AECOM

Developing a new noise calculation method

Task 3: Draft Standard

National Highways

Project Reference: T0478

10 June 2024

Delivering a better world

Quality information

Prepared by	Checked by	Verified by	Approved by
Matt Muirhead PhD MIOA Associate Director	Suzanne Scott MIOA, CSci Associate Acoustician Fiona Rogerson Senior Consultant	Suzanne Scott MIOA, CSci Associate Acoustician	Chris Skinner MSci MIOA Regional Director - Acoustics

Revision History

Revision	Revision date	Details	Authorized	Name	Position
01	28/03/24	Draft for comment	CS	Chris Skinner	Regional Director
02	10/06/24	Final version	CS	Chris Skinner	Regional Director

Distribution List

# Hard Copies	PDF Required	Association / Company Name

Prepared for:

National Highways

Prepared by:

Matt Muirhead

AECOM Limited
Midpoint, Alencon Link
Basingstoke
Hampshire RG21 7PP
United Kingdom

T: +44 (0)1256 310200
aecom.com

Table of Contents

Tables

1. Introduction

1.1 Background

Environmental noise in the UK is a significant source of pollution and can lead to harmful adverse impacts on health. The official methodologies adopted in the UK for calculating environmental noise from road and rail sources are relatively old, with the Calculation of Road Traffic Noise (CRTN) being published in 1988 and the Calculation of Railway Noise (CRN) in 1995. While these methods have been supplemented with additional guidance on their use, they remain relatively inflexible in their approach and do not account for all scenarios that practitioners would wish to consider in the 21st century.

To address this issue, a new calculation method is being developed for use in the UK. This report presents the part of the methodology concerned with calculating the sound power levels of motorised road traffic.

1.2 Scope

This report presents the procedures for calculating sound power levels associated with road traffic. It is based upon the method created as part of the Harmonoise and IMAGINE research programmes. The method classifies motor vehicles into several categories and provides a means by which equivalent sound power levels, made up of rolling and propulsion noise components in 1/3rd octave frequency bands, can be calculated for vehicles in each category. Sound power levels are first calculated for a set of reference conditions and then corrected to account for changes to these reference conditions. Individual vehicles are treated as equivalent point sources and summed to represent traffic flow along a road.

Section 2 presents the equations that govern the calculations. It is set out as follows:

- The vehicle categories and their definitions are given in Section 2.1.
- Section 2.2 describes the reference conditions to which core rolling and propulsion noise components, given in Section 2.3, pertain.
- The corrections to these core components are presented in Section 2.4.
- The method for combining the vehicle noise, given in terms of equivalent point sources, into road traffic noise for a given road in presented in Section 2.5.

1.3 Terms and definitions

Table 1 lists the symbols used in the formulae governing the methodology and their definition.

Table 1: Glossary of terms

Symbol	Unit	Description
$\alpha_{i,m}$	-	Frequency dependent correction for road surface
β_m	-	Speed coefficient for road surface
η	%	Longitudinal road gradient
φ	radians	Vertical angle between the source and receiver
ψ	radians	Horizontal angle between the source and receiver
a	ms^{-2}	Vehicle acceleration

Symbol	Unit	Description
a_{max}	ms^{-2}	Maximum vehicle acceleration for which corrections to the sound power are valid
A_P	-	Frequency dependent propulsion noise coefficient
A_R	-	Frequency dependent rolling noise coefficient
B_P	-	Frequency dependent speed coefficient for propulsion noise
B_R	-	Frequency dependent speed coefficient for rolling noise
C_P	-	Frequency dependent propulsion noise coefficients for acceleration and gradient
f	Hz	1/3rd octave band centre frequency
i	-	1/3rd octave frequency band
K	-	Correction coefficient for air temperature
l	m	Length of road section to be represented by vehicle point source
L_{Aeq}	dB	Equivalent A-weighted sound pressure level
L_{Amax}	dB	Maximum A-weighted sound pressure level
$L_{W,line,eq}$	dB/m	Equivalent line source strength (average sound power per unit length)
L_{WP}	dB	Vehicle sound power – propulsion noise component
$\Delta L_{WP,acc}$	dB	Correction to the propulsion noise component for vehicle acceleration or deceleration
$\Delta L_{WP,gradient}$	dB	Correction to the propulsion noise component to account for the road gradient
$\Delta L_{WP,road}$	dB	Correction to the propulsion noise component for the road surface
L_{WR}	dB	Vehicle sound power – rolling noise component
$\Delta L_{WR,axles}$	dB	Correction to the rolling noise component of category 3 vehicles to account for the number of axles
$\Delta L_{WR,double}$	dB	Correction to the rolling noise component of category 3 vehicles to account for double mounted tyres
$\Delta L_{WR,road}$	dB	Correction to the rolling noise component for the road surface
$\Delta L_{WR,temp}$	dB	Correction to the rolling noise component for the air temperature

