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for Traffic Noise Control**

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Acoustic performance of low noise road pavements



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Preface

This report on the acoustic performance of low noise road pavements has been produced by the Danish Road Institute/Road Directorate as a part of the EU project SILVIA [1]. SILVIA is a collaborative RTD project supported by the European Commission under its Competitive and Sustainable Growth (GROWTH) programme. The project started in September 2002 and was completed by the end of 2005.

The Danish Transport Research Institute is the Danish partner in the SILVIA project. The institute has subcontracted the work to the Danish Road Institute/Road Directorate.

Results from noise measurements in different European countries have been collected from partners of the SILVIA project and analysed. A primary objective was to establish typical average vehicle noise levels for different pavement types used in Europe with a special focus on the low noise solutions. The work carried out as well as the outcome of the analyses presented in this report was part of task 4.5 on Evaluation and analysis of Work Package 4 on Low-noise durable pavements of the SILVIA project.

The authors express their warm thanks to the colleagues and laboratories in the SILVIA project who have supplied measurement data to the analyses. Without these contributions it would not have been possible to produce this report.

Danish Road Institute

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Executive summary

The aim of the work reported here has been to collect and analyse data on noise levels from vehicles in the traffic on a variety of road surfaces. The noise levels were measured by SILVIA project partners. Typical average vehicle noise levels should be established for pavements used in Europe.

We grouped the pavements into “families” each of which were presupposed to have homogeneous characteristics. The pavements we have data for include bituminous as well as cement concrete pavements and dense as well as porous pavements.

Based on the analyses we conclude that typical vehicle noise levels during pass-by on various types of road surface are as given in the table below. The levels are given relatively to the level at a reference surface of the same age. The bituminous surface families are: dense asphalt concrete (DAC); stone mastic asphalt (SMA); mastic asphalt (MA); single layer porous asphalt (PAC), double layer porous asphalt (DPAC); thin layers (TSF); hot rolled asphalt (HRA) and surface dressing (SD). The cement concrete surfaces are: exposed aggregate concrete (EACC); burlap textured concrete (CCb) and porous cement concrete (PCC)

	Light vehicles [dB]	Heavy vehicles [dB]
Reference = DAC / SMA / MA / EACC	0	0
Paving Stones	8	5
HRA / CC or CCB / SD	3	2
TSF	-3	-1
PAC/PCC	-3	-3
DPAC	-4	-4

Noise levels at surfaces like hot rolled asphalt (HRA), cement concrete (CC) or burlap structured cement concrete (CCb) and surface dressing (SD) tend to be higher by 2 or 3 dB than noise levels at average dense asphalt concrete (DAC) or stone mastic asphalt (SMA).

On the other hand, noise levels at thin-surface layers (TSF) tend to be 3 dB lower for cars and 1 dB lower for heavy vehicles than at average DAC/SMA. Porous pavements on the average yield noise reductions in the order of 3 or 4 dB.

The potential noise reduction as reflected by the lowest noise levels measured for a family of pavements is in the order of 5 – 10 dB for thin-layer surfaces and porous asphalt. Burlap structured cement concrete (CCb) and cement concrete with exposed aggregate (EACC) occasionally could be seen to provide noise reduction in the order of 3 dB.

1 Introduction

According to the programme of the SILVIA project [1], the main purpose of task 4.5 was to evaluate and analyse the results of the four preceding tasks in work package 4. The themes for these four tasks were:

- Compilation of existing data.
- Construction of new test sections.
- Measurements and experiments.
- Durability assessment.

The partners in the SILVIA project assigned manpower for task 4.5 were:

- DWW, Dutch road institute.
- Skanska contractors, Sweden.
- TUW, Technical University of Vienna, Austria.
- TRL, Transport Research Laboratory, United Kingdom.
- DRI, Danish Road Institute/Road Directorate, Denmark.

DRI had the leadership of task 4.5. In order to organize the task DRI produced a work plan [2]. According to this plan the evaluation and analysis work have been distributed among partners as follows:

- DWW – Compilation and evaluation of data on maintenance.
- Skanska – Compilation of data and durability assessment.
- TUW – Compilation and evaluation of data on winter maintenance.
- TRL – Compilation of data on rejuvenation and recycling.
- DRI – Compilation and evaluation of new and existing noise data.

Partners have agreed to produce separate reports on the above five topics as the final outcome of task 4.5 The present report is the result of the work carried out by DRI on compiling and evaluating new and existing noise data. A compilation of the total outcome of the SILVIA project can be found in the SILVIA Guidance Manual [29].

2 Method

2.1 Pavement types

The goal of this report is to make an acoustical evaluation of different types of low noise pavement that are used in Europe and to establish typical average vehicle noise levels. This is done by collecting results from various European countries and by performing a comprehensive evaluation of these results. The pavements are grouped into families with similar characteristics. The types and families included in this survey are based on bituminous as well as on cement concrete pavements.

The bituminous types are:

- Dense asphalt concrete (DAC).
- Single layer porous asphalt (PAC).
- Double layer porous asphalt (DPAC).
- Thin layers (TSF).
- Stone mastic asphalt (SMA).
- Hot rolled asphalt (HRA).
- Surface dressing (SD).

The cement concrete (CC) types are:

- Exposed aggregate concrete (EACC).
- Burlap textured concrete (longitudinally structured) (CCb).
- Porous cement concrete (PCC).

The reason for this broad selection of pavement types is that the SILVIA project is not only focusing on the most noise reducing pavement types like for example porous pavements. The project is instead focussing on all pavements that might lead to a lower noise level than could have been expected when using another type of pavement. Therefore cement concrete pavement and hot rolled asphalt are also included, even though they are generally considered belonging to the noisy types.

2.2 Reference surface

The noise reducing effect of a given pavement is often stated in reports and articles. Such a noise reduction is given relatively to a certain reference pavement. It is extremely important for the noise reduction which type of reference pavement is used, and the age as well as the wear and tear of the reference pavement is important. In different European countries there are often different national or regional traditions, recommendations or even standards for which reference pavement to use. The national reference pavements are often the pavement types most often used. In Denmark for example dense asphalt concrete (DAC) with a maximum aggregate size of 11 mm or sometimes 8 mm are normally used as a reference whereas in the Netherlands and in Sweden stone mastic asphalt (SMA) with 16 mm maximum aggregate is often used.

In the standard for Statistical Pass-By noise measurements a reference pavement is described. This reference surface specified in ISO 11819-1 section 10.1 [3] is a dense, smooth-textured, asphalt concrete surface with a maximum aggregate size of 11 – 16 mm. In order to be in accordance with Har-

monoise [4] the surface type should preferably be either DAC or SMA – both aged at least 2 years but not at the end of its lifetime.

In order to overcome the problem of variation in reference pavements used, it has been decided that this European evaluation of vehicle noise levels at different pavement types will be performed based on absolute noise levels measured under the same standard conditions.

2.3 Measurement method

The measurement methods, as well as the measurement conditions and the acoustical surroundings can significantly influence the results of measurements. In order to ensure homogeneity and standardisation in the measurement results included in this analysis of the acoustic performance of pavements, DRI at the initial state of the project produced a note on measurement procedures [5]. This note was discussed and agreed upon at meetings with all partners in work package 4. DRI used this note as a background for a first evaluation of the measurement results and for giving feed-back and asking for clarification and supplementary information from those having performed the measurements and written the measurement reports/documentation.

In this evaluation of vehicle noise levels at different pavements it is important that noise data included are as accurate and comparable as possible. Therefore it was decided to use the statistical pass-by method (SPB) in ISO 11819-1 [3] for the measurements. At the moment this is the only relevant ISO standardised measurement method. It was discussed also to use data from measurements according to the CPX-method which is not yet an ISO standard. The decision was to rely on the more accurate SPB method. In work package 2 of the SILVIA project a round robin test of European CPX equipment was made as well as an evaluation of the CPX method [1], [29].

2.4 Demands on documentation

It has been discussed to coordinate and ‘standardize’ the reports for the new measurements carried out in the SILVIA project. DRI has stressed the importance of a standardised substance of the reports rather than a standardised style. Specification of a standardized report format is not considered as a goal in itself, but it may rather be a result of the compilation as a spin-off.

Noise measurements had to be performed in as much agreement as possible with the requirements in ISO 11819-1 [3]. This implies that:

- The measurement distance should be 7.5 m from the vehicle centre line. However, deviations of approximately $\pm 25\%$ were accepted, provided the results were normalised to 7.5 m horizontal distance (the correction formula should be stated).
- 1.2 m was a mandatory measurement height. In case of deviating measurement distance (d), it was suggested to maintain the measurement “angle”, by adjusting the measurement height correspondingly ($h_m = 1.2 \cdot d / 7.5$).

The standard requires free field measurements, but +6 dB measurement on a façade along the road was accepted. Such measurements had to be carried out as stated in ISO/DIS 1996-2:2003 [6] and corrected to free field values.

It was anticipated that rather small differences would have to be looked for, and therefore it was decided to report the results for each type of surface separately for each vehicle category. The vehicle categories are defined in ISO 11819-1 Annex A [3] applying a weight limit of 3500 kg (gross weight). It was decided to include the following categories¹⁾:

- Light vehicles, cat. 1: Cars (incl. MPV's with max. 8 seats, 2 axles, max 4 wheels).
- Heavy vehicles, cat. 2a: Dual-axle trucks or busses (4 – 6 wheels).
- Heavy vehicles, cat. 2b: Multi-axle trucks or busses (≥ 3 axles).

Construction trucks (for partly off-road use e. g. concrete mixer trucks), agricultural tractors, machines, military vehicles and the like were excluded. Electrically powered vehicles, mopeds and motorcycles (including 3-wheel motorcycles) were excluded as well– although such vehicle data are relevant. Vehicles with studded tyres and all vehicles with audible defects were also disregarded. For the Harmonoise project [4] a much finer classification was suggested. Most important might be a subdivision of the multi-axle trucks into two groups (3 – 5 axles and ≥ 6 axles) and a registration of trucks with high exhaust. It was recommended to record such additional data but the evaluation was based on the classification in ISO 11819-1 [3] as stated above. Busses may be regarded as a subgroup of the heavy vehicles (2a or 2b), and should whenever possible be classified separately. In case of doubt in classifying a vehicle the measurement result should be omitted.

For each vehicle category the average results at the stated reference speeds should be reported, supplemented by the number of vehicles, the intercept and slope of the regression line, and the residual standard deviation.

The results should be given as 1/3-octave band levels (preferably A-weighted) and as total A-weighted levels without correction for the influence of temperature. The reference speeds are given in ISO 11819-1 Table 1 [3], cf. Table 2.1. Measurements should only include vehicles cruising by (excluding accelerating and decelerating vehicles). The definition of dry surfaces is given in ISO 11819-1 [3], while the definition and description of a wet surface would have to be discussed and agreed upon. No measurement results from wet pavements have been included in the analysis.

Table 2.1: Reference speeds according to the SPB standard [3].

Vehicle type	Reference speeds [km/h]		
Light vehicles	50	80	110
Heavy vehicles, dual-axle	50	70	85
Heavy vehicles, multi-axle	50	70	85

The proposed documentation in the report on each measurement series was:

- An unambiguous reference to the underlying detailed technical documentation
- Statement of the applied noise measurement standard including possible deviations
- Precise information on the measurement site, date, company, name of 'operator'

¹⁾ thereby excluding vans, cars with trailers or caravans, minibuses, motor homes, SUV's, off-road 4WD cars, etc. because this is a rather inhomogeneous group of vehicles.

- Information on the general measurement conditions (map, height of buildings, vegetation, road gradient or bend, weather, etc.)
- Information on noise measurement conditions (instrumentation, measurement procedure, microphone height, free field or +6 dB-measurements, horizontal distance between microphone and centre of lane, whether noise on the right or left side of the vehicle was measured, background noise (sources, spectrum), L_{veh} for vehicle categories 1, 2a, and 2b, results of the regression analysis)
- Information on traffic conditions (measurement procedure, instrumentation, and for each vehicle category: number of pass-bys, speed - average and standard deviation)
- Information on surface conditions (measurement procedure, instrumentation, detailed description of surface (recipe, thickness, size distribution of aggregate), age, loading (yearly average daily traffic, speed, percentage heavies), state and wear, built-in air void, permeability (Becker's method), sound absorption (per 1/3-octave band, measurement method), texture (MPD in wheel tracks averaged over 5 m, preferably spectrum analysis - ISO 13473 [30]), other physical characteristics, dry/wet, surface temperature).

To facilitate fast data exchange, a proposal for a standard Excel sheet summarizing the results of measurements was distributed by VTI.

2.5 General considerations on measurement reports

In general all measured quantities should be supplemented by an estimate (or judgement) of its uncertainty. Furthermore the measurement procedure and instrumentation should be specified. We are looking for small differences, and consequently the instrumentation and the measurement technique are important. The vehicle speed must for example be measured accurately: an uncertainty of 3 % on the speed corresponds to a noise level uncertainty of around 0.5 dB. If the speed is measured from the roadside it is important to correct for any angle error.

Another quantity that is difficult to measure reliably is temperature: the air temperature must be measured using a radiation-shielded thermometer at a proposed height of 1 m while it was recommended to measure the road surface temperature using an infrared thermometer covering a spot with a diameter of at least 0.1 m.

The noise measurement equipment should be subject to regular and traceable control and calibration. The date of the last control should be stated.

3 Results and discussion

3.1 Data included in the analyses

Measurement reports and data sheets have been received from many SILVIA partners. DRI thoroughly evaluated the results and in some cases DRI asked for supplementary information and documentation. The definition of the type/family a given pavement belongs to was troublesome in some cases. It was necessary to ask for adjustments of the reported data to the reference speeds indicated in the SPB standard [3]. Table 3.1 shows the designations used in the present report for the different pavement types/families.

Table 3.1: Abbreviations used in this report.

Pavement type	Designation
Dense asphalt concrete	DAC
Stone mastic asphalt	SMA
Mastic asphalt (Gussasphalt, German type)	MA
Single layer Porous Asphalt	PAC
Double layer Porous Asphalt	DPAC
Thin layers	TSF
Hot rolled asphalt	HRA
Surface dressing	SD
Exposed aggregate concrete	EACC
Burlap textured concrete (longitudinally structured)	CCb
Porous cement concrete	PCC

Table 3.2 gives an overview of the contents of the measurement reports and data sheets included in the analyses. Some partners are mentioned in Chapter 1. The remaining partners were the Swedish National Road and Transport Research Institute (VTI), the Technical University of Gdansk (TUG) in Poland, the Dutch Information and Technology Centre for Transport (CROW), the German Federal Highway Research Institute (BAST) and the Belgian Road Research Centre (BRRC).

A total of almost 200 noise measurements at ten different pavement types made in seven North, East and Central European countries have been included in the analyses. A summary of these data is given in Appendix A to D. All data have been compiled and analysed in an Excel spreadsheet. The data cover urban roads, highways and motorways.

More data were received by DRI than have actually been included in the analysis, but for various reasons it was not possible to have all data conform to the specifications in Chapter 2:

- The reference speeds used were different from the speeds defined in the SPB method [3] and the information needed to convert the results in a reliable way was unavailable.
- The SPB measurement method [3] was not followed in all its aspects, e.g. the measurement height differed from 1.2 m. Figure 3.1A illustrates the variability of spectral differences in results of noise measurements performed at four different thin layer surfaces, simultaneously at 1.2 m and 5 m [7]. Figure 3.1B-D show similar results from porous and dense surfaces [8].
- The results were given for a mix of vehicle categories and not separately for each of the three categories defined in Section 2.4.
- The CPX method had been used.

Table 3.2: List of measurement results included in the analyses.

Partner	Reference No.	Pavement types											
		DAC	PAC	DPAC	TSF	SMA	HRA	SD	CC	PCC	EACC	CCb	Other
DRI	10 to 15	X		X	X								
VTI	16	X	X	X		X							
TUG	17 - 18	X				X		X	X			X	X
CROW	7				X								
TRL	19				X	X	X	X			X	X	
BASt	20		X	X		X				X		X	X
BRRC	21 to 27	X	X	X		X				X	X		
DWW	28	X	X	X		X							

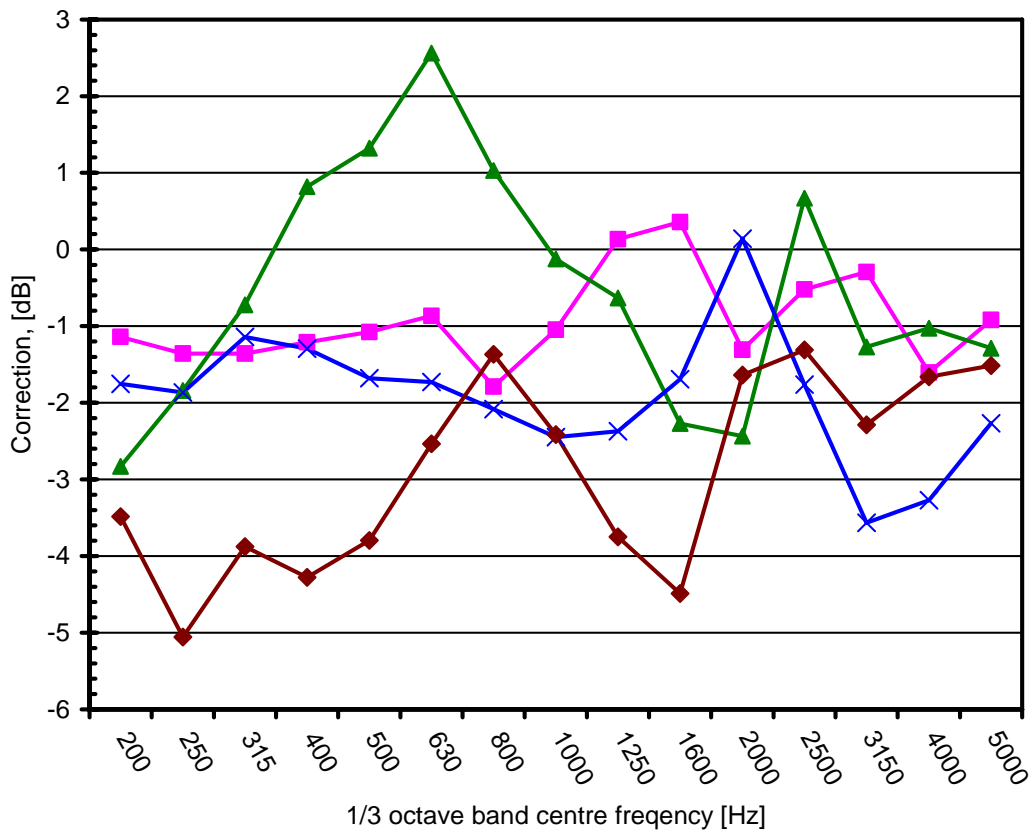


Figure 3.1A: Differences in frequency spectra measured simultaneously at a height of 1.2 and 5 m at each of four thin layer road surfaces [7]. The Y axis is the correction to add to the noise level measured at 1.2 m in order to get the noise level measured at 5 m.

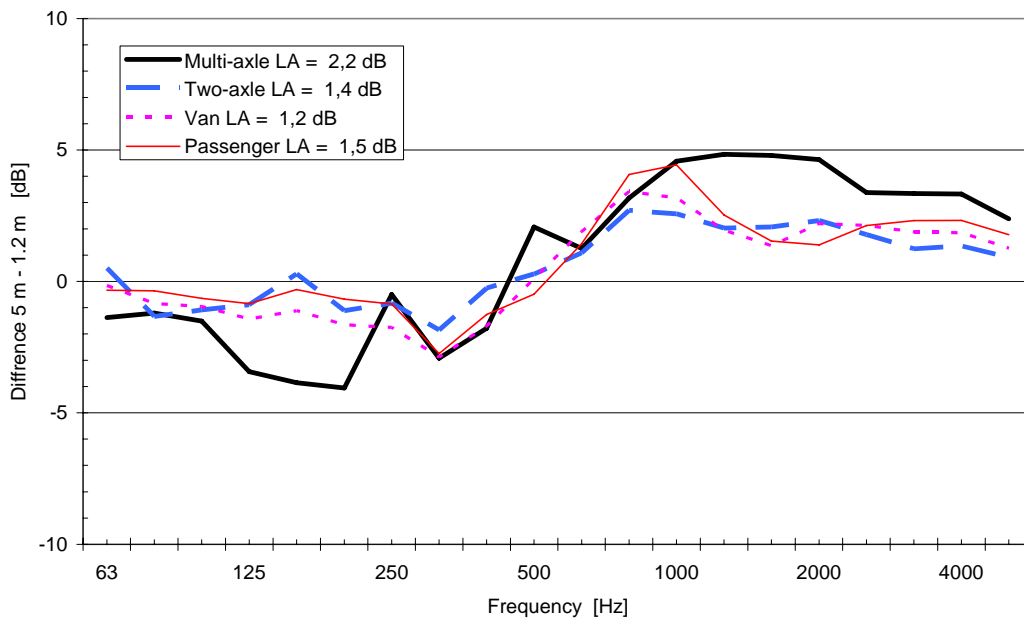


Figure 3.1B: Differences in frequency spectra measured simultaneously at a height of 1.2 m and 5 m at test section No. II (PA 5 / PA 16, 55 mm total thickness) [8].

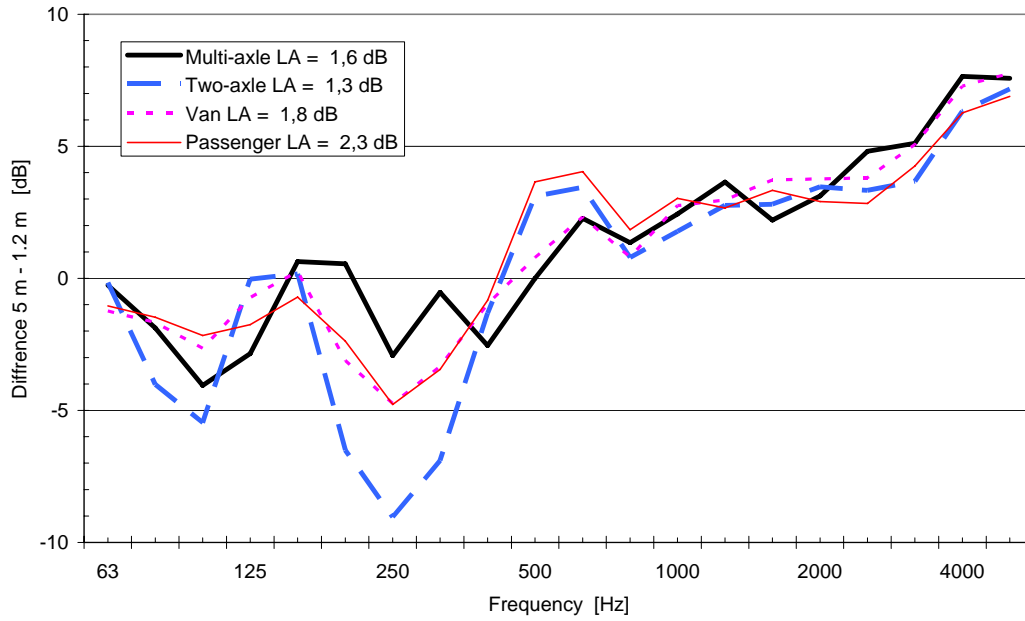


Figure 3.1C: Differences in frequency spectra measured simultaneously at a height of 1.2 m and 5 m at test section No. III (PA 5 / PA 16, 90 mm total thickness) [8].

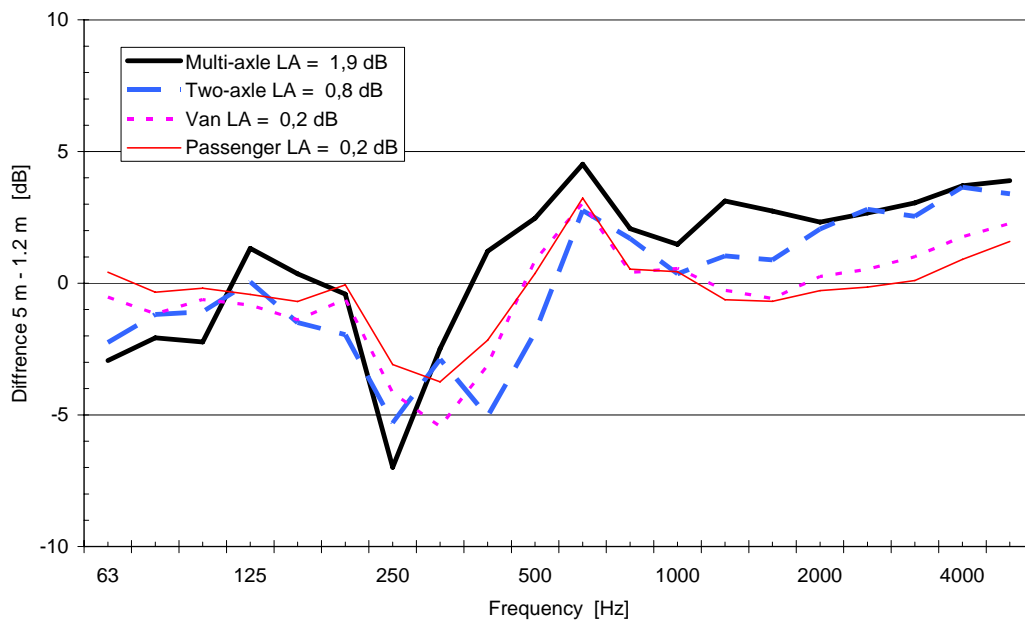


Figure 3.1D: Differences in frequency spectra measured simultaneously at a height of 1.2 and 5 m at reference section No. IV (DAC 8) [8].

3.2 Important parameters

Many parameters influence the noise levels from road traffic. In the present analysis as many parameters as possible should be kept constant in order to be able to evaluate the influence of the pavement type on the noise. Generally the SPB method [3] ensures comparable measurement results. However, in the collected dataset some variation occurred due to:

- Variance between individual pavements in each type/family, including the maximum aggregate size.
- The age of the pavement.
- Measurement uncertainty.
- The influence of temperature.

3.2.1 Individual differences within a pavement type

The pavements have been grouped into types or families. This means for example that all dense asphalt concrete (DAC) pavements have been included in the computed average noise level at DAC pavements. These pavements have different maximum aggregate size, a parameter that is important for the noise level. But there were not enough pavements of each type with the same maximum aggregate size to make reliable averages for such subgroups. Porous pavements with different built-in air void have been clustered as well as thin layer pavements optimized in different ways for lower noise levels.

On this background the average results of the analyses give indications of typical noise levels at the different pavement types. For every pavement type also the range of the noise level has been recorded in order to highlight the variance of noise levels within each pavement type. The minimum noise levels indicate how low noise levels have been reached for each pavement type with a pavement recipe optimized for noise reduction.

Data on the physical structure of pavement surfaces such as texture, permeability and acoustical absorption are often used to characterise and analyse the noise levels at different pavements. In the present project, results and measurement reports on such parameters have not been supplied to DRI to any large extent and such physical parameters have therefore not been included in the analyses.

3.2.2 Pavement age

The noise levels at a given pavement changes over time. It would have been ideal to establish noise level time series over the lifetime of each pavement types/family. The available data, however, are not sufficient for this. Instead it has been decided to pool all data for each pavement type in order to properly characterize its acoustical performance. This introduces uncertainty as data on pavements with different age are pooled.

The age distribution of the pavements included in the analyses is displayed in Figure 3.2 and the individual pavement ages are listed in Appendix B - D. Almost 60 of the measurements (or 30%) were performed when the pavement was new (0 - 1 year old) while nearly all the rest were between 2 and 10 years old at the time of measurement.

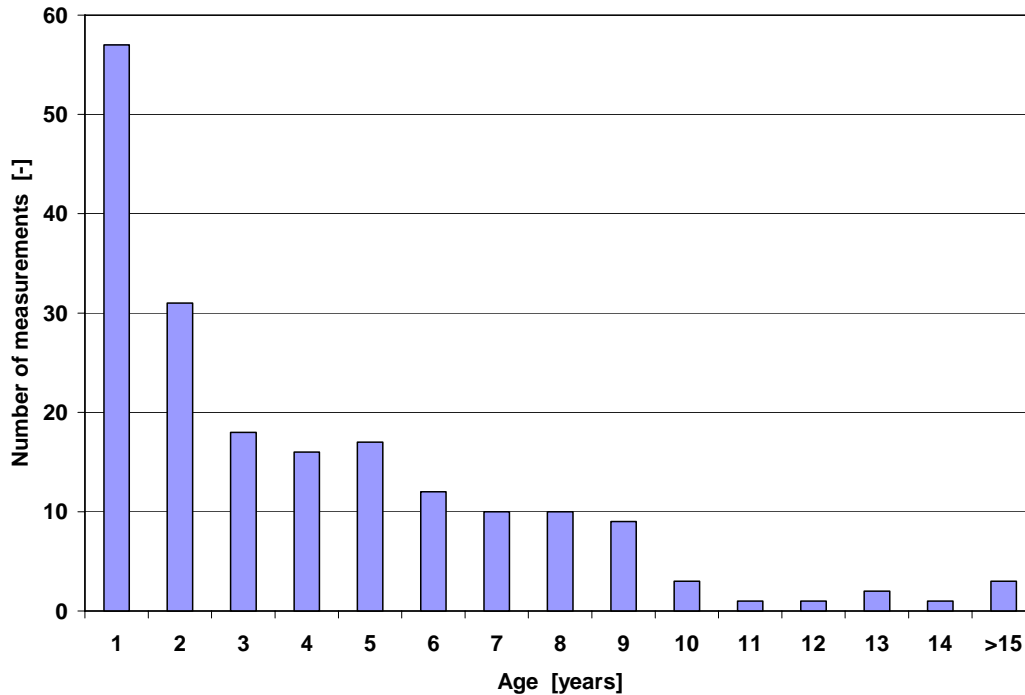


Figure 3.2 Distribution of the age of the pavements included in the analyses.

3.2.3 Measurement uncertainty

The SPB measurement method [3] is an accurate and reliable method to measure vehicle noise levels at road pavements. According to [3] the uncertainty due to random variation in individual vehicle noise emission is in the order of ± 0.3 dB for light vehicles and ± 0.7 dB for heavy vehicles when the requirements of the standard are fulfilled. This uncertainty is stated as 95 % confidence intervals around L_{veh} . On top of this come other contributions from instrumentation etc.

It is important to include a sufficient number of individual vehicles in each measurement series. The following requirements are specified in [3]:

- At least 100 light vehicles (passenger cars).
- At least a total of 80 heavy vehicles (sum of trucks/busses with two and more than two axles).
- At least 30 heavy vehicles with two axles.
- At least 30 heavy vehicles with more than two axles.

As it can be seen in Appendix B to D practically all measurements fulfil the first requirement for light vehicles. Therefore the results for this category must be considered accurate.

The requirements on the number of heavy vehicles were not always fulfilled. The reason presumably is that it is often very time consuming to wait for enough heavy vehicles to pass the measurement position in an “undisturbed” manner and at the same time have acceptable measurement conditions. Therefore larger uncertainty must be expected on the noise levels from heavy vehicles.

In the analyses measurements from Sweden, Denmark, Poland, Germany, Belgium, The Netherlands and Great Brittan were pooled. This was done based on the assumption that the noise emission is the same from the vehicles in these countries. Recently a Nordic project has revealed 1 – 2 dB higher noise levels from light vehicles in Finland, Norway and Sweden than in Denmark under nominally identical conditions [9]. Part of the explanation might be use of larger aggregates and tear and wear

due to studded tyres used during winter in Finland, Norway and Sweden. No attempt has been made in the present report to distinguish between national road surfaces or vehicle fleets.

Vehicles were only included in SPB measurements when they were driving at a constant speed excluding noise from acceleration or deceleration. This ensures comparable measurement results from the seven countries even though there might be differences in the drivers' behaviour in these countries.

3.2.4 Influence of temperature

The temperature has an influence on the emission of tire/road noise: the noise level increases with decreasing temperature. There is not yet an international standard specifying how the noise level can be corrected for temperature effects even though various procedures have been suggested in the literature. According to the SPB method [3] the noise levels shall be corrected to a reference air temperature of 20 °C. But as there is no generally acknowledged method for making such corrections, it is only mandatory [3] to report uncorrected noise levels. On this background and as there was no obvious correction procedure to follow it was decided not to make temperature corrections before the data analyses. With the actual temperatures occurring during the measurement series dealt with here the temperature probably has influenced the noise levels from passenger cars by $\pm 0.5 - 1$ dB.

In many of the measurement series the road temperature as well as the air temperature was registered. The temperatures can be seen in Figure 3.3 and in Appendix B - D. According to the SPB method [3] the air temperature shall be in the interval from 5 to 30 °C and the road temperature in the interval from 5 to 50 °C. Figure 3.3 shows that the air temperature during all measurements was between 5 and 31 °C and more or less fulfils the requirements. The road temperature varied between 0 and 45 °C and the great majority of measurements were performed within the road temperature requirements of [3].

On the basis of the temperature data Figure 3.3 shows the relation between the road temperature and the air temperature. There is a rather good correlation ($R^2 = 0.83$) between road and air temperature. The road temperature was on the average 10 °C higher than the air temperature when the air temperature was 30 °C and the road temperature was on the average a little lower (3 °C) than the air temperature when the air temperature was 5 °C. In general, for a given air temperature there was a ± 5 °C variation in road temperature.

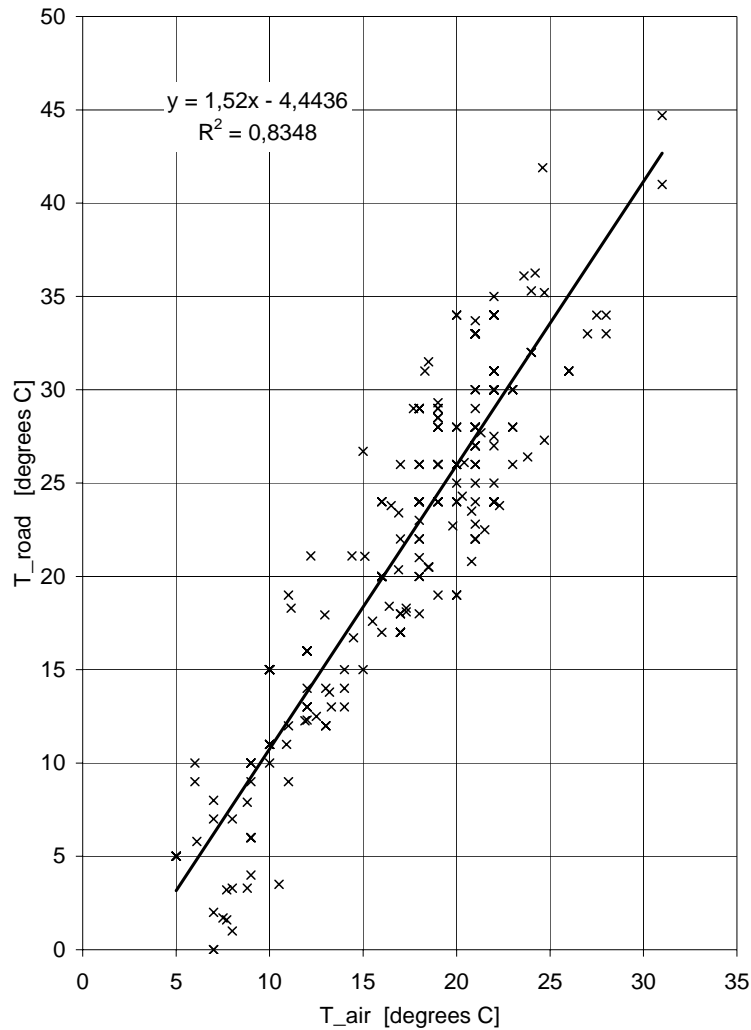


Figure 3.3: The road temperature as a function of the air temperature (data from the measurement series included in the analyses).

3.3 Comparison of the vehicle noise levels measured at different pavement types

The vehicle noise levels measured at different pavement types are given separately for passenger cars (category 1), dual-axle heavy vehicles (category 2a), and multi-axle heavy vehicles (category 2b) in Table 3.3 - 3.5.

For each vehicle category the table shows results grouped according to the reference speed. The results are also shown in Figure 3.4 – 3.6. The results given for each pavement type are:

- The number of measurement series included.
- The average value of the vehicle noise level L_{veh} (L_{pAFmax}).
- The range of these values given as the minimum L_{pAFmax} and the maximum L_{pAFmax} from any site in the family.

The maximum aggregate size is known to influence tyre/road noise and the tables give:

- The minimum aggregate size (min-aggr.).
- The maximum aggregate size (max-aggr.).
- The average aggregate size (avg-aggr.).

3.3.1 *Passenger cars*

Figure 3.4A shows that at a speed of 50 km/h the quietest pavements were the two layer porous pavements (DPAC) and the thin layers (TSF) with an average vehicle noise level of 66 - 67 dB. The dense asphalt concrete (DAC) had an average vehicle noise level of 70 - 71 dB, the same as the average for 6 Dutch single layer porous pavements (PAC 16) aged 2 – 7 years. The stone mastic asphalt (SMA) had an average vehicle noise level of 72 dB. This implies a noise reduction of 4 -6 dB by changing a DAC or SMA to a DPAC or TSF pavement.

The more noisy types are cement concrete (CC) and surface dressings (SD) with average vehicle noise levels of 74 - 76 dB. The paving stones gave the highest level of 79 dB.

The variation between the maximum and minimum noise level for each pavement type is between 3 and 8 dB. Although age variation is part of the explanation for this it seems evident that the vehicle noise level at a pavement belonging to a certain pavement type is not only defined by the pavement type/family. The vehicle noise level also depends on the actual recipe used for the pavement, including whether or not it has been optimized for low noise. Maximum aggregate size and shape, built in air voids, porosity and surface texture have significant influence on the noise level. Also the procedures and conditions for the building process such as the compaction are important to the noise levels at the completed pavement.

The minimum noise levels in Figure 3.4 A can be seen as representing for each pavement type the potential for low noise versions of this type with our current state of knowledge and technology. The minimum noise levels indicate the possibilities for noise reduction when pavement recipes and pavement building procedures have been optimized. For the two-layer porous pavements (DPAC) and the thin layers (TSF) noise levels down to 62 - 63 dB can be reached. From such noise reducing versions of porous and thin pavements there is a difference of 14 dB to the noisy cement concrete and 18 dB to the paving stones.

Figure 3.4 B-C give the average vehicle noise levels for passenger cars at 80 and 110 km/h, respectively. Also at these speeds the porous pavements and the thin layers gave the lowest vehicle noise levels. Generally the same ranking of the pavements is seen for the high speeds of 80 and 110 km/h as at 50 km/h.

The vehicle noise levels for the pavement types that are often used as reference pavements (DAC or SMA) are similar also at 80 km/h and 110 km/h. For these pavements the noise level increased by 7 - 8 dB when the speed is increased from 50 to 80 km/h, corresponding to a speed dependence of $34 - 39 \cdot \lg_{10}(v)$. The increase in noise level is 10 - 12 dB when the speed is increased from 50 to 110 km/h, corresponding to a speed dependence of $29 - 35 \cdot \lg_{10}(v)$.

At 110 km/h the noisiest pavement type was hot rolled asphalt (HRA) and surface dressings (SD) with an average vehicle noise level of 86 to 88 dB. The average level at DAC and SMA was 82 dB and at the porous pavements the average noise levels were 79 - 80 dB. The best porous pavements go down to 76 dB. The thin layers average noise level was 82 dB and at the best type 79 dB. Three of the TSF surfaces yielded 85 – 86 dB average vehicle noise levels while the remaining four thin-layers yielded 79 – 80 dB. The consequence is that at 110 km/h the overall average vehicle noise level at TSF-surfaces was the same as at DAC or SMA. This is different from the trend seen at 50 km/h and 80 km/h for a noise reduction in the order of 4 dB at TSF.

For the high speed roads the overall variation in average noise levels was 16 dB. For the high speed roads there are no data included for paving stones which were the most noisy pavement type on 50 km/h roads.

Table 3.3: The vehicle noise levels for passenger cars at different pavement types.

Cars	Number of measurements	Avg	Min	Max	Min	Max	Avg
	[-]	L_{pAFmax} [dB]	L_{pAFmax} [dB]	L_{pAFmax} [dB]	aggr. [mm]	aggr. [mm]	aggr. [mm]
CC or CCb, cars-50	2	75.6	74.0	77.2			
DAC or DACo, cars-50	25	70.5	67.9	74.1	6	16	10.4
DPAC, cars-50	20	66.7	62.9	70.4	5	8	6.2
PAC, cars-50	6	70.0	66.8	73.0	16	16	16.0
Paving stones, cars-50	1	79.6					
SD, cars-50	2	74.0	72.3	75.7	8	16	12.0
SMA, cars-50	13	71.9	68.6	74.3	6	16	9.9
TSF, cars-50	6	65.8	61.5	68.9	6	6	6.0
DAC, cars-80	20	78.2	73.9	82.8	14	16	15.8
DPAC, cars-80	9	72.9	68.3	78.2	7	8	7.6
EACC, cars-80	2	75.6	74.5	76.8	7	7	7.0
PAC, cars-80	23	76.0	71.9	81.4	14	16	15.8
PCC, cars-80	2	74.5	74.0	74.9	7	7	7.0
Slurry seal, cars-80	1	78.4					5.0
SMA, cars-80	15	78.7	76.5	82.1	10	16	11.6
TSF, cars-80	2	72.4	70.3	74.4	6	6	6.0
CCb, cars-110	10	84.6	79.8	90.7	2	2	2.0
DAC or DACo, cars-110	17	82.2	79.4	83.8	8	16	14.8
DPAC, cars-110	9	78.9	76.4	82.5	5	11	7.7
EACC, cars-110	6	83.9	80.9	85.8	10	10	10.0
HRA, cars-110	8	86.3	84.1	87.9	20	20	20.0
MA (guss-), cars-110	4	81.9	81.1	82.9	5	8	6.5
PAC, cars-110	23	79.7	76.2	84.6	8	16	15.0
PCC, cars-110	4	77.1	75.8	78.6	8	8	8.0
SD, cars-110	2	87.8	87.7	87.9			
SMA, cars-110	15	82.3	78.3	86.1	8	16	10.3
TSF, cars-110	7	82.3	79.4	85.7	8	8	8.0

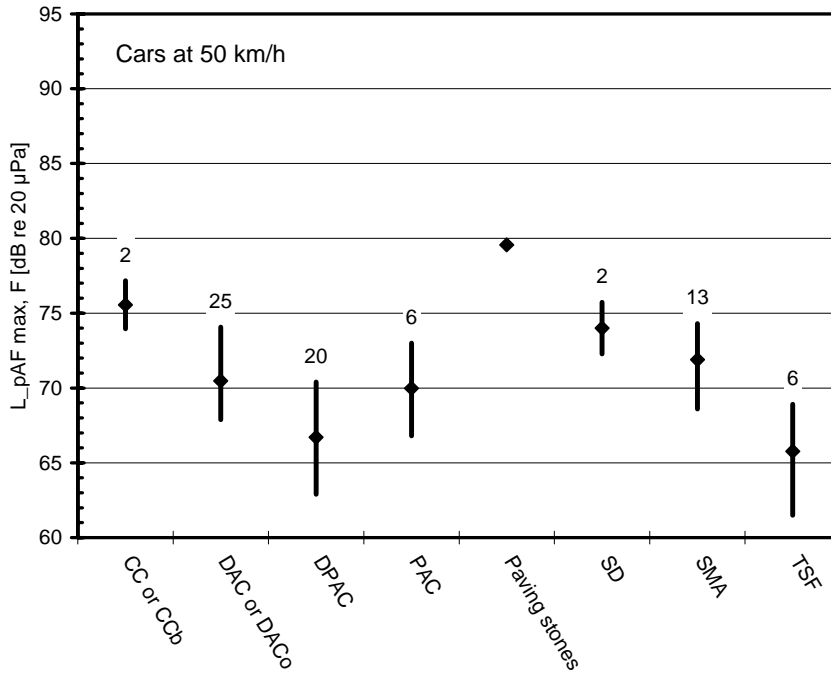


Figure 3.4A: Average vehicle noise levels for cars at different pavement types at 50 km/h. Vertical lines show the range, labels show the number of pavements.

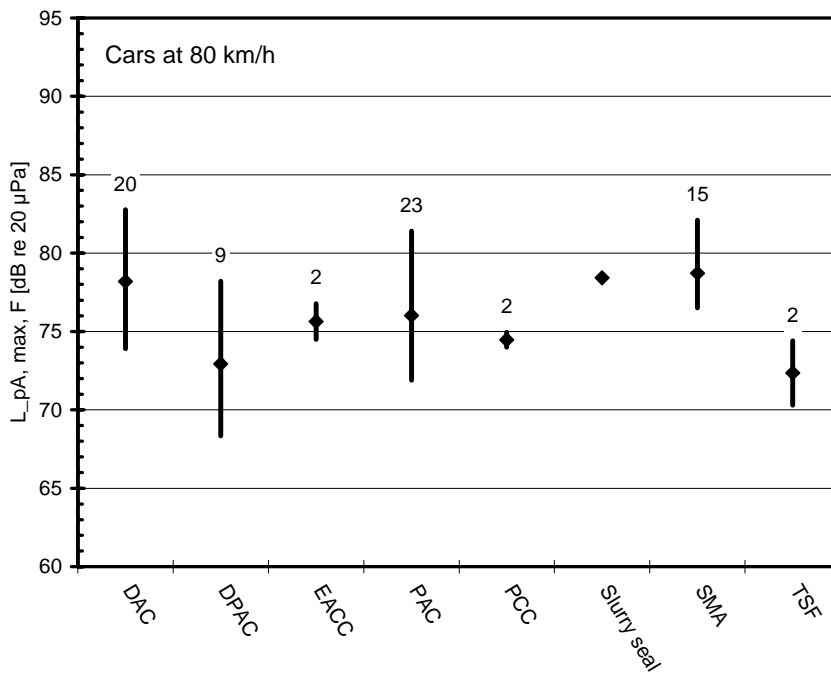


Figure 3.4B: Average vehicle noise levels for cars at different pavement types at 80 km/h. Vertical lines show the range, labels show the number of pavements.

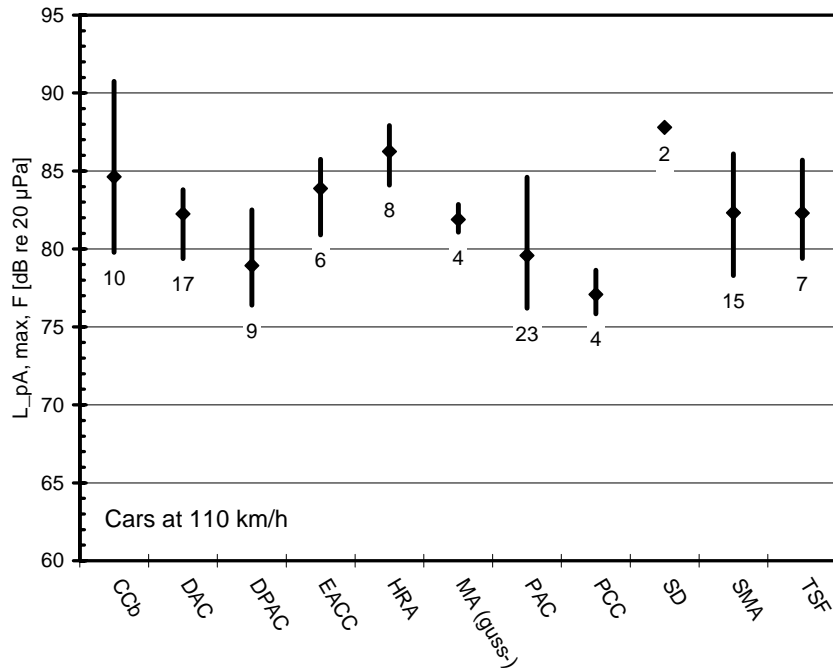


Figure 3.4C: Average vehicle noise levels for cars at different pavement types at 110 km/h. Vertical lines show the range, labels show the number of pavements.

3.3.2 Dual-axle trucks

The vehicle noise levels for dual-axle trucks are shown in Table 3.4 and Figure 3.5 A-B. No figure is shown for 70 km/h as only a few pavements were represented in the data.

At 50 km/h the average noise levels at DAC and SMA were 78 – 79 dB; that is 1 – 2 dB higher than the average noise level at the thin-layer surfaces and 4 – 5 dB lower than at the cement concrete surfaces.

On urban roads it can be difficult to get enough pass-bys of heavy vehicles in SPB measurements. This might be the reason why no data were available for heavy vehicles on porous pavements on urban roads.

The highest noise levels at 85 km/h are seen at cement concrete (CCb), hot rolled asphalt (HRA) and surface dressing (SD) with average vehicle noise levels of 87 dB. That is 1 – 2 dB higher than at dense asphalt concrete (DAC) and stone mastic asphalt (SMA) with levels of 85 - 86 dB. At the porous pavements the average noise levels were 80 - 82 dB, 4 – 6 dB lower than at DAC/SMA. The best porous pavement goes down to 78 dB. The thin layers average noise level was 84 dB with the best type at 82 dB.

The difference between the noisiest and the most silent individual pavement for heavy vehicles at 85 km/h was 13 dB.

Table 3.4: The vehicle noise levels at different pavement types for dual-axle trucks.

Dual-axle trucks	Number of measurements	Avg L_{pAFmax}	Min L_{pAFmax}	Max L_{pAFmax}	Min aggr.	Max aggr.	Avg aggr.
	[-]	[dB]	[dB]	[dB]	[mm]	[mm]	[mm]
CC or CCb, dual-ax-50	2	83.0	78.9	87.1			
DAC, dual-ax-50	15	77.8	72.9	81.6	6	16	10.2
Paving stones, dual-ax-50	1	83.2					
SD, dual-ax-50	2	79.7	79.6	79.9	8	16	12.0
SMA, dual-ax-50	6	79.1	77.3	85.3	6	12.8	8.6
TSF, dual-ax-50	3	77.1	75.5	78.7	6	6	6.0
DAC, dual-ax-70	1	83.1					16.0
Slurry seal, dual-ax-70	1	84.1					5.0
SMA, dual-ax-70	1	81.9					16.0
CCb, dual-ax-85	9	87.4	80.6	91.4	2	2	2.0
DAC, dual-ax-85	5	85.8	84.4	88.0	8	16	11.8
DPAC, dual-ax-85	4	81.8	79.7	83.8	5	11	7.3
EACC, dual-ax-85	6	85.6	83.0	86.6	10	10	10.0
HRA, dual-ax-85	8	87.0	85.9	88.0	20	20	20.0
MA (guss-), dual-ax-85	4	82.3	80.2	83.4	5	8	6.5
PAC, dual-ax-85	4	82.1	79.4	83.8	8	16	10.0
PCC, dual-ax-85	3	80.1	78.4	81.5			
SD, dual-ax-85	2	87.3	87.2	87.3			
SMA, dual-ax-85	10	85.2	82.9	87.0	8	16	10.1
TSF, dual-ax-85	7	84.2	81.8	86.3	8	8	8.0

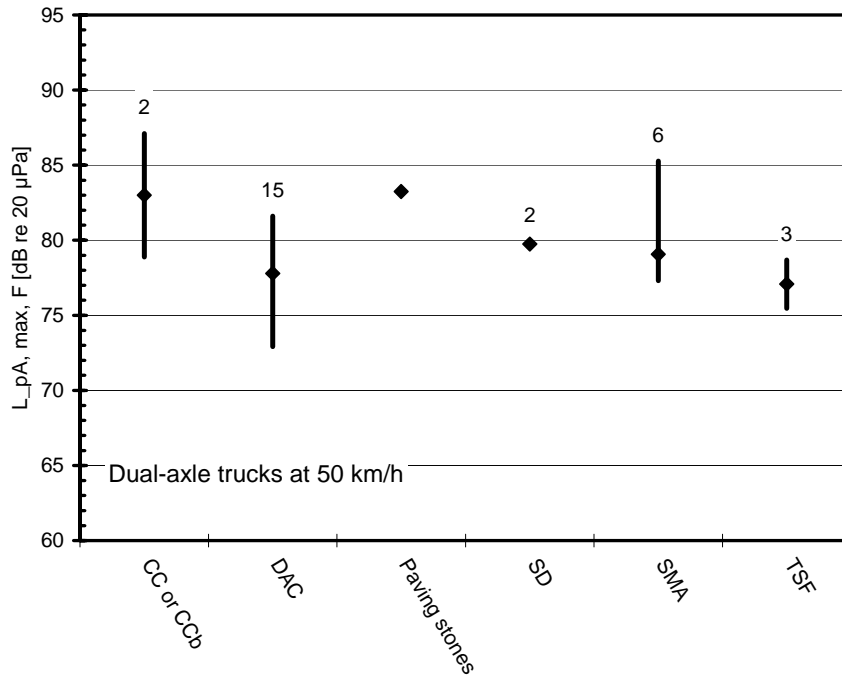


Figure 3.5A: Average vehicle noise levels for dual-axle trucks at different pavement types at 50 km/h. Vertical lines show the range, labels show the number of pavements.

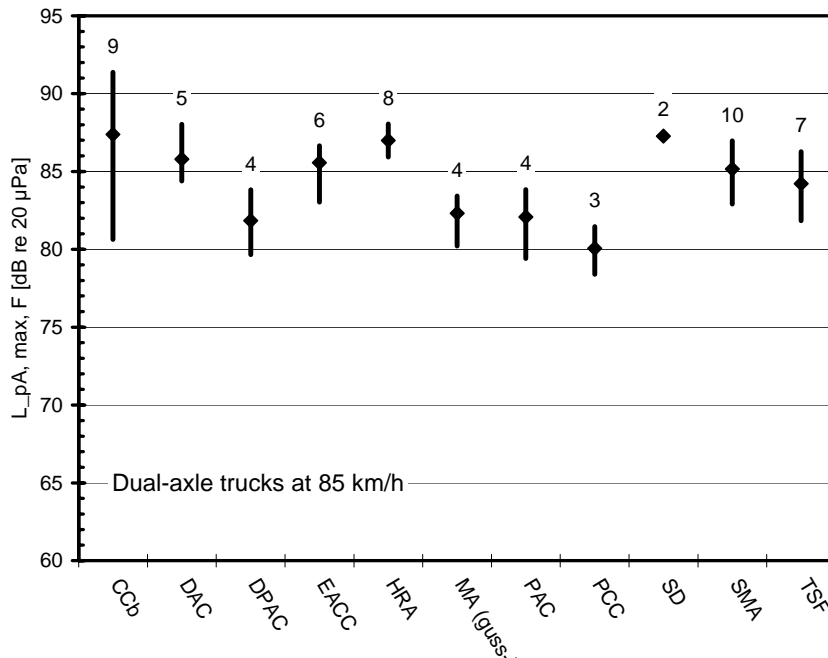


Figure 3.5B: Average vehicle noise levels for dual-axle trucks at different pavement types at 85 km/h. Vertical lines show the range, labels show the number of pavements.

3.3.3 Multi-axle trucks

The vehicle noise levels for multi-axle trucks are shown in Table 3.5 and Figure 3.6 A-C.

More or less the same trends are seen in the noise levels from multi-axle trucks as for two-axle trucks. The average vehicle noise levels at DAC and SMA were 2 - 3 dB higher for multi-axle than for two-axle trucks (81 dB at 50 km/h, 85-86 dB at 70 km/h and 88 dB at 85 km/h). The highest average noise levels at 85 km/h are seen at cement concrete (CCb), hot rolled asphalt (HRA) and surface dressing (SD) with average vehicle noise levels of 89 - 90 dB. The porous pavement average noise levels were 83 - 84 dB, while the best porous pavement goes down to an average vehicle noise level of 79 dB. The thin layers average noise level was 86 dB with the best type at 83 dB.

Table 3.5: The vehicle noise levels at different pavement types for multi-axle trucks.

Multi-axle trucks	Number of measurements	Avg L_{pAFmax}	Min L_{pAFmax}	Max L_{pAFmax}	Min aggr.	Max aggr.	Avg aggr.
	[-]	[dB]	[dB]	[dB]	[mm]	[mm]	[mm]
CC or CCb multi-ax-50	2	82.2	79.6	84.7			
DAC or DACo multi-ax-50	10	80.5	78.0	83.3	6	16	13.4
Paving stones, multi-ax-50	1	85.6					
SD multi-ax-50	2	82.6	79.2	86.1			
SMA multi-ax-50	8	81.4	79.6	83.3	6	13	10.6
DAC, multi-ax-70	9	85.8	81.8	89.2	16	16	16.0
DPAC, multi-ax-70	1	84.3					
PAC, multi-ax-70	17	81.5	77.7	85.0	16	16	16
Slurry seal, multi-ax-70	1	85.9					5.0
SMA, multi-ax-70	10	84.8	81.1	87.7	11	16	11.5
CCb, multi-ax-85	10	90.1	84.6	94.2	2	2	2.0
DAC, multi-ax-85	18	87.9	83.9	89.5	8	16	14.8
DPAC, multi-ax-85	6	83.2	80.3	86.6	5	11	7.5
EACC, multi-ax-85	6	87.4	85.1	88.4	10	10	10.0
HRA, multi-ax-85	8	89.0	87.8	90.4	20	20	20.0
MA (guss-), multi-ax-85	4	86.0	83.2	91.3	5	8	6.5
PAC, multi-ax-85	22	84.1	80.2	87.0	8	16	15.0
PCC, multi-ax-85	4	83.5	79.1	90.9	8	8	8.0
SD, multi-ax-85	2	89.5	89.5	89.6			
SMA, multi-ax-85	19	87.8	82.9	91.0	8	16	10.5
TSF, multi-ax-85	7	85.8	82.9	88.0	8	8	8.0

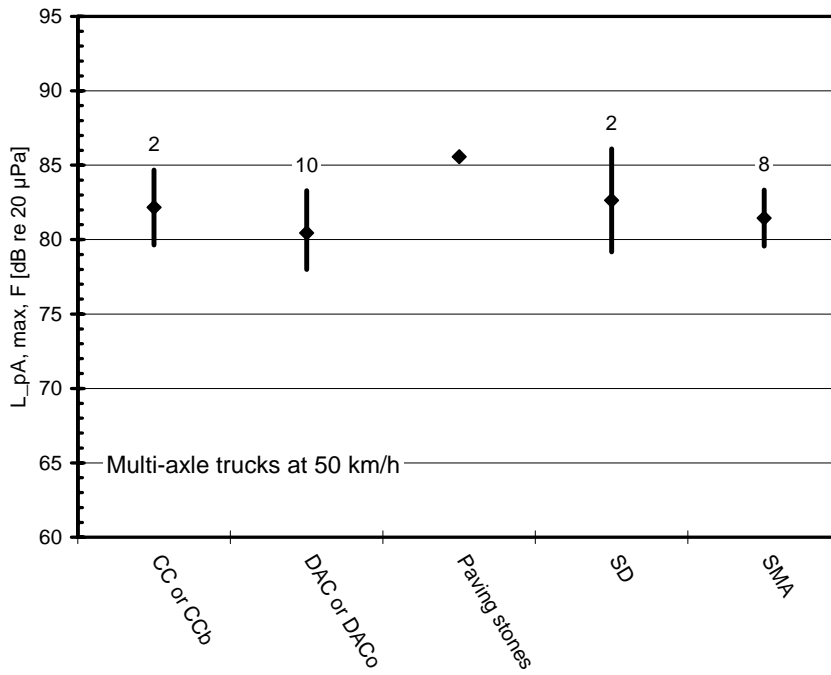


Figure 3.6A: Avg. vehicle noise levels at different pavement types for multi-axle trucks at 50 km/h. Vertical lines show the range, labels show the number of pavements.

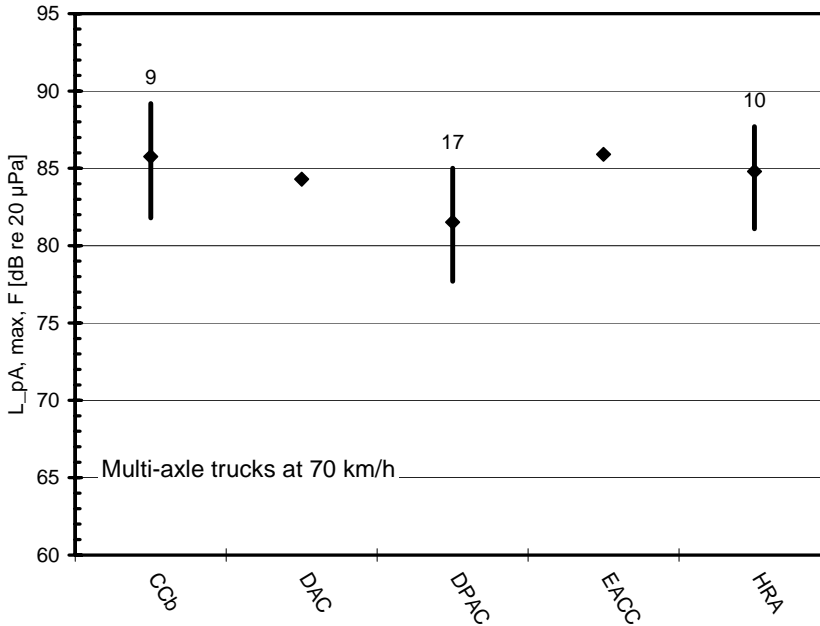


Figure 3.6B: Avg. vehicle noise levels at different pavement types for multi-axle trucks at 70 km/h. Vertical lines show the range, labels show the number of pavements.

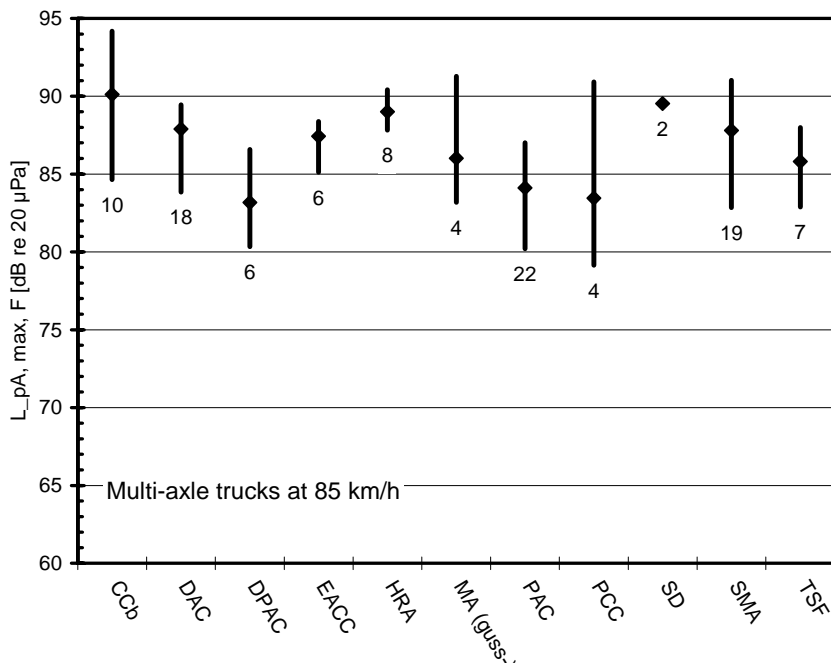


Figure 3.6C: Avg. vehicle noise levels at different pavement types for multi-axle trucks at 85 km/h. Vertical lines show the range, labels show the number of pavements.

3.4 Typical noise levels at each family of pavements

Table 3.6 shows a summary of the noise levels from Tables 3.3 – 3.5. The results are given per category of vehicle and per reference speed. The first two lines contain the vehicle noise levels measured at the DAC- and SMA-surfaces. Each of these noise levels is based on 5 – 25 measurement results, except for dual-axle trucks at 70 km/h where only one result is available. As a reference value the average of the vehicle noise levels measured at DAC- and SMA-surfaces is given in the third line of Table 3.6.

The remaining lines in Table 3.6 show the vehicle noise levels at the other pavement families relatively to the reference value for the actual vehicle category and reference speed. A parenthesis in the table indicates that the number in the parenthesis is based on 3 or fewer individual measurement results. The remaining numbers are averages of 4 or more measurement results. How many can be seen in Table 3.3 – 3.5. Almost no data are available on the heavy vehicle noise levels at thin-layer or porous pavement on low speed roads.

There is a large range of 13 - 14 dB between the passenger car noise levels measured at (one) paving stone surface and the average noise level measured at 20 two-layer porous asphalt pavements (DPAC) and 6 thin layer surfaces (TSF), respectively.

Table 3.6: Average vehicle noise levels for pavement families, cf.text

Speed [km]	50	80	110	50	70	85	50	70	85
Pavement	Light vehicles [dB]			Dual-axle trucks [dB]			Mult-axle trucks [dB]i		
DAC	70.5	78.2	82.2	77.8	83.1	85.8	80.5	85.8	87.9
SMA	71.9	78.7	82.3	79.1	81.9	85.2	81.4	84.8	87.8
Reference	71.2	78.5	82.3	78.4	82.5	85.5	80.9	85.3	87.8
Paving Stones	(8.4)	-	-	(4.8)	-	-	(4.6)	-	-
HRA	-	-	4.0	-	-	1.5	-	-	1.2
CC or CCB	(4.4)	-	2.4	(4.6)	-	1.9	1.2	-	2.3
SD	(2.8)	-	(5.5)	(1.3)	-	(1.8)	(1.7)	-	(1.7)
Slurry Seal	-	(0.0)	-	-	(1.6)	-	-	(0.6)	-
MA	-	-	-0.4	-	-	-3.2	-	-	-1.8
EACC	-	(-2.8)	1.6	-	-	0.1	-	-	-0.4
PAC	-1.2	-2.4	-2.6	-	-	-3.4	-	-3.8	-3.7
PCC	-	(-4.0)	-5.2	-	-	(-5.4)	-	-	-4.4
DPAC	-4.5	-5.5	-3.3	-	-	-3.6	-	-1.0	-4.7
TSF	-5.4	-6.1	0.0	-1.3	-	-1.3	-	-	-2.0

Table 3.7 shows representative values of relative vehicle noise levels at groups of pavement families. The one pavement stone surface yielded the highest noise levels. A group consisting of hot rolled asphalt (HRA), cement concrete (CC) and surface dressings (SD) yielded noise levels exceeding those measured at the reference surfaces by 2 – 3 dB.

The average vehicle noise levels measured at one-layer or two-layer porous pavement (PAC, PCC or DPAC) were 3 or 4 dB lower than at the reference surfaces while at the thin-layer surfaces (TSF) the average noise levels from cars were 3 dB and from trucks 1 dB lower than at the reference surfaces.

Within results from each family there were substantial differences in noise level. The numbers given in Table 3.6 and 3.7 are averages over families of pavement including any variation due to differences in pavement age.

Table 3.7: Representative average vehicle noise levels for groups of pavement families.

	Light vehicles [dB]	Heavy vehicles [dB]
Reference = DAC / SMA / MA / EACC	0	0
Paving Stones	8	5
HRA / CC or CCB / SD	3	2
TSF	-3	-1
PAC/PCC	-3	-3
DPAC	-4	-4

Table 3.8 repeats the reference values from Table 3.6. The following rows in the table show the *minimum* values of the vehicle noise level measured at any pavement of each family. These numbers could be seen as representing the lowest noise levels obtainable with the present knowledge and available technology.

Table 3.8 indicates that up to 10 dB noise reduction relatively to average DAC/SMA-pavements should be obtainable by applying porous asphalt. This one extreme result was measured by BRRC at a 2 months old DPAC at Bambois (7 mm maximum aggregate size in the top layer; air temperature 31 °C).

Also at a new thin layer TSF 6 almost 10 dB noise reduction has been measured (Hoevelaken, CROW [7]).

More often noise reductions somewhere between 5 and 10 dB have been found.

The noise levels from vehicles driving on hot rolled asphalt can be comparable to those at average DAC/SMA-surfaces although the general trend is for somewhat higher noise levels at HRA-pavements.

Cement concrete (CBB) was found in a few cases (BASt A6, BCC3 and BCC4) to generate significantly lower noise levels than average DAC/SMA.

Table 3.8 Minimum vehicle noise levels for pavement families.

Speed [km/h]	50	80	110	50	70	85	50	70	85
	Light vehicles [dB]			Dual-axle trucks [dB]			Multi-axle trucks [dB]		
REF	71.2	78.5	82.3	78.4	82.5	85.5	80.9	85.3	87.8
HRA	-	-	1.8	-	-	0.5	-	-	0.0
CC or CCb	2.8	-	-2.5	0.5	-	-4.8	-1.3	-	-3.2
SD	1.1	-	5.4	1.1	-	1.8	-1.8	-	1.7
MA	-	-	-1.2	-	-	-5.3	-	-	-4.7
EACC	-	-4.0	-1.4	-	-	-2.4	-	-	-2.7
TSF	-9.7	-8.2	-2.9	-3.0	-	-3.6	-	-	-5.0
PAC	-4.4	-6.6	-6.1	-	-	-6.1	-	-7.6	-7.6
PCC	-	-4.5	-6.4	-	-	-7.1	-	-	-8.7
DPAC	-8.3	-10.1	-5.9	-	-	-5.8	-	-	-7.5

4 Conclusions

Based on the analyses we conclude that typical vehicle noise levels during pass-by on different kind of road surfaces are as given in Table 3.7.

Noise levels at surfaces like hot rolled asphalt (HRA), cement concrete (CC) or burlap structured cement concrete (CCb) and surface dressing (SD) tend to be higher by 2 or 3 dB than noise levels at average dense asphalt concrete (DAC) or stone mastic asphalt (SMA).

On the other hand, noise levels at thin-surface layers (TSF) tend to be 3 dB lower for cars and 1 dB lower for heavy vehicles than at average DAC/SMA. Porous pavements on the average yield noise reductions in the order of 3 or 4 dB.

The potential noise reduction as reflected by the lowest noise levels measured for a family of pavements is in the order of 5 – 10 dB for thin-layer surfaces and porous asphalt. Burlap structured cement concrete (CCb) and cement concrete with exposed aggregate (EACC) were seen in a few cases to provide a noise reduction in the order of 3 dB.

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Appendix A. Measurement results grouped by pavement type

The tables in this appendix give the results sorted according to type of pavement. These tables show the acoustical performance of the different pavement types at different speeds.

The results for each pavement type are *a)* the number of measurements, *b)* the average value of the vehicle noise levels L_{veh} (L_{pAFmax}), *c)* the range of these values given as minimum L_{pAFmax} and maximum L_{pAFmax} . The maximum aggregate size influences the tyre/road noise level, and *d)* the minimum (min-aggr.), *e)* maximum (max-aggr.), and *f)* average aggregate sizes (avg-aggr.) are also stated for the pavements.

A.1 Dense asphalt concrete

	Number of measurements	Avg L_{pAFmax}	Min L_{pAFmax}	Max L_{pAFmax}	Min aggr.	Max aggr.	Avg aggr.
	[-]	[dB]	[dB]	[dB]	[mm]	[mm]	[mm]
DACorDACo, cars-50	25	70.5	67.9	74.1	6	16	10.4
DAC, cars-80	20	78.2	73.9	82.8	14	16	15.8
DAC or DACo, cars-110	18	82.2	79.4	83.8	8	16	14.8
DAC, dual-ax-50	15	77.8	72.9	81.6	6	16	10.2
DAC, dual-ax-70	1	83.1					16.0
DAC, dual-ax-85	5	85.8	84.4	88.0	8	16	11.8
DAC or DACo multi-ax-50	10	80.5	78.0	83.3	6	16	13.4
DAC, multi-ax-70	9	85.8	81.8	89.2	16	16	16.0
DAC, multi-ax-85	18	87.9	83.9	89.5	8	16	14.8

A.2 SMA

	Number of measurements	Avg L_{pAFmax}	Min L_{pAFmax}	Max L_{pAFmax}	Min aggr.	Max aggr.	Avg aggr.
	[-]	[dB]	[dB]	[dB]	[mm]	[mm]	[mm]
SMA, cars-50	13	71.9	68.6	74.3	6	16	9.9
SMA, cars-80	15	78.7	76.5	82.1	10	16	11.6
SMA, cars-110	15	82.3	78.3	86.1	8	16	10.3
SMA, dual-ax-50	6	79.1	77.3	85.3	6	12.8	8.6
SMA, dual-ax-70	1	81.9					16.0
SMA, dual-ax-85	10	85.2	82.9	87.0	8	16	10.1
SMA multi-ax-50	8	81.4	79.6	83.3	6	13.0	10.6
SMA, multi-ax-70	10	84.8	81.1	87.7	11	16	11.5
SMA, multi-ax-85	19	87.8	82.9	91.0	8	16	10.5

A.3 Thin pavements

	Number of measurements [-]	Avg L_{pAFmax} [dB]	Min L_{pAFmax} [dB]	Max L_{pAFmax} [dB]	Min aggr. [mm]	Max aggr. [mm]	Avg aggr. [mm]
TSF, cars-50	6	65.8	61.5	68.9	6	6	6.0
TSF, cars-80	2	72.4	70.3	74.4	6	6	6.0
TSF, cars-110	7	82.3	79.4	85.7	8	8	8.0
TSF, dual-ax-50	3	77.1	75.5	78.7	6	6	6.0
TSF, dual-ax-85	7	84.2	81.8	86.3	8	8	8.0
TSF, multi-ax-85	7	85.8	82.9	88.0	8	8	8.0

A.4 Guss asphalt

	Number of measurements [-]	Avg L_{pAFmax} [dB]	Min L_{pAFmax} [dB]	Max L_{pAFmax} [dB]	Min aggr. [mm]	Max aggr. [mm]	Avg aggr. [mm]
MA (guss-), cars-110	4	81.9	81.1	82.9	5	8	6.5
MA, dual-ax-85	4	82.3	80.2	83.4	5	8	6.5
MA, multi-ax-85	4	86.0	83.2	91.3	5	8	6.5

A.5 Hot rolled asphalt

	Number of measurements [-]	Avg L_{pAFmax} [dB]	Min L_{pAFmax} [dB]	Max L_{pAFmax} [dB]	Min aggr. [mm]	Max aggr. [mm]	Avg aggr. [mm]
HRA, cars-110	8	86.3	84.1	87.9	20	20	20.0
HRA, dual-ax-85	8	87.0	85.9	88.0	20	20	20.0
HRA, multi-ax-85	8	89.0	87.8	90.4	20	20	20.0

A.6 Surface dressing

	Number of measurements [-]	Avg L_{pAFmax} [dB]	Min L_{pAFmax} [dB]	Max L_{pAFmax} [dB]	Min aggr. [mm]	Max aggr. [mm]	Avg aggr. [mm]
SD, cars-50	2	74.0	72.3	75.7	8	16	12
SD, cars-110	2	87.8	87.7	87.9			
SD, dual-ax-50	2	79.7	79.6	79.9	8	16	12.0
SD, dual-ax-85	2	87.3	87.2	87.3			
SD multi-ax-50	2	82.6	79.2	86.1			
SD, multi-ax-85	2	89.5	89.5	89.6			

A.7 Slurry seal

	Number of measurements [-]	Avg L_{pAFmax} [dB]	Min L_{pAFmax} [dB]	Max L_{pAFmax} [dB]	Min aggr. [mm]	Max aggr. [mm]	Avg aggr. [mm]
Slurry seal, cars-80	1	78.4					5.0
Slurry seal, dual-ax-70	1	84.1					5.0
Slurry seal, multi-ax-70	1	85.9					5.0

A.8 Porous pavement

	Number of measurements [-]	Avg L_{pAFmax} [dB]	Min L_{pAFmax} [dB]	Max L_{pAFmax} [dB]	Min aggr. [mm]	Max aggr. [mm]	Avg aggr. [mm]
PAC, cars-50	6	70.0	66.8	73.0	16	16	16
PAC, cars-80	23	76.0	71.9	81.4	14	16	15.8
PAC, cars-110	23	79.7	76.2	84.6	8	16	15.0
PAC, dual-ax-85	4	82.1	79.4	83.8	8	16	10.0
PAC, multi-ax-70	17	81.5	77.7	85.0	16	16	16
PAC, multi-ax-85	22	84.1	80.2	87.0	8	16	15.0

A.9 Two layer porous pavement

	Number of measurements [-]	Avg L_{pAFmax} [dB]	Min L_{pAFmax} [dB]	Max L_{pAFmax} [dB]	Min aggr. [mm]	Max aggr. [mm]	Avg aggr. [mm]
DPAC, cars-50	20	66.7	62.9	70.4	5	8	6.2
DPAC, cars-80	9	72.9	68.3	78.2	7	8	7.6
DPAC, cars-110	9	78.9	76.4	82.5	5	11	7.7
DPAC, dual-ax-85	4	81.8	79.7	83.8	5	11	7.3
DPAC, multi-ax-70	1	84.3					
DPAC, multi-ax-85	6	83.2	80.3	86.6	5	11	7.5

A.10 Cement concrete including burlap type

	Number of measurements [-]	Avg L_{pAFmax} [dB]	Min L_{pAFmax} [dB]	Max L_{pAFmax} [dB]	Min aggr. [mm]	Max aggr. [mm]	Avg aggr. [mm]
CC or CCb, cars-50	2	75.6	74.0	77.2			
CCb, cars-110	10	84.6	79.8	90.7	2	2	2.0
CC or CCb, dual-ax-50	2	83.0	78.9	87.1			
CCb, dual-ax-85	9	87.4	80.6	91.4	2	2	2.0
CC or CCb multi-ax-50	2	82.2	79.6	84.7			
CCb, multi-ax-85	10	90.1	84.6	94.2	2	2	2.0

A.11 Exposed aggregate cement concrete

	Number of measurements [-]	Avg L_{pAFmax} [dB]	Min L_{pAFmax} [dB]	Max L_{pAFmax} [dB]	Min aggr. [mm]	Max aggr. [mm]	Avg aggr. [mm]
EACC, cars-80	2	75.6	74.5	76.8	7	7	7
EACC, cars-110	6	83.9	80.9	85.8	10	10	10.0
EACC, dual-ax-85	6	85.6	83.0	86.6	10	10	10.0
EACC, multi-ax-85	6	87.4	85.1	88.4	10	10	10.0

A.12 Porous cement concrete

	Number of measurements [-]	Avg L_{pAFmax} [dB]	Min L_{pAFmax} [dB]	Max L_{pAFmax} [dB]	Min aggr. [mm]	Max aggr. [mm]	Avg aggr. [mm]
PCC, cars-80	2	74.5	74.0	74.9	7	7	7.0
PCC, cars-110	4	77.1	75.8	78.6	8	8	8.0
PCC, dual-ax-85	3	80.1	78.4	81.5			
PCC, multi-ax-85	4	83.5	79.1	90.9	8	8	8.0

A.13 Paving stones

	Number of measurements [-]	Avg L_{pAFmax} [dB]	Min L_{pAFmax} [dB]	Max L_{pAFmax} [dB]	Min aggr. [mm]	Max aggr. [mm]	Avg aggr. [mm]
Paving stones, cars-50	1	79.6					
Paving stones, dual-ax-50	1	83.2					
Paving stones, multi-ax-50	1	85.6					

Appendix B. Car measurements included in analyses

This appendix gives for each measurement report *a)* the recorded number of pass-by noise levels from cars, *b)* the road temperature and the air temperature, *c)* the reference speed; *d)* the surface type, *e)* the maximum aggregate size, *f)* the surface age at the time of measurement, and *e)* the average value of the vehicle noise levels L_{veh} (L_{pAFmax}).

Lab/report	No. of vehicles	Temp [°C].		Speed [km/h]	Surf. type	Max. aggr. [mm]	Surf. age [yr]	L_{pAFmax} [dB]
		road	air					
VTI, RV34, surf1	63	13	13.3	80	DAC	16	13.0	82.8
VTI, RV34, surf7	77	12.5	12.5	80	SMA	16	1.0	82.1
VTI, E18, E1	115	7.9	8.8	110	SMA	16	0.3	86.1
VTI, E18, E2	114	5.8	6.1	110	DAC	11	0.1	82.8
VTI, E18, E3	112	13.8	13.2	110	DPAC	11	0.1	77.0
VTI, E18, E4	117	11	10.9	110	PAC	16	0.1	82.0
DRI, Kgl, 2003	131		8.5	50	DAC	8	0.5	69.2
DRI, Kgl, 2003	77		7	50	DAC	11	0.5	69.9
DRI, Kgl, 2003	109		8	50	SMA	8	0.5	68.6
DRI, Kgl, 2003	105		10	50	TSFc	6	0.5	67.3
DRI, Kgl, 2003	122		7	50	DAC	11	0.5	69.9
DRI, Kgl, 2003	130		8	50	DACo	6	0.5	67.9
DRI, SFr, 2004	36	26	17	50	DAC	8	0.8	69.0
DRI, SFr, 2004	92	21.1	14.4	50	DAC	11	0.8	70.2
DRI, SFr, 2003	104	1.6	7.7	50	SMA	6	0.3	69.6
DRI, SFr, 2003	120	1.7	7.5	50	DACo	6	0.3	69.5
DRI, Ubh, 2003	138	3.3	8.8	50	DAC	11	0.5	70.7
DRI, Ubh, 2003	142	3.2	7.7	50	SMA	6	0.5	69.6
DRI, Ubh, 2003	130	3.3	8	50	TSFc	6	0.5	68.9
DRI, Ubh, 2003	130	3.5	10.5	50	DACo	6	0.5	69.5
DRI, Kgl, 2005	106	26.7	15	50	DAC	8	2.0	68.8
DRI, Kgl, 2005	99	31.5	18.5	50	SMA	8	2.0	68.7
DRI, Kgl, 2005	116	36.1	23.6	50	TSFc	6	2.0	67.2
DRI, Kgl, 2005	122	17.6	15.5	50	DAC	11	2.0	70.6
DRI, Kgl, 2005	107	23.8	16.5	50	DACo	6	2.0	68.6
BRRC, Bambois	100	44.7	31	80	DPAC	7	0.2	68.3
BRRC, Bambois	100	41	31	80	DAC			78.8
BRRC, Bambois 64	108	41.9	24.6	80	DPAC	7	1.0	69.5
BRRC, Bambois 64	103	36.25	24.2	80	DAC			74.7
BRRC, Bambois 78	105	18.3	11.15	80	DPAC	7	1.3	70.9

Lab/report	No. of vehicles	Temp [°C].		Speed [km/h]	Surf. type	Max. aggr. [mm]	Surf. age [yr]	L _{pAFmax} [dB]
		road	air					
BRRC, Bambois 78	105	21.1	12.2	80	DAC			76.0
BRRC, Bambois 78	102	12.3	12	80	DPAC	7	1.4	69.5
BRRC, Herne, 2004	101	27.7	21.3	80	SMA	10	8.0	77.9
BRRC, Herne, 1996				80	SMA	10	0.2	78.5
BRRC, Herne, 2004	102	18.4	16.4	80	SMA	14	8.0	76.5
BRRC, Herne, 1996				80	SMA	14	0.2	78.5
BRRC, Herne, 2004	105	22.7	19.8	80	PCC	7	8.0	74.9
BRRC, Herne, 1996				80	PCC	7	0.2	74.0
BRRC, Herne, 2004	103	26.1	20.4	80	PAC	14	8.0	76.2
BRRC, Herne, 1996				80	PAC	14	0.2	76.0
BRRC, Herne, 2004	105	18.1	17.3	80	EACC	7	8.0	76.8
BRRC, Herne, 1996				80	EACC	7	0.2	74.5
BRRC, Herne, 2004	101	23.4	16.9	80	DAC	14	8.0	81.2
BRRC, Herne, 1996				80	DAC	14	0.2	79.5
CROW, N317	105	35	22	80	TSF	6	0.0	70.3
CROW, Gooiseweg	105	10	6	80	TSF	6	1.0	74.4
CROW, Heerhugow.	108	15	10	50	TSF	6	0.0	65.1
CROW, Leusden	108	25	21	50	TSF	6	0.0	64.6
CROW, Hoevelaken	105		20	50	TSF	6	0.0	61.5
TUG, DK1, GG1	98		18	50	DAC	16	24.0	74.1
TUG, DK6, GW4	143		18	50	SMA	11	3.0	74.1
TUG, DK8, PT7	129		18	50	CC		1 or 2	77.2
TUG, No253, BT9	117		20	50	SD	8	0.0	72.3
TUG, A2, A2P6	133		25	110	DACm	16	1.0	82.7
TUG, DK1, GG2	150		24	50	DAC	16	7.0	73.2
TUG, DK6, GL3	150		19	50	DAC	16	17.0	73.2
TUG, DK65, BB6	115		18	50	Paving stones		>30	79.6
TUG, DK50, SM8	140		18	50	CCb		1.0	74.0
TUG, DK11, PK5	108		24	110	DACo	12.8	2.0	82.9
TUG, DK8, BW14	108		17	110	SMA	9.6	1.0	82.3
TUG, DK8, BW23	99		20	80	Slurry seal	5	9.0	78.4
TUG, DK8, BW6	103		20	50	DAC	12.8	7.0	73.8
TUG, DK8, BW8	92		18	50	SMA	12.8	2.0	73.1
TUG, DK8, BW11	118		17	50	SD	16 0	7.0	75.7
TRL, M6, SMA1	104		16	110	SMA	10	0.2	78.3

Lab/report	No. of	Temp [°C].		Speed	Surf.	Max. aggr.	Surf. age	L_{pAFmax} [dB]
	vehicles	road	air	[km/h]	type	[mm]	[yr]	
TRL, M6, SMA2	107	27	22	110	SMA	10	3.1	80.8
TRL, A50, EACC1	57		16	110	EACC	10	0.2	80.9
TRL, A50, EACC2	87		19	110	EACC	10	1.3	82.4
TRL, A50, EACC3	101	17	16	110	EACC	10	5.3	84.0
TRL, A50, EACC4	121	11	10	110	EACC	10	6.8	84.9
TRL, A50, EACC5	117	7	8	110	EACC	10	8.8	85.3
TRL, A50, EACC6	106	10	10	110	EACC	10	0.2	85.8
TRL, A50, HRA1	56		20	110	HRA	20	1.3	84.1
TRL, A50, HRA2	65		20	110	HRA	20	5.3	85.2
TRL, A50, HRA3	103	25	20	110	HRA	20	6.8	85.8
TRL, A50, HRA4	117	19	19	110	HRA	20		87.1
TRL, A50, HRA5	106	14	14	110	HRA	20		87.9
TRL, A50, BCC1	123	16	12	110	CCb		8.7	89.4
TRL, A50, BCC2	117	14	12	110	CCb		9.3	89.6
TRL, A50, BCC3	115	12	13	110	CCb		10.3	90.7
TRL, A27, HRA1	120	9	11	110	HRA	20	3.3	87.0
TRL, A27, HRA2	127	9	6	110	HRA	20	4.3	86.8
TRL, A27, HRA3	114	22	21	110	HRA	20	4.8	86.2
TRL, A3, TSF1	129	15	14	110	TSF		3.4	85.1
TRL, A3, TSF2	119	18	18	110	TSF		4.4	85.7
TRL, A3, TSF3		21	18	110	TSF		4.9	85.3
TRL, A34, TSF1	127	20	16	110	TSF			79.4
TRL, A34, TSF2	111	14	13	110	TSF			80.3
TRL, A34, TSF3	106	17	17	110	TSF			80.1
TRL, A34, SSD1	119	15	15	110	SD			87.7
TRL, A34, SSD2	115	12	11	110	SD			87.9
BAS _t 1, A9, PAC1	239	22	17	110	PAC	8	2.3	76.9
BAS _t 2, A9, PAC2	230	20	16	110	PAC	8	4.1	77.5
BAS _t 3, A9, PAC3	147	24	19	110	PAC	8	6.4	80.0
BAS _t 4, A3, DPAC1	346	6	9	110	DPAC	5	0.0	78.7
BAS _t 5, A3, DPAC2	428	7	7	110	DPAC	5	0.6	80.0
BAS _t 6, A30, DPAC	273	10	9	110	DPAC	8	0.3	76.5
BAS _t 7, B56, SMA1	149	33	28	110	SMA	8	5.8	81.7
BAS _t 8, B56, SMA2	100	21	15	110	SMA	8	7.0	81.3
BAS _t 9, A9, SMA1	278	31	26	110	SMA	11	3.8	83.5
BAS _t 10, A9, SMA2	170	31	22	110	SMA	11	5.5	83.5

Lab/report	No. of	Temp [°C].		Speed	Surf.	Max. aggr.	Surf. age	L_{pAFmax}
	vehicles	road	air	[km/h]	type	[mm]	[yr]	[dB]
BAS11, A9, SMA3	320	24	21	110	SMA	11	7.8	84.1
BAS12, B56-1, MA1	171	12	13	110	MA	8	1.2	82.9
BAS13, B56-1, MA2	155	18	13	110	MA	8	2.0	81.7
BAS14, B56-2, MA1	157	13	14	110	MA	5	1.2	82.0
BAS15, B56-2, MA2	181	20	17	110	MA	5	2.1	81.1
BAS16, B56-1, PCC1	165	8	7	110	PCC	8	1.2	78.6
BAS17, B56-1, PCC2	116	17	14	110	PCC	8	2.0	75.9
BAS18, B56-2, PCC1	142	10	09	110	PCC	8	1.2	78.0
BAS19, B56-2, PCC2	119	12	12	110	PCC	8	2.0	75.8
BAS20, A6, BCC1	277	34	28	110	CCb	2	2.8	81.7
BAS21, A6, BCC2	177	24	18	110	CCb	2	4.8	81.6
BAS22, A6, BCC3	97	33	27	110	CCb	2	5.9	79.8
BAS23, A6, BCC4	98	17	17	110	CCb	2	7.1	81.4
BAS24, A5, BCC	84	23	18	110	CCb	2	5.9	83.4
BAS25, A7, BCC1	133	9	9	110	CCb	2	12.6	84.4
BAS26, A7, BCC2	112	26	23	110	CCb	2	13.3	84.3
DRI, OSg, 1999	377	29	17.7	50	DAC	8	0.1	69.4
DRI, OSg, 1999	429	29.3	19	50	DPAC	5	0.1	62.9
DRI, OSg, 1999	404	33.7	21	50	DPAC	5	0.1	63.4
DRI, OSg, 1999	449	31	18.3	50	DPAC	8	0.1	64.7
DRI, OSg, 2000	347	18.3	17.3	50	DAC	8	0.8	70.0
DRI, OSg, 2000	433	31	26	50	DPAC	5	0.8	65.9
DRI, OSg, 2000	333	34	27.5	50	DPAC	5	0.8	65.2
DRI, OSg, 2000	329	29	21	50	DPAC	8	0.8	64.6
DRI, OSg, 2001	341	22.8	21	50	DAC	8	1.8	69.2
DRI, OSg, 2001	406	27.3	24.7	50	DPAC	5	1.8	66.0
DRI, OSg, 2001	351	26.4	23.8	50	DPAC	5	1.8	65.1
DRI, OSg, 2001	327	23.8	22.3	50	DPAC	8	1.8	65.3
DRI, OSg, 2002	234	23.5	20.8	50	DAC	8	2.8	70.0
DRI, OSg, 2002	377	35.3	24	50	DPAC	5	2.8	68.5
DRI, OSg, 2002	307	35.2	24.7	50	DPAC	5	2.8	66.0
DRI, OSg, 2002	211	22.5	21.5	50	DPAC	8	2.8	65.8
DRI, OSg, 2003	144	28.5	19	50	DAC	8	3.8	71.0
DRI, OSg, 2003	148	28.5	19	50	DPAC	5	3.8	69.6
DRI, OSg, 2003	154	20.5	18.5	50	DPAC	5	3.8	69.2
DRI, OSg, 2003	129	20.5	18.5	50	DPAC	8	3.8	67.9

Lab/report	No. of	Temp [°C].		Speed	Surf.	Max. aggr.	Surf. age	L_{pAFmax}
	vehicles	road	air	[km/h]	type	[mm]	[yr]	[dB]
DRI, OSg, 2004	252	24.3	20.3	50	DAC	8	4.9	71.1
DRI, OSg, 2004	127	27.5	22	50	DPAC	5	4.9	70.1
DRI, OSg, 2004	137	20.5	18.5	50	DPAC	5	4.9	70.4
DRI, OSg, 2004	267	20.8	20.8	50	DPAC	8	4.9	69.2
DRI, M10, 2004	96	0	7	110	DAC	11	0.3	82.4
DRI, M10, 2004	92	1	8	110	SMA	8	0.3	81.9
DRI, M10, 2004	96	4	9	110	DACo	8	0.3	79.4
DRI, M10, 2004	108	0	7	110	TSFC	8	0.3	80.2
DRI, M10, 2004	87	2	7	110	SMA	8	0.3	80.8
DWW/M+P ZOAB1: N36	146	30	22	50	PAC	16	2	66.8
DWW/M+P ZOAB13: N57	105	34	22	50	PAC	16	7	70.7
DWW/M+P ZOAB14: N57	107	28	19	50	PAC	16	7	67.8
DWW/M+P ZOAB1b: N36	106	29	18	50	PAC	16	3	69.1
DWW/M+P ZOAB15b: N33	106	30	23	50	PAC	16	4	72.5
DWW/M+P ZOAB20: N273	109	26	19	50	PAC	16	7	73
DWW/M+P DAB3: N9	131	33	21	50	DAC	16	3	70
DWW/M+P DAB8: N61	120	20	16	50	DAC	16	2	70.2
DWW/M+P DAB13: N259	107	26	20	50	DAC	16	3	72.9
DWW/M+P SMA2: N271	111	31	22	50	SMA	11	6	73.5
DWW/M+P SMA3: N61	129	20	16	50	SMA	11	2	74.3
DWW/M+P SMA5: N59	133	15	10	50	SMA	11	3	72.9
DWW/M+P SMA6: N35	113	26	21	50	SMA	11	9	72.8
DWW/M+P SMA8: N35	105	27	21	50	SMA	11	6	73.2
DWW/M+P SMA9: N273	108	24	16	50	SMA	11	9	70.6
DWW/M+P SMA10: N273	108	24	18	50	SMA	11	4	73.7
DWW/M+P DPAC3: A4	101	16	12	50	DPAC	8	5	66.7
DWW/M+P DPAC4: A4	104	15	10	50	DPAC	8	5	67.7
DWW/M+P ZOAB1: N36	146	30	22	80	PAC	16	2	72.4
DWW/M+P ZOAB2: A37	117	34	22	80	PAC	16	1	73.6
DWW/M+P ZOAB3: A37	116	33	21	80	PAC	16	1	73
DWW/M+P ZOAB5: A31	120	28	20	80	PAC	16	4	74.9
DWW/M+P ZOAB6: A32	114	28	21	80	PAC	16	3	76.9
DWW/M+P ZOAB9: A32	112	24	20	80	PAC	16	4	76.5
DWW/M+P ZOAB10: A32	113	13	12	80	PAC	16	10	73.9
DWW/M+P ZOAB11: A15	135	17	17	80	PAC	16	9	80.4
DWW/M+P ZOAB13: N57	105	34	22	80	PAC	16	7	76

Lab/report	No. of	Temp [°C].		Speed	Surf.	Max. aggr.	Surf. age	L_{pAFmax}
	vehicles	road	air	[km/h]	type	[mm]	[yr]	[dB]
DWW/M+P ZOAB14: N57	107	28	19	80	PAC	16	7	71.9
DWW/M+P ZOAB1b: N36	106	29	18	80	PAC	16	3	74.8
DWW/M+P ZOAB4b: N34	105	28	23	80	PAC	16	4	77.1
DWW/M+P ZOAB7b: A4	106	5	5	80	PAC	16	6	81.4
DWW/M+P ZOAB8b: A4	110	5	5	80	PAC	16	6	75.5
DWW/M+P ZOAB12b: A7	112	26	18	80	PAC	16	2	74.5
DWW/M+P ZOAB15b: N33	106	30	23	80	PAC	16	4	79
DWW/M+P ZOAB16b: N3	104	19	20	80	PAC	16	8	76.5
DWW/M+P ZOAB17b: A7	107	29	19	80	PAC	16	9	75.9
DWW/M+P ZOAB18b: N3	104	24	22	80	PAC	16	12	76.9
DWW/M+P ZOAB19: A35	106	24	19	80	PAC	16	4	75.8
DWW/M+P ZOAB20: N273	109	26	19	80	PAC	16	7	79.4
DWW/M+P DAB1: N259	113	25	22	80	DAC	16	4	76.8
DWW/M+P DAB2: N48	107	28	21	80	DAC	16	3	76.6
DWW/M+P DAB3: N9	131	33	21	80	DAC	16	3	76.9
DWW/M+P DAB4: A79	138	18	17	80	DAC	16	3	78.9
DWW/M+P DAB5: N48	108	22	18	80	DAC	16	5	77.9
DWW/M+P DAB6: A79	113	22	21	80	DAC	16	8	79.9
DWW/M+P DAB7: A6	128	24	22	80	DAC	16	9	80
DWW/M+P DAB8: N61	120	20	16	80	DAC	16	2	73.9
DWW/M+P DAB9: A27	107	24	18	80	DAC	16	3	77.6
DWW/M+P DAB10: A58	105	32	24	80	DAC	16	2	77.6
DWW/M+P DAB11: A4	102	26	20	80	DAC	16	4	78.7
DWW/M+P DAB12: A6	105	34	20	80	DAC	16	10	77.6
DWW/M+P DAB14: A17	106	-	22	80	DAC	16	2	78.6
DWW/M+P DAB15: A17	106	30	22	80	DAC	16	2	79.7
DWW/M+P SMA1: A31	137	30	21	80	SMA	11	3	81
DWW/M+P SMA2: N271	111	31	22	80	SMA	11	6	80.1
DWW/M+P SMA3: N61	129	20	16	80	SMA	11	2	77.4
DWW/M+P SMA4: N59	124	19	11	80	SMA	11	2	77.3
DWW/M+P SMA5: N59	133	15	10	80	SMA	11	3	76.6
DWW/M+P SMA6: N35	113	26	21	80	SMA	11	9	78.5
DWW/M+P SMA7: A6	104	20	18	80	SMA	11	3	81.1
DWW/M+P SMA8: N35	105	27	21	80	SMA	11	6	78.9
DWW/M+P SMA9: N273	108	24	16	80	SMA	11	9	76.9
DWW/M+P SMA10: N273	108	24	18	80	SMA	11	4	79.5

Lab/report	No. of	Temp [°C].		Speed	Surf.	Max. aggr.	Surf. age	L_{pAFmax}
	vehicles	road	air	[km/h]	type	[mm]	[yr]	[dB]
DWW/M+P DPAC1: A8	112	6	9	80	DPAC	8	6	78.2
DWW/M+P DPAC2: A8	101	11	10	80	DPAC	8	6	76.4
DWW/M+P DPAC3: A4	101	16	12	80	DPAC	8	5	72.5
DWW/M+P DPAC4: A4	104	15	10	80	DPAC	8	5	74.2
DWW/M+P DPAC5: A17	105	-	9	80	DPAC	8	9	76.7
DWW/M+P ZOAB1: N36	146	30	22	110	PAC	16	2	76.2
DWW/M+P ZOAB2: A37	117	34	22	110	PAC	16	1	76.9
DWW/M+P ZOAB3: A37	116	33	21	110	PAC	16	1	76.7
DWW/M+P ZOAB5: A31	120	28	20	110	PAC	16	4	78.5
DWW/M+P ZOAB6: A32	114	28	21	110	PAC	16	3	79.8
DWW/M+P ZOAB9: A32	112	24	20	110	PAC	16	4	79.9
DWW/M+P ZOAB10: A32	113	13	12	110	PAC	16	10	77.5
DWW/M+P ZOAB11: A15	135	17	17	110	PAC	16	9	83.4
DWW/M+P ZOAB13: N57	105	34	22	110	PAC	16	7	79.5
DWW/M+P ZOAB1b: N36	106	29	18	110	PAC	16	3	78.7
DWW/M+P ZOAB4b: N34	105	28	23	110	PAC	16	4	81.2
DWW/M+P ZOAB7b: A4	106	5	5	110	PAC	16	6	84.6
DWW/M+P ZOAB8b: A4	110	5	5	110	PAC	16	6	78.9
DWW/M+P ZOAB12b: A7	112	26	18	110	PAC	16	2	78.1
DWW/M+P ZOAB15b: N33	106	30	23	110	PAC	16	4	83.4
DWW/M+P ZOAB16b: N3	104	19	20	110	PAC	16	8	79.9
DWW/M+P ZOAB17b: A7	107	29	19	110	PAC	16	9	80.3
DWW/M+P ZOAB18b: N3	104	24	22	110	PAC	16	12	81
DWW/M+P ZOAB19: A35	106	24	19	110	PAC	16	4	79.7
DWW/M+P ZOAB20: N273	109	26	19	110	PAC	16	7	83.7
DWW/M+P DAB2: N48	107	28	21	110	DAC	16	3	80.1
DWW/M+P DAB3: N9	131	33	21	110	DAC	16	3	81.7
DWW/M+P DAB4: A79	138	18	17	110	DAC	16	3	82.1
DWW/M+P DAB5: N48	108	22	18	110	DAC	16	5	82.6
DWW/M+P DAB6: A79	113	22	21	110	DAC	16	8	83.6
DWW/M+P DAB7: A6	128	24	22	110	DAC	16	9	83.8
DWW/M+P DAB9: A27	107	24	18	110	DAC	16	3	81.7
DWW/M+P DAB10: A58	105	32	24	110	DAC	16	2	81.8
DWW/M+P DAB11: A4	102	26	20	110	DAC	16	4	82.2
DWW/M+P DAB12: A6	105	34	20	110	DAC	16	10	82.1
DWW/M+P DAB14: A17	106	-	22	110	DAC	16	2	82

Lab/report	No. of vehicles	Temp [°C].		Speed [km/h]	Surf. type	Max. aggr. [mm]	Surf. age [yr]	L_{pAFmax} [dB]
		road	air					
DWW/M+P DAB15: A17	106	30	22	110	DAC	16	2	83.7
DWW/M+P SMA1: A31	137	30	21	110	SMA	11	3	84.3
DWW/M+P SMA5: N59	133	15	10	110	SMA	11	3	79
DWW/M+P SMA7: A6	104	20	18	110	SMA	11	3	84.3
DWW/M+P SMA8: N35	105	27	21	110	SMA	11	6	82.8
DWW/M+P DPAC1: A8	112	6	9	110	DPAC	8	6	82.5
DWW/M+P DPAC2: A8	101	11	10	110	DPAC	8	6	81.1
DWW/M+P DPAC3: A4	101	16	12	110	DPAC	8	5	76.4
DWW/M+P DPAC4: A4	104	15	10	110	DPAC	8	5	78.6
DWW/M+P DPAC5: A17	105	-	9	110	DPAC	8	9	79.6

Appendix C. Two-axle truck measurements included in analyses

This appendix gives for each measurement report *a*) the recorded number of pass-by noise levels from two-axle trucks, *b*) the road temperature and the air temperature, *c*) the reference speed; *d*) the surface type, *e*) the maximum aggregate size, *f*) the surface age at the time of measurement, and *e*) the average value of the vehicle noise levels L_{veh} (L_{pAFmax}).

Lab/report	No of	Temp.	[°C]	Speed	Surf.	Max.	Surf.	L_{pAFmax}
	vehicles	Road	air	[km/h]	type	aggr. mm	age years	[dB]
VTI, RV34, surf1	7	13.0	13.3	70	DAC	16	13.0	83.1
VTI, RV34, surf7	8	12.5	12.5	70	SMA	16	1.0	81.9
VTI, E18, E1	34	7.9	8.8	85	SMA	16	0.3	86.1
VTI, E18, E2	34	5.8	6.1	85	DAC	11	0.1	84.9
VTI, E18, E3	33	13.8	13.2	85	DPAC	11	0.1	79.7
VTI, E18, E4	33	11.0	10.9	85	PAC	16	0.1	83.0
DRI, Kgl, 2003	11		8.5	50	DAC	8	0.5	77.0
DRI, Kgl, 2003	24		8.0	50	SMA	8	0.5	77.8
DRI, Kgl, 2003	20		10.0	50	TSFc	6	0.5	75.5
DRI, Kgl, 2003	31		7.0	50	DAC	11	0.5	76.9
DRI, Kgl, 2003	19		8.0	50	DACo	6	0.5	75.5
DRI, SFr, 2004	15	26.0	17.0	50	DAC	8	0.8	76.0
DRI, SFr, 2004	47	21.1	14.4	50	DAC	11	0.8	78.8
DRI, SFr, 2003	58	1.6	7.7	50	SMA	6	0.3	78.4
DRI, SFr, 2003	48	1.7	7.5	50	DACo	6	0.3	77.4
DRI, Ubh, 2003	9	3.3	8.8	50	DAC	11	0.5	79.7
DRI, Ubh, 2003	12	3.2	7.7	50	SMA	6	0.5	77.3
DRI, Ubh, 2003	10	3.3	8.0	50	TSFc	6	0.5	77.1
DRI, Ubh, 2003	12	3.5	10.5	50	DACo	6	0.5	78.3
DRI, Kgl, 2005	18	26.7	15.0	50	DAC	8	2.0	77.4
DRI, Kgl, 2005	19	31.5	18.5	50	SMA	8	2.0	77.6
DRI, Kgl, 2005	23	36.1	23.6	50	TSFc	6	2.0	78.7
DRI, Kgl, 2005	27	17.6	15.5	50	DAC	11	2.0	77.4
DRI, Kgl, 2005	17	23.8	16.5	50	DACo	6	2.0	78.0
TUG, DK1, GG1	18		18.0	50	DAC	16	24.0	81.6
TUG, DK6, GW4	23		18.0	50	SMA	11	3.0	85.3
TUG, DK8, PT7	19		18.0	50	CC		1 or 2	87.1
TUG, No253, BT9	28		20.0	50	SD	8	0.0	79.6
TUG, A2, A2P6	17		25.0	85	DACm	16	1.0	86.3
TUG, DK1, GG2	27		24.0	50	DAC	16	7.0	72.9

Acoustic performance of low noise road pavements

Lab/report	No of	Temp.	[°C]	Speed	Surf.	Max.	Surf.	L_{pAFmax} [dB]
	vehicles	Road	air	[km/h]	type	aggr. mm	age years	
TUG, DK6, GL3	31		19.0	50	DAC	16	17.0	79.2
TUG, DK65, BB6	18		18.0	50	Pav. st		>30	83.2
TUG, DK50, SM8	20		18.0	50	CCb		1.0	78.9
TUG, DK11, PK5	14		24.0	85	DACo	12.8	2.0	84.4
TUG, DK8, BW14	30		17.0	85	SMA	9.6	1.0	84.4
TUG, DK8, BW23	34		20.0	70	Slurrys	5	9.0	84.1
TUG, DK8, BW6	32		20.0	50	DAC	12.8	7.0	80.8
TUG, DK8, BW8	19		18.0	50	SMA	12.8	2.0	78.0
TUG, DK8, BW11	23		17.0	50	SD	16	7.0	79.9
TRL, M6, SMA1	40		16.0	85	SMA	10	0.2	83.2
TRL, M6, SMA2	44	27.0	22.0	85	SMA	10	3.1	83.9
TRL, A50, EACC1	22		16.0	85	EACC	10	0.2	83.0
TRL, A50, EACC2	28		19.0	85	EACC	10	1.3	85.8
TRL, A50, EACC3	35	17.0	16.0	85	EACC	10	5.3	85.7
TRL, A50, EACC4	39	11.0	10.0	85	EACC	10	6.8	86.0
TRL, A50, EACC5	47	7.0	8.0	85	EACC	10	8.8	86.2
TRL, A50, EACC6	31	10.0	10.0	85	EACC	10	0.2	86.6
TRL, A50, HRA1	23		20.0	85	HRA	20	1.3	86.5
TRL, A50, HRA2	22		20.0	85	HRA	20	5.3	86.3
TRL, A50, HRA3	34	25.0	20.0	85	HRA	20	6.8	87.0
TRL, A50, HRA4	54	19.0	19.0	85	HRA	20		88.0
TRL, A50, HRA5	34	14.0	14.0	85	HRA	20		88.0
TRL, A50, BCC1	43	16.0	12.0	85	CCb			90.8
TRL, A50, BCC2	46	14.0	12.0	85	CCb			90.5
TRL, A50, BCC3	36	12.0	13.0	85	CCb			91.4
TRL, A27, HRA1	44	9.0	11.0	85	HRA	20		87.1
TRL, A27, HRA2	43	9.0	6.0	85	HRA	20		85.9
TRL, A27, HRA3	51	22.0	21.0	85	HRA	20		87.0
TRL, A3, TSF1	46	15.0	14.0	85	TSF			85.6
TRL, A3, TSF2	48	18.0	18.0	85	TSF			86.0
TRL, A3, TSF3		21.0	18.0	85	TSF			86.3
TRL, A34, TSF1	43	20.0	16.0	85	TSF			81.8
TRL, A34, TSF2	42	14.0	13.0	85	TSF			81.9
TRL, A34, TSF3	94	17.0	17.0	85	TSF			82.7
TRL, A34, SSD1	43	15.0	15.0	85	SD			87.3
TRL, A34, SSD2	48	12.0	11.0	85	SD			87.2

Acoustic performance of low noise road pavements

Lab/report	No of	Temp.	[°C]	Speed	Surf.	Max.	Surf.	L_{pAFmax} [dB]
	vehicles	Road	air	[km/h]	type	aggr. mm	age years	
BASSt, A9, PAC1	9	22.0	17.0	85	PAC	8	2.3	79.4
BASSt, A9, PAC2	31	20.0	16.0	85	PAC	8	4.1	82.1
BASSt, A9, PAC3	43	24.0	19.0	85	PAC	8	6.4	83.8
BASSt, A3, DPAC1	28	6.0	9.0	85	DPAC	5	0.0	83.0
BASSt, A3, DPAC2	22	7.0	7.0	85	DPAC	5	0.6	83.8
BASSt, A30, DPAC	12	10.0	9.0	85	DPAC	8	0.3	80.8
BASSt, B56, SMA1	9	33.0	28.0	85	SMA	8	5.8	85.4
BASSt, B56, SMA2	0	21.1	15.1	85	SMA	8	7.0	
BASSt, A9, SMA1	9	31.0	26.0	85	SMA	11	3.8	82.9
BASSt, A9, SMA2	36	31.0	22.0	85	SMA	11	5.5	86.1
BASSt, A9, SMA3	9	24.0	21.0	85	SMA	11	7.8	86.3
BASSt, B56-1, MA1	13	12.0	13.0	85	MA	8	1.2	83.4
BASSt, B56-1, MA2	5	17.9	13.0	85	MA	8	2.0	80.2
BASSt, B56-2, MA1	10	13.0	14.0	85	MA	5	1.2	83.1
BASSt, B56-2, MA2	11	20.4	16.9	85	MA	5	2.1	82.5
BASSt B56-1 PCC1	2	8.0	7.0	85	PCC	8	1.2	78.4
BASSt B56-1 PCC2	4	16.7	14.5	85	PCC	8	2.0	80.3
BASSt B56-2 PCC1	4	10.0	9.0	85	PCC	8	1.2	81.5
BASSt B56-2 PCC2	0	12.3	11.9	85	PCC	8	2.0	
BASSt, A6, BCC1	13	34.0	28.0	85	CCb	2	2.8	85.4
BASSt, A6, BCC2	28	24.0	18.0	85	CCb	2	4.8	84.1
BASSt, A6, BCC3	6	33.0	27.0	85	CCb	2	5.9	80.6
BASSt, A6, BCC4	0	17.0	17.0	85	CCb	2	7.1	
BASSt, A5, BCC	12	23.0	18.0	85	CCb	2	5.9	87.1
BASSt, A7, BCC1	40	9.0	9.0	85	CCb	2	12.6	88.7
BASSt, A7, BCC2	29	26.0	23.0	85	CCb	2	13.3	87.9
DRI, M10, 2004	50	0.0	7.0	85	DAC	11	0.3	88.0
DRI, M10, 2004	32	1.0	8.0	85	SMA	8	0.3	86.3
DRI, M10, 2004	36	4.0	9.0	85	DACo	8	0.3	85.4
DRI, M10, 2004	35	0.0	7.0	85	TSFC	8	0.3	85.2
DRI, M10, 2004	35	2.0	7.0	85	SMA	8	0.3	87.0

Appendix D. Multi-axle truck measurements included in analyses

This appendix gives for each measurement report *a)* the recorded number of pass-by noise levels from multi-axle trucks, *b)* the road temperature and the air temperature, *c)* the reference speed; *d)* the surface type, *e)* the maximum aggregate size, *f)* the surface age at the time of measurement, and *e)* the average value of the vehicle noise levels L_{veh} (L_{pAFmax}).

Lab/report	No of	Temp.	[°C]	Speed	Surf.	Max.	Surf.	L_{pAFmax} [dB]
	vehicles	road	air	[km/h]	type	aggr. mm	Age years	
VTI, RV34, surf1	29	13	13.3	70	DAC	16	13.0	89.2
VTI, RV34, surf7	26	12.5	12.5	70	SMA	16	1.0	86.8
VTI, E18, E1	67	7.9	8.8	85	SMA	16	0.3	88.9
VTI, E18, E2	54	5.8	6.1	85	DAC	11	0.1	87.6
VTI, E18, E3	69	13.8	13.2	85	DPAC	11	0.1	81.6
VTI, E18, E4	64	11	10.9	85	PAC	16	0.1	85.4
DRI, SFr, 2004	18	26	17	50	DAC	8	0.8	78.3
DRI, SFr, 2004	36	21.1	14.4	50	DAC	11	0.8	80.2
DRI, SFr, 2003	59	1.6	7.7	50	SMA	6	0.3	79.6
DRI, SFr, 2003	36	1.7	7.5	50	DACo	6	0.3	78.2
TUG, DK1, GG1	58		18	50	DAC	16	24.0	80.4
TUG, DK6, GW4	57		18	50	SMA	11	3.0	83.3
TUG, DK8, PT7	85		18	50	CC		1 or 2	84.7
TUG, No253, BT9	36		20	50	SD	8	0.0	86.1
TUG, A2, A2P6	44		25	85	DAC mod.	16	1.0	87.6
TUG, DK1, GG2	61		24	50	DAC	16	7.0	83.3
TUG, DK6, GL3	48		19	50	DAC	16	17.0	83.2
TUG, DK65, BB6	54		18	50	Pav. stone		>30	85.6
TUG, DK50, SM8	52		18	50	CCb		1.0	79.6
TUG, DK11, PK5	52		24	85	DACo	12.8	2.0	88.5
TUG, DK8, BW14	55		17	85	SMA	9.6	1.0	86.8
TUG, DK8, BW23	46		20	70	Slurry seal	5	9.0	85.9
TUG, DK8, BW6	42		20	50	DAC	12.8	7.0	82.4
TUG, DK8, BW8	58		18	50	SMA	12.8	2.0	82.0
TUG, DK8, BW11	48		17	50	SD	16	7.0	79.2
TRL, M6, SMA1	43		16	85	SMA	10	0.2	84.2
TRL, M6, SMA2	44	27	22	85	SMA	10	3.1	85.5
TRL, A50, EACC1	31		16	85	EACC	10	0.2	85.1
TRL, A50, EACC2	43		19	85	EACC	10	1.3	87.0
TRL, A50, EACC3	45	17	16	85	EACC	10	5.3	87.7
TRL, A50, EACC4	48	11	10	85	EACC	10	6.8	88.0

Acoustic performance of low noise road pavements

Lab/report	No of vehicles	Temp. road	[°C] air	Speed [km/h]	Surf. type	Max. aggr. mm	Surf. Age years	L_{pAFmax} [dB]
TRL, A50, EACC5	57	7	8	85	EACC	10	8.8	88.3
TRL, A50, EACC6	61	10	10	85	EACC	10		88.4
TRL, A50, HRA1	31		20	85	HRA	20	0.2	88.0
TRL, A50, HRA2	42		20	85	HRA	20	1.3	88.8
TRL, A50, HRA3	46	25	20	85	HRA	20	5.3	89.2
TRL, A50, HRA4	51	19	19	85	HRA	20	6.8	89.9
TRL, A50, HRA5	52	14	14	85	HRA	20		90.4
TRL, A50, BCC1	50	16	12	85	CCb			93.6
TRL, A50, BCC2	55	14	12	85	CCb			93.7
TRL, A50, BCC3	48	12	13	85	CCb			94.2
TRL, A27, HRA1	43	9	11	85	HRA	20		89.2
TRL, A27, HRA2	52	9	6	85	HRA	20		87.8
TRL, A27, HRA3	45	22	21	85	HRA	20		88.6
TRL, A3, TSF1	46	15	14	85	TSF			87.4
TRL, A3, TSF2	48	18	18	85	TSF			88.0
TRL, A3, TSF3		21	18	85	TSF			87.9
TRL, A34, TSF1	52	20	16	85	TSF			82.9
TRL, A34, TSF2	59	14	13	85	TSF			83.3
TRL, A34, TSF3	40	17	17	85	TSF			83.7
TRL, A34, SSD1	55	15	15	85	SD			89.5
TRL, A34, SSD2	59	12	11	85	SD			89.6
BASt, A9, PAC1	12	22	17	85	PAC	8	2.3	84.5
BASt, A9, PAC2	197	20	16	85	PAC	8	4.1	84.6
BASt, A9, PAC3	132	24	19	85	PAC	8	6.4	86.3
BASt, A3, DPAC1	22	6	9	85	DPAC	5	0.0	80.3
BASt, A3, DPAC2	31	7	7	85	DPAC	5	0.6	86.6
BASt, A30, DPAC	53	10	9	85	DPAC	8	0.3	81.3
BASt, B56, SMA1	17	33	28	85	SMA	8	5.8	88.7
BASt, B56, SMA2	7	21	15	85	SMA	8	7.0	90.2
BASt, A9, SMA1	4	31	26	85	SMA	11	3.8	91.0
BASt, A9, SMA2	195	31	22	85	SMA	11	5.5	89.8
BASt, A9, SMA3	156	24	21	85	SMA	11	7.8	90.1
BASt, B56-1, MA1	14	12	13	85	MA	8	1.2	83.9
BASt, B56-1, MA2	10	18	13	85	MA	8	2.0	85.8
BASt, B56-2, MA1	7	13	14	85	MA	5	1.2	91.3
BASt, B56-2, MA2	2	20	17	85	MA	5	2.1	83.2

Acoustic performance of low noise road pavements

Lab/report	No of vehicles	Temp. road	[°C] air	Speed [km/h]	Surf. type	Max. aggr. mm	Surf. Age years	L_{pAFmax} [dB]
BASSt, B56-1, PCC1	18	8	7	85	PCC	8	1.2	83.0
BASSt, B56-1, PCC2	9	17	14	85	PCC	8	2.0	79.1
BASSt, B56-2, PCC1	4	10	9	85	PCC	8	1.2	80.8
BASSt, B56-2, PCC2	8	12	12	85	PCC	8	2.0	90.9
BASSt, A6, BCC1	61	34	28	85	CCb	2	2.8	88.9
BASSt, A6, BCC2	118	24	18	85	CCb	2	4.8	88.8
BASSt, A6, BCC3	72	33	27	85	CCb	2	5.9	86.9
BASSt, A6, BCC4	2	17	17	85	CCb	2	7.1	84.6
BASSt, A5, BCC	46	23	18	85	CCb	2	5.9	89.6
BASSt, A7, BCC1	262	9	9	85	CCb	2	12.6	90.3
BASSt, A7, BCC2	107	26	23	85	CCb	2	13.3	90.4
DRI, M10, 2004	92	0	7	85	DAC	11	0.3	89.25
DRI, M10, 2004	67	1	8	85	SMA	8	0.3	88.09
DRI, M10, 2004	61	4	9	85	DAC _o	8	0.3	86.98
DRI, M10, 2004	51	0	7	85	TSFC	8	0.3	87.48
DRI, M10, 2004	77	2	7	85	SMA	8	0.3	88.14
DWW/M+P DAB15: A17	29	30	22	85	DAC	16	2.0	89.5
DWW/M+P DAB7: A6	94	24	22	85	DAC	16	9	89.3
DWW/M+P SMA10: N273	32	24	18	85	SMA	11	4	89.3
DWW/M+P DAB10: A58	37	32	24	85	DAC	16	2	89.0
DWW/M+P DAB11: A4	45	26	20	85	DAC	16	4	88.8
DWW/M+P DAB14: A17	33	-	22	70	DAC	16	2	88.7
DWW/M+P SMA1: A31	33	30	21	85	SMA	11	3	88.6
DWW/M+P DAB4: A79	41	18	17	85	DAC	16	3	88.5
DWW/M+P SMA7: A6	14	20	18	85	SMA	11	3	88.5
DWW/M+P DAB14: A17	33	-	22	85	DAC	16	2	88.2
DWW/M+P DAB12: A6	40	34	20	85	DAC	16	10	88.1
DWW/M+P DAB1: N259	38	25	22	85	DAC	16	4	87.9
DWW/M+P DAB6: A79	32	22	21	85	DAC	16	8	87.9
DWW/M+P SMA8: N35	31	27	21	85	SMA	11	6	87.8
DWW/M+P DAB5: N48	40	22	18	85	DAC	16	5	87.8
DWW/M+P SMA1: A31	33	30	21	70	SMA	11	3	87.7
DWW/M+P DAB9: A27	39	24	18	85	DAC	16	3	87.7
DWW/M+P DAB7: A6	94	24	22	70	DAC	16	9	87
DWW/M+P ZOAB11: A15	40	17	17	85	PAC	16	9	87.0
DWW/M+P SMA9: N273	38	24	16	85	SMA	11	9	87.0

Acoustic performance of low noise road pavements

Lab/report	No of vehicles	Temp. road	[°C] air	Speed [km/h]	Surf. type	Max. aggr. mm	Surf. Age years	L_{pAFmax} [dB]
DWW/M+P SMA2: N271	41	31	22	85	SMA	11	6	86.8
DWW/M+P DAB15: A17	29	30	22	70	DAC	16	2	86.7
DWW/M+P ZOAB7b: A4	22	5	5	85	PAC	16	6	86.3
DWW/M+P SMA10: N273	32	24	18	70	SMA	11	4	86.2
DWW/M+P ZOAB15b: N33	27	30	23	85	PAC	16	4	86.2
DWW/M+P SMA6: N35	66	26	21	85	SMA	11	9	86.0
DWW/M+P ZOAB20: N273	39	26	19	85	PAC	16	7	86.0
DWW/M+P DAB3: N9	54	33	21	85	DAC	16	3	86.0
DWW/M+P ZOAB17b: A7	23	29	19	85	PAC	16	9	85.8
DWW/M+P SMA8: N35	31	27	21	70	SMA	11	6	85.5
DWW/M+P SMA2: N271	41	31	22	70	SMA	11	6	85.4
DWW/M+P DPAC1: A8	14	6	9	85	DPAC	8	6	85.4
DWW/M+P DAB3: N9	54	33	21	70	DAC	16	3	85.2
DWW/M+P ZOAB11: A15	40	17	17	70	PAC	16	9	85
DWW/M+P DAB5: N48	40	22	18	70	DAC	16	5	84.9
DWW/M+P DAB1: N259	38	25	22	70	DAC	16	4	84.7
DWW/M+P ZOAB9: A32	47	24	20	85	PAC	16	4	84.7
DWW/M+P SMA9: N273	38	24	16	70	SMA	11	9	84.6
DWW/M+P ZOAB6: A32	43	28	21	85	PAC	16	3	84.6
DWW/M+P ZOAB7b: A4	22	5	5	70	PAC	16	6	84.4
DWW/M+P DPAC1: A8	14	6	9	70	DPAC	8	6	84.3
DWW/M+P SMA6: N35	66	26	21	70	SMA	11	9	84.2
DWW/M+P ZOAB16b: N3	21	19	20	85	PAC	16	8	84.2
DWW/M+P ZOAB5: A31	19	28	20	85	PAC	16	4	84.0
DWW/M+P ZOAB20: N273	39	26	19	70	PAC	16	7	83.9
DWW/M+P ZOAB19: A35	25	24	19	85	PAC	16	4	83.9
DWW/M+P DAB8: N61	55	20	16	85	DAC	16	2	83.9
DWW/M+P DPAC5: A17	37	-	9	85	DPAC	8	9	83.8
DWW/M+P DAB6: A79	32	22	21	70	DAC	16	8	83.7
DWW/M+P ZOAB6: A32	43	28	21	70	PAC	16	3	83.6
DWW/M+P SMA3: N61	50	20	16	70	SMA	11	2	83.6
DWW/M+P ZOAB12b: A7	17	26	18	85	PAC	16	2	83.5
DWW/M+P ZOAB1b: N36	16	29	18	85	PAC	16	3	83.3
DWW/M+P SMA2: N271	41	31	22	50	SMA	11	6	83.1
DWW/M+P ZOAB15b: N33	27	30	23	70	PAC	16	4	83
DWW/M+P SMA4: N59	49	19	11	70	SMA	11	2	83
DWW/M+P ZOAB13: N57	54	34	22	85	PAC	16	7	82.9

Acoustic performance of low noise road pavements

Lab/report	No of vehicles	Temp. road	[°C] air	Speed [km/h]	Surf. type	Max. aggr. mm	Surf. Age years	L_{pAFmax} [dB]
DWW/M+P SMA5: N59	57	15	10	85	SMA	11	3	82.9
DWW/M+P ZOAB3: A37	42	33	21	85	PAC	16	1	82.8
DWW/M+P ZOAB2: A37	35	34	22	85	PAC	16	1	82.8
DWW/M+P ZOAB18b: N3	29	24	22	85	PAC	16	12	82.7
DWW/M+P ZOAB16b: N3	21	19	20	70	PAC	16	8	82.6
DWW/M+P ZOAB1: N36	65	30	22	85	PAC	16	2	82.5
DWW/M+P ZOAB10: A32	25	13	12	85	PAC	16	10	82.4
DWW/M+P ZOAB9: A32	47	24	20	70	PAC	16	4	82.2
DWW/M+P ZOAB8b: A4	19	5	5	70	PAC	16	6	81.9
DWW/M+P DAB8: N61	55	20	16	70	DAC	16	2	81.8
DWW/M+P SMA8: N35	31	27	21	50	SMA	11	6	81.4
DWW/M+P ZOAB5: A31	19	28	20	70	PAC	16	4	81.4
DWW/M+P ZOAB2: A37	35	34	22	70	PAC	16	1	81.2
DWW/M+P DAB13: N259	20	26	20	50	DAC	16	3	81.1
DWW/M+P ZOAB13: N57	54	34	22	70	PAC	16	7	81.1
DWW/M+P SMA5: N59	57	15	10	70	SMA	11	3	81.1
DWW/M+P SMA6: N35	66	26	21	50	SMA	11	9	80.9
DWW/M+P SMA10: N273	32	24	18	50	SMA	11	4	80.7
DWW/M+P ZOAB1: N36	65	30	22	70	PAC	16	2	80.6
DWW/M+P SMA9: N273	38	24	16	50	SMA	11	9	80.5
DWW/M+P ZOAB18b: N3	29	24	22	70	PAC	16	12	80.2
DWW/M+P ZOAB14: N57	50	28	19	85	PAC	16	7	80.2
DWW/M+P ZOAB1b: N36	16	29	18	70	PAC	16	3	79.5
DWW/M+P ZOAB12b: A7	17	26	18	70	PAC	16	2	79.4
DWW/M+P DAB1: N259	38	25	22	50	DAC	16	4	79.3
DWW/M+P ZOAB19: A35	25	24	19	70	PAC	16	4	78.3
DWW/M+P ZOAB13: N57	54	34	22	50	PAC	16	7	78.1
DWW/M+P DAB8: N61	55	20	16	50	DAC	16	2	78
DWW/M+P ZOAB14: N57	50	28	19	70	PAC	16	7	77.7

