

About the Calculation of Road Noise – a Comparison of European Methods

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Introduction

With support from BAST, the Federal Institute for Road Construction, it was investigated what different methods are used in Europe to calculate road noise and how the methods applied differ from those used in RLS-90. The aim of the study was to understand the different approaches and to be able to take them into account in the intended revision of RLS-90.

In the following only some aspects can be described – the complete report will be published soon by BAST.

The emission in dependence of the parameters

The A-weighted sound pressure level caused by a piece of road was calculated in a distance of 10 m to find the dependency from speed and lateral road gradient. Even if this was the calculation of an immission, it reflects the wanted dependence from parameters including ground reflection and source geometry

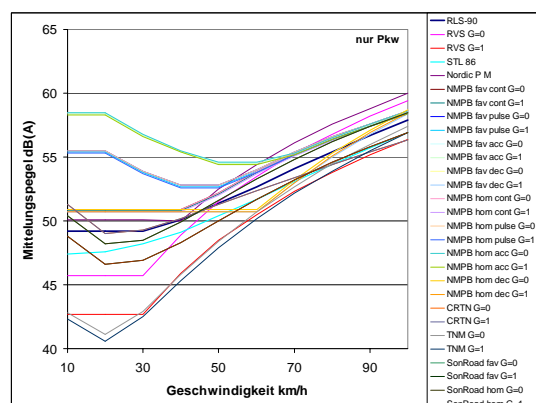


Figure 1: The dependence of sound emission of a piece of road with passenger cars from speed calculated with different methods

Summing up it can be stated that the emission for passenger cars is similar and differs maximum 5 dB above 50 km/h. With trucks this interval is roughly 8 dB and therefore larger. Extremely different are the methods to imply the lateral gradient and it is remarkable that it is taken into account in most cases as a single number correction even if the other calculations are based on narrow frequency bands.

With the existing RLS-90 reflections of first order are calculated according to the mirror image method. All higher order reflections are taken into account with a single number correction on the A-weighted level in cases where the road is located between closed facades. This correction for high order reflections was investigated more thoroughly and derived analytically and with computer simulations. The result was a slight overestimation of the correction by the existing RLS-90 – in reality it will not exceed 2 dB. Taking this into account a real calculation up to high orders seems

not to be necessary – it is recommended to revise the calculation of this influence but to keep the correction methodology.

Newer methods show all the tendency to use narrow frequency bands – the broadest are 1/3 octave bands. But the increase in accuracy seems to be limited if influences like lateral slope or road surface are not also determined frequency dependent. Weighting these aspects of accuracy and the drawback of reduced transparency and traceability with narrow frequency bands the application of octave bands seems to be sufficient for a robust methodology used legal purposes.

It is further recommended to separate the emission in engine and tyre noise similar to other newer methods (e. g. SonRoad). This allows to relate the increase of emission with slope only to engine noise and the increase with speed on tyre noise.

Aspects of modelling

Single lane roads are modelled as line sources, as long as timely averaged levels shall be calculated. Different heights are used in some models for tyres and engine. Roads with more than one lane are modelled with one linesource for each lane (NMPB), with two linesources located on the axis of the outmost two lanes (RLS-90) or one single linesource 3,5 m behind the road curb opposite from the receiver (CRTN).

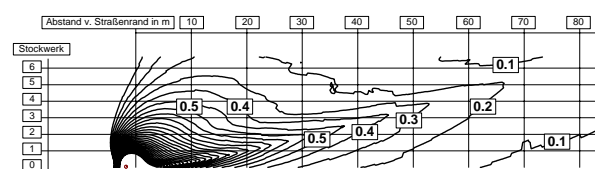


Figure 2: Deviation of levels caused by the RLS-90 approximation (2 linesources) for a road with 8 lanes.

To derive the error caused by the RLS-90 approximation the levels were calculated on a vertical grid once with each lane as a separate linesource and once with 2 linesources according to RLS-90. The arithmetic differences of these levels are shown in figure 2. As it can be seen in the diagram the differences are smaller or equal to 0.5 dB everywhere in this case. With noise protection screens near the barrier edge up to 2 dB. But it should be taken into account that the detailed distribution of traffic on the different lanes is not known and may even vary in time. The RLS-90 approximation with 2 linesources is therefore an acceptable approach in most cases. In complicated cases it is always possible to model each lane separately.

Calculation of sound propagation

To compare sound propagation according to different methodologies the sound level was calculated in varying distances from a piece of road with a receiver height of 3 m. The resulting level was normalized with the level resulting from free propagation with only geometrical attenuation. The resulting diagrams show the influence of ground and – in some cases – meteorology. Some of these normalized propagation curves for NMPB and for Harmonoise are shown in figures 3 and 4.

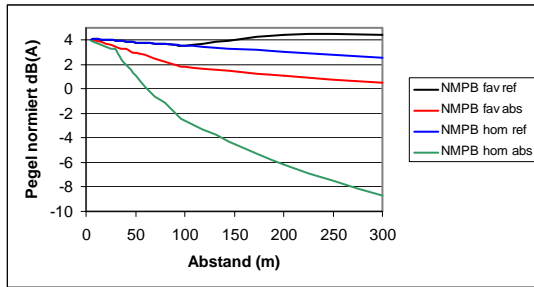


Figure 3: Propagation (ground and meteo influence) with NMPB

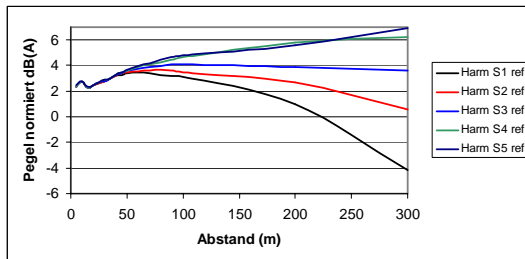


Figure 4: Propagation (ground and meteo influence) with Harmonoise for reflecting ground and with 5 stability classes

In both cases meteorology is an important input parameter, while RLS-90 is related to favorable propagation conditions.

Different methods are applied to take ground influence into account. While the simpler engineering models like ISO 9613-2, RLS-90 or RVS 4.0 produce an empirically based level increase with reflecting ground or attenuation with absorbing ground depending on the height of the sound ray, the newer methods like SonRoad, Harmonoise and NORD 2000 model the coherent superposition of direct ray and ground reflection including phase relations based on different length of these rays and on the impedance of the ground. To account for the extension of the reflecting surface element the concept of Fresnelzones is applied.

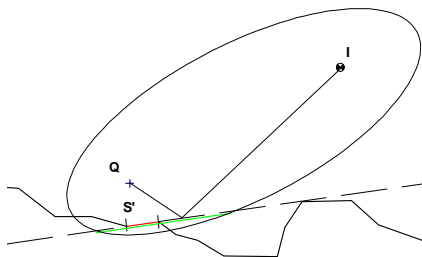


Figure 5: Construction of a Fresnelzone to determine the contribution of a surface element S' to the reflected sound.

The influence of these strategies on accuracy and performance of a the calculation were investigated by calculating sound levels from a

road above an artificial wavy ground. Figure 6 shows the distribution of sound levels calculated with Fresnelzones and with coherent superposition of direct and reflected sound. It was found that these more complex concepts produce in some cases unexpected and difficult to verify patterns and need much more space of time in some cases.

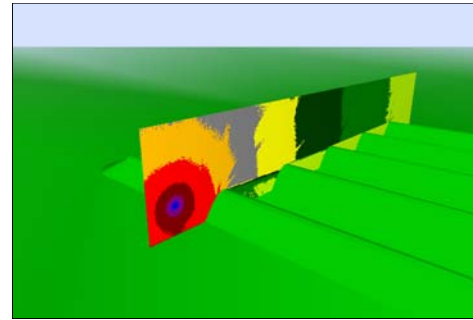


Figure 6: Vertical grid with levels calculated with coherent superposition of direct and reflected sound.

(The examples investigated have been calculated with the SonRoad and the Harmonoise method implemented in the software CadnaA).

Further investigations

The study includes the calculation of diffraction and reflection and the modelling and calculation with more complex constructions like screens with cantilevers, galleries and tunnel openings.

To investigate the general influence of meteorology the noise map of a complete city was calculated twice using the NMPB method. In both cases the meteorological conditions of two different french cities were applied. The resulting difference map shows very small influences of meteorology far away from built up areas. This comparison proves that it is not necessary to take into account meteorological influences with methods that shall be used legally to check if limiting values are exceeded. The decrease of precision, transparency and performance will not be balanced by an adequate increase of accuracy.

Generally it is recommended in all decisions not to include more detailed and complex calculation strategies only because a better accuracy is assumed, but always to check an acceptable balance between accuracy, precision and transparency. Precision is important because the result of a calculation for the same scenario based on a legally implemented method undertaken by different experts should be the same. If unexpected results are found, it should be possible to trace the calculation with acceptable effort – this needs a requirement about transparency.

For the development of a revised RLS-90 it is recommended to follow the principle: “Not all what can be done must be done”.