Symbol	Unit	Description
$\Delta L_{WR,tyrewidth}$	dB	Correction to the rolling noise component of category 1 vehicles to account for tyre width
$\Delta L_{WR,wetness}$	dB	Correction to the rolling noise component for category 1 vehicles to account for surface wetness
ΔL_{hd}	dB	Correction for horizontal directivity
ΔL_{vd}	dB	Correction for vertical directivity
m	-	Vehicle category
Q	vehicles/s	Flow of traffic
T	°C	Air temperature
v	km/h or m/s	Vehicle speed
v_{ref}	km/h	Reference speed

2. The method

2.1 Vehicle categories

Road traffic is split into the vehicle categories given in Table 2 for the purpose of the calculation methodology.

Table 2: Vehicle categories

Category	Name	Description	UN ECE Vehicle Class
1	Light motor vehicles	1C – Passenger cars < 3.5 tons	M1
		1V – Delivery vans < 3.5 tons	N1
		1CE – Passenger cars < 3.5 tons when powered by an electric motor	M1
2	Medium heavy vehicles	Delivery vans, trucks and buses > 3.5 tons, with two axles	M2, M3 and N2, N3
3	Heavy vehicles	Heavy duty vehicle > 3.5 tons with more than two axles	M2 and N2 with trailer, M3 and N3
4	Powered two wheelers	4A – mopeds and quads up to 50cc	L1, L2, L6
		4B – motorbikes over 50cc	L3, L4, L5, L7

2.2 Reference conditions

The sound from each vehicle in categories 1 to 3 is represented by two equivalent point sources located in the vertical plane of the nearside wheel. The lower of these two sources represents 80% of the rolling noise and 20% of the propulsion noise and the higher 20% of the rolling noise and 80% of the propulsion noise. For category 1, these are located, 0.01 m and 0.3 m above local ground level. For categories 2 and 3 the higher point source is located 0.75 m above local ground level. For category 4 the two point sources are replaced by one point source 0.3 m above local ground level.

The source equations (**1**) and (2) are used to determine the sound power level of the rolling and propulsion components respectively, across a range of speeds from 20 km/h to 130 km/h and 1/3rd octave bands from 25 Hz to 10 kHz, under a series of reference conditions. These are defined as follows:

- a constant vehicle speed
- a flat road surface
- an air temperature of 20°C
- a virtual reference road surface, equivalent to a surface with a Road Surface Influence (RSI) of 0 dB
- a dry road surface
- an average tyre width of 187 mm for vehicles in category 1
- no studded tyres
- 4-axles for vehicles in category 3
- a ratio of 35% illegal replacement exhaust silencing systems in category 4
- a sound reflecting surface under the vehicle.

2.3 Source equations

The sound power associated with the rolling noise for each vehicle category is given by:

$$L_{WR} = A_R + B_R log_{10}\left(\frac{v}{v_{ref}}\right) \quad (1)$$

where A_R and B_R are given, for each 1/3rd octave band, in Appendix A, v is the speed of the vehicle in km/h and v_{ref} = 70 km/h.

The sound power associated with the propulsion noise for each vehicle category is given by:

$$L_{WP} = A_P + B_P\left(\frac{v - v_{ref}}{v_{ref}}\right) \quad (2)$$

where A_P and B_P are given, for each 1/3rd octave band, in Appendix A.

The speed range of validity is from 20 km/h to 130 km/h. Vehicle speeds below or above this range should be set to 20 km/h or 130 km/h respectively.

2.4 Correction factors

In situations where the reference conditions do not apply, corrections to the sound power levels given in (1) and (2) are required. These correction factors, applied to either the rolling noise component, propulsion noise component, or the overall level, are described in this section.

2.4.1 Road surfaces

The effect of the road surface on the rolling noise, for vehicles in categories 1-3, is given by:

$$\Delta L_{WR,road} = \alpha_{i,m} + \beta_m log_{10}\left(\frac{v}{v_{ref}}\right) \quad (3)$$

where $\alpha_{i,m}$ is a spectral correction for each 1/3rd octave frequency band i and vehicle category m, and β is a speed dependency of the rolling noise correction. These values are given in Appendix A for a variety of common road surface types.

For propulsion noise the correction is defined as a spectral adjustment, given as:

$$\Delta L_{WP,road} = max\{\alpha_{i,m}, 0\} \quad (4)$$

2.4.2 Air temperature

The rolling noise component is influenced by temperature and a correction is applied as given by:

$$\Delta L_{WR,temp} = K \times (20℃ - T) \quad (5)$$

where K is defined in Appendix A for different road surface types and T is the local ambient air temperature in degrees Celsius.

2.4.3 Acceleration

Corrections to the propulsion noise for internal combustion engine vehicles under acceleration or deceleration are given by:

$$\Delta L_{WP,acc} = \begin{cases} C_P \times a & \text{for } a \geq -1\ ms^{-2} \\ C_P \times (-1) & \text{for } a < -1\ ms^{-2} \end{cases} \qquad |a| \leq a_{max} \quad (6)$$

where a is the acceleration of the vehicle in ms^{-2} and C_P is given, for each vehicle category and 1/3rd octave band, in Appendix A. The value of a_{max} is 2 ms^{-2} for category 1, 1 ms^{-2} for category 2 and 3 and 4 ms^{-2} for category 4. No acceleration correction is applied for category 1CE.

2.4.4 Gradient

Frequency dependent corrections to the propulsion noise, for category 1 and 4 vehicles, for roads that are not flat are given by:

$$\Delta L_{WP,gradient} = \begin{cases} C_P \times g \times \frac{\eta}{100\%} & \text{for } \eta \geq -2\% \\ C_P \times g \times \frac{-2}{100\%} & \text{for } -8\% < \eta < -2\% \\ -C_P \times g \times \frac{\eta + 10\%}{100\%} & \text{for } \eta \leq -8\% \end{cases} \tag{7}$$

where g is acceleration due to gravity (approximately 9.8 ms^{-2}) and η is the longitudinal gradient of the road expressed as a percentage.

The equivalent expressions for category 2 and 3 vehicles are given by:

$$\Delta L_{WP,gradient} = \begin{cases} C_P \times g \times \frac{\eta}{100\%} & \text{for } \eta \geq -2\% \\ -C_P \times g \times \frac{\eta + 4\%}{100\%} & \text{for } \eta < -2\% \end{cases} \tag{8}$$

2.4.5 Surface wetness

For a wet road surface with a water layer thickness of 2 mm, a correction to the rolling noise component of category 1 vehicles may be applied as follows:

$$\Delta L_{WR,wetness} = max\{(15 \times log_{10}(f) - 12 \times log_{10}(v/v_{ref}) - 48), 0\} \tag{9}$$

where f is the centre frequency of each 1/3rd octave band.

2.4.6 Directivity

The vertical directivity of each point source for category 1 vehicles is given by:

$$\Delta L_{vd} = -\psi \times \pi/9 \tag{10}$$

where ψ is the angle (in radians) between the receiver, the source and the point directly below the receiver at the same height as the source. For vehicles in categories 2 and 3 the equivalent expression is:

$$\Delta L_{vd} = -\psi \times \pi/6 \tag{11}$$

Horizontal directivity does not impact the calculation of L_{Aeq} noise levels but is relevant to the calculation of L_{Amax}. In this instance the horizontal directivity with respect to point sources at 0.01 m height is given by:

$$\Delta L_{hd} = \begin{cases} 0 \text{ for } f \leq 1250\ Hz \text{ or } f \geq 8000\ Hz \\ \left(-1.5 + 2.5 \times \left|\sin\left(\frac{\pi}{2} - \varphi\right)\right|\right) \times \sqrt{\cos(\psi)} \text{ for } 1600 \leq f \leq 6300\ Hz \end{cases} \tag{12}$$

where φ is the horizontal angle between the vertical plane containing the source and receiver points and the vertical plane containing the source in the direction of travel of the vehicle. With respect to sources at 0.75 m height the horizontal directivity is given by:

$$\Delta L_{hd} = \left(1.546 \times \left(\frac{\pi}{2} - \varphi\right)^3 - 1.425 \times \left(\frac{\pi}{2} - \varphi\right)^2 + 0.22 \times \left(\frac{\pi}{2} - \varphi\right) + 0.6\right) \times \sqrt{\cos(\psi)} \tag{13}$$

No horizontal directivity correction is applied to sources at 0.3 m height.

2.4.7 Tyre widths

For vehicles in category 1 a correction to the rolling noise component to account for different tyre widths may be applied as follows:

$$\Delta L_{WR,tyrewidth} = 0.04 \times (tyre\ width - 187\ mm) \quad (14)$$

for a given tyre width in millimetres. If data on tyre widths is unavailable but vehicle weight is known, an associated tyre width may be estimated as:

$$tyre\ width \approx 0.062 \times vehicle\ weight + 118\ mm \quad (15)$$

where the vehicle weight is given in kilograms.

2.4.8 Truck tyre configuration

For vehicles in category 3 with trailer axles carrying double mounted tyres, a rolling noise correction is applied as follows:

$$\Delta L_{WR,double} = 0.8\ \text{dB} \quad (16)$$

and a further correction with respect to the number of axles (#axles) is given by:

$$\Delta L_{WR,axles} = \begin{cases} 6.8 \times log_{10}\left(\frac{\#axles}{4}\right) & \text{for single tyres} \\ 9.1 \times log_{10}\left(\frac{\#axles}{4}\right) & \text{for double mounted tyres} \end{cases} \quad (17)$$

2.5 Aggregation to traffic flow

To calculate the noise exposure from traffic on a given road, the single vehicle sound power levels need to be translated to an equivalent sound pressure level at a receiver position, averaged over a certain time period. For a steady flow of vehicles *Q* with an average speed *v* an equivalent line source strength (average sound power per unit length) $L_{W,\ line,\ eq}$ is given by:

$$L_{W,line.eq} = L_{W,0} + 10log_{10}\left(\frac{Q}{v}\right) \quad (18)$$

where $L_{W,0}$ is the instantaneous sound power level of the rolling or propulsion noise of a single vehicle. $L_{W,\ line,\ eq}$ is expressed in dB per m, *Q* in vehicles per second and *v* in m/s. The rolling and propulsion noise contributions are calculated separately resulting in two equivalent line sources for the entire vehicle stream, divided over two different source heights. The line sources are located in the vertical plane of the nearest wheel and therefore are offset different dependent upon the receiver location.

The sound emission of the vehicles on the road is represented by a series of evenly distributed, incoherent point sources with a total sound power of:

$$L_{W,line.eq} + 10log_{10}l \quad (19)$$

where *l* is the length of the section represented by the point source in metres. The equivalent sound power levels for different groups of vehicles (e.g. by vehicle class or speed) or different lanes can be summed as follows:

$$L_{W,eq,total} = 10log_{10}\left[\sum_{i=1}^{N} 10^{L_{W,eq,i}/10}\right] \quad (20)$$

where $L_{W,eq,i}$ are the N separate equivalent line sound power levels to be added.

3. Bibliography

REF 1. Department of Transport and the Welsh Office (1988) The Calculation of Road Traffic Noise

REF 2. Shilton S (2020) Proposed standard for the calculation of sound levels outdoors v5.1 (unpublished)

REF 3. Shilton S (2020) BS CSLO Scoping Panel Discussion Document v5.1 (unpublished)

REF 4. EU Commission (2015) Directive 2015/996 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council

REF 5. EU Commission (2020) Delegated Directive 2021/1226 amending, for the purposes of adapting to scientific and technical progress, Annex II to Directive 2002/49/EC of the European Parliament and of the Council as regards common noise assessment methods

REF 6. Peeters B (2006) Assessment Programme for Parameters of the "general" European vehicle fleet, IMA52TR-060111-MP10

REF 7. Salomons E, van Maercke D, Defrance J and de Roo F (2011) The Harmonoise Sound Propagation Model, Acta Acustica Vol.97 pp.62-74.

REF 8. EU Commission (2002) Directive 2002/49/EC of the European Parliament and of the Council relating to the assessment and management of environmental noise

REF 9. Peeters B and van Blokland G (2007) The Noise Emission Model for European Road Traffic, IMA52TR-060821-MP10

REF 10. Muirhