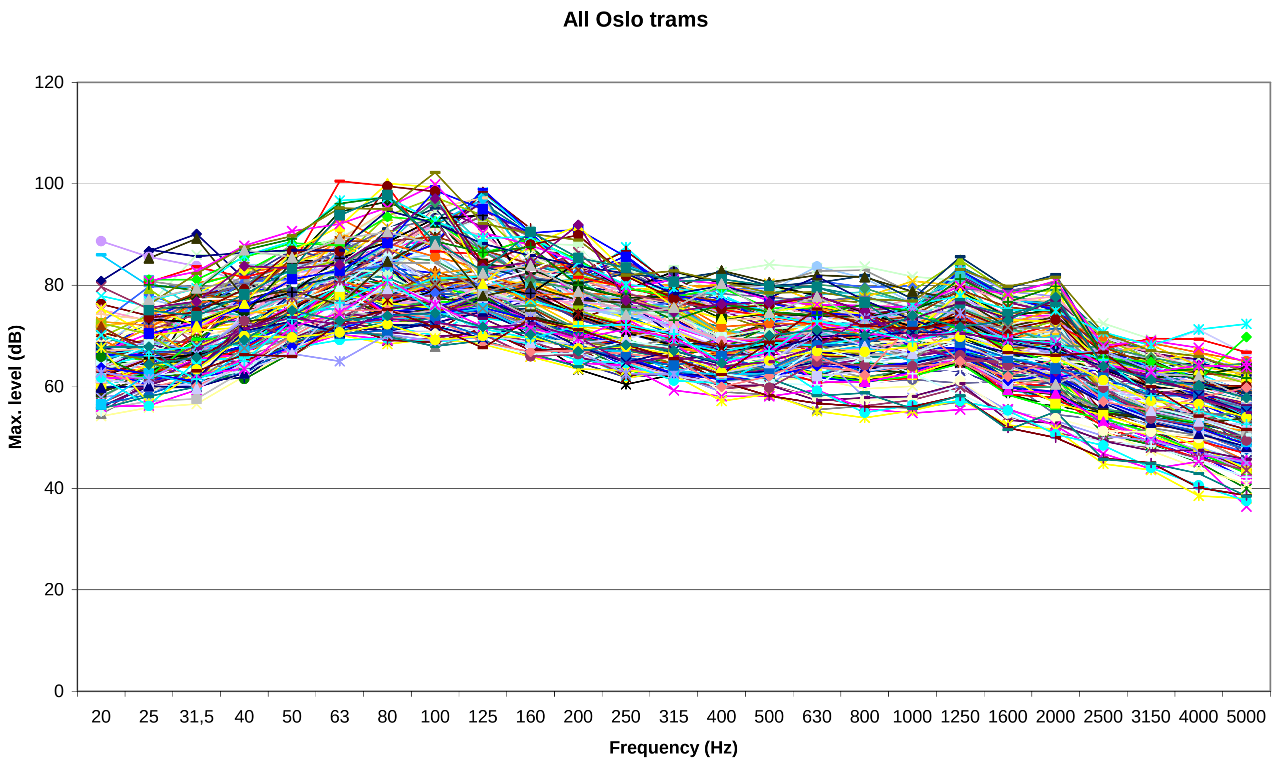
2. THE TRAM AS A NOISE SOURCE

The trams in Oslo are mainly of the type SL-95 from the Italian manufacturer Ansaldo. Measurements have been made at 5 different sites in Oslo. A total of 172 events have been measured.

There are two different ways of grouping the sites:

- Track rigidly into the street versus tracks on ballast
- Track maintenance condition

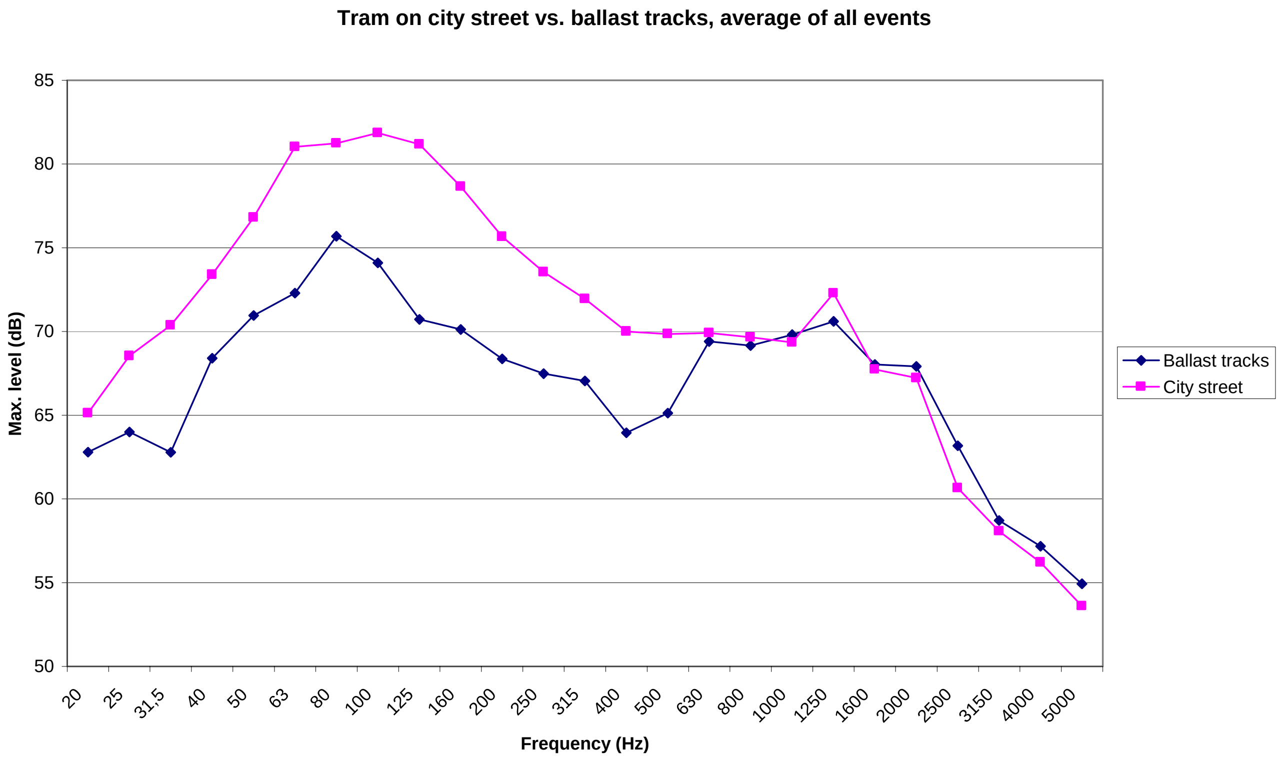
Each passage of a tram is measured as a discrete event, the parameters measured are Leq, Lmax and duration in 1/3-octave bands for each event. The figure below shows the maximal levels in 1/3-ocatve bands for each of these events.



In general there seems to be a distinct high at low frequencies. The general shape of all the trams seems to be about the same. We shall see that this is not quite so.

2.1. RIGID TRACK VERSUS TRACK ON BALLAST

The figure below shows the difference between tracks in city streets and tracks on ballast (like a railway). The difference is very obvious at low frequencies.



Unfortunately the tram lines usually run in streets that are also used by other vehicles. So putting the tram line on a ballast track is not at option in the critical cases.

2.2. WELL MAINTAINED VERSUS POORLY MAINTAINED TRACK

These measurements were made specifically to test the difference between different maintenance conditions. Driveby speed was carefully controlled for each passage on two different sites. One site is a worndown track where the trams regularly stop at a gradient, the other is a totally new track which is kept in excellent condition. All these measurements were made with the same tram and the same driver, and made at night with no other traffic around. Two different speeds were used, 20 km/h and 40 km/h.

At 20 km/h there’s a clear difference in the spectra, but the spectra are reasonably parallel. The difference must be due to the condition of the rail, as all other factors were carefully controlled. In this case the classification of the rail maintenance was immediately obvious.

At 40 km/h, though, a serious problem arises. With the bad rails there's a pronounced peak in the spectrum at 125 Hz.

3. INDOOR NOISE FROM TRAMS CALCULATED BY EMPIRICAL METHODS

The indoor level can be calculated using the same type of method as has been presented earlier for road traffic noise [1]. A simple example has been used, using all 172 tram passages as an outdoor source. The wall that has been used, is a case with masonry walls, double glazing and ventilation through slits in the window. Our database StairWay contains level difference spectra for three such houses, which are quite typical of inner city houses in Oslo. The level difference for such walls has been calculated for three different noise sources: Tram maximal level, tram energy (SEL/Leq) level and city street road traffic. The calculated level difference was as shown in the table below.

Level difference (dB)	Tram max. level	Tram SEL/Leq	City traffic
Expected level difference	29,9	32,2	34,3
Standard deviation	4,7	3,7	2,8

The table shows us two things:

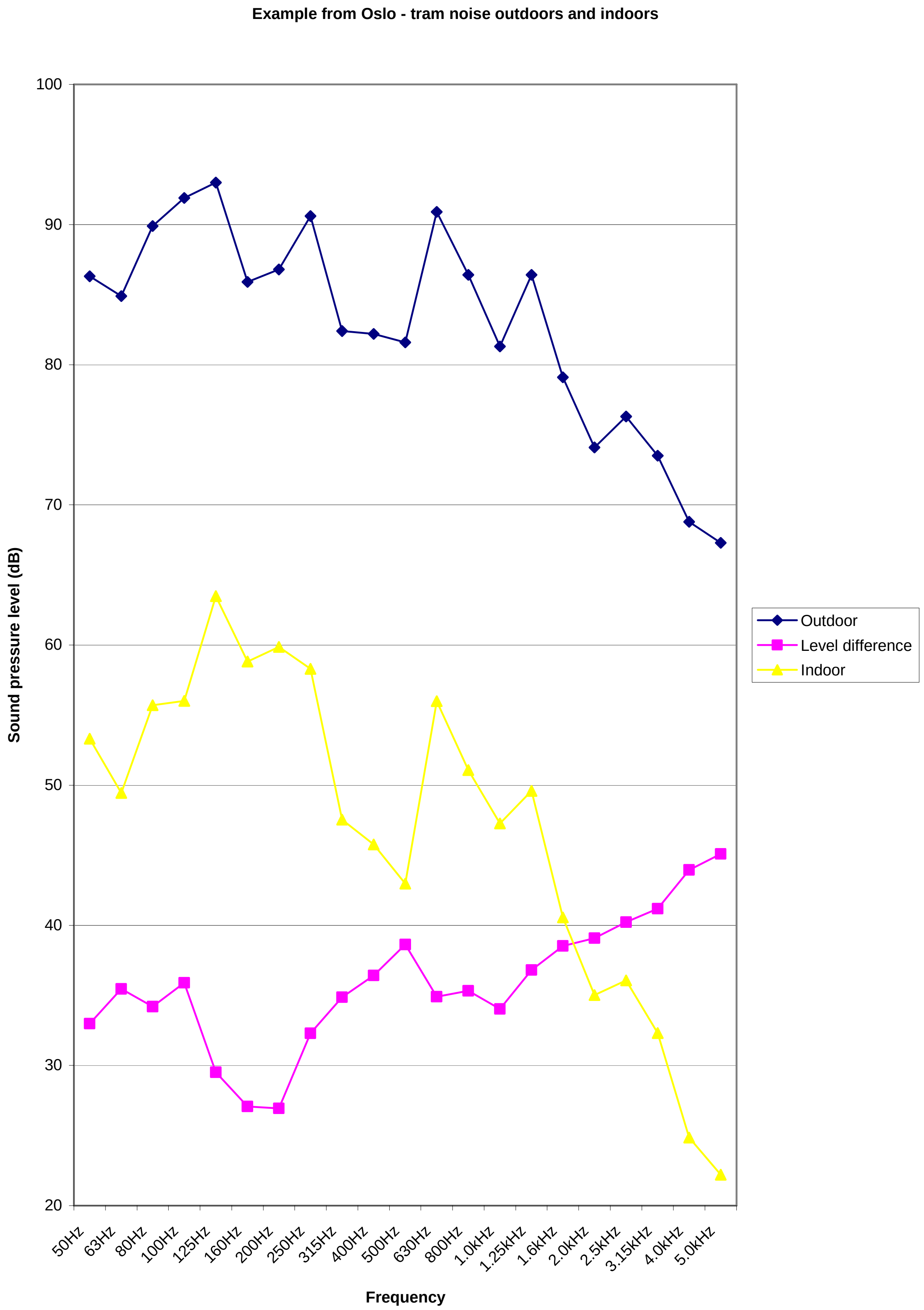
Ordinary walls give significantly less sound insulation against trams than against city traffic. The uncertainty in determining indoor noise from trams is quite large.

4. INDOOR NOISE FROM TRAMS – A CASE FROM OSLO

The most serious problem with a peak in the outdoor spectrum occurs when it corresponds with a dip in the level difference spectrum. The graph next page speaks for itself. The outdoor level has a peak at 125 Hz, while there's a trough in the level difference from 125-200 Hz, resulting in a high peak in the indoor level.

In this case, the wall consisted of a 350 mm thick massive brick wall, the windows were brand new, properly mounted special noise windows with a laboratory tested Rw + Ctr of 39 dB. But our measurements showed a difference between outdoor and indoor A-weighted level of only 33 dB. This is due to a case of unfortunate mismatch between outdoor spectrum and façade sound insulation.

This case shows that single number ratings for building components are of little or no use in prediction of indoor levels for other noise sources than the rating was designed for. The Norwegian approved method [2] for calculation of indoor noise is based on such single number ratings, none of them suitable for use with these trams.



Example from Oslo - tram noise outdoors and indoors
Sound pressure level (dB)
100
90
80
70
60
50
40
30
20
50Hz
63Hz
80Hz
100Hz
125Hz
160Hz
200Hz
250Hz
315Hz
400Hz
500Hz
630Hz
800Hz
1.0kHz
1.25kHz
1.6kHz
2.0kHz
2.5kHz
3.15kHz
4.0kHz
5.0kHz
Frequency
Outdoor
Level difference
Indoor

5. CONCLUSIONS

Trams are a very problematic source of indoor noise. A lot more knowledge is required, particularly about the noise emitted from trams. Some objective, easily controllable way of classification of the state of rail maintenance is required. But the difference between outdoor and indoor levels is always significantly less than for city traffic.

If no other information is available, we suggest that the insulation in dBA against tram noise is set to:

For Leq or SEL considerations: 2 dB poorer than against city traffic noise

For maximal level considerations: 4 dB poorer than against city traffic noise

Please note that this is not a conservative approach, the façade may give even less protection than suggested by this simple approach.

6. REFERENCES

[1] Olafsen, S. "An empirical method for prediction of indoor traffic noise" *EuroNoise 2003, Napoli*.

[2] Olafsen, S., Hov, L.B., “An improved empirical method for indoor traffic noise, *BNAM 2004, Mariehamn*.

[3] Olafsen, S. “Accuracy of practical determination of indoor traffic noise – part II, measurements”, I-INCE Symposium, Le Mans, 2005

[4] Byggforsk Håndbok 47, “Insulation against outdoor noise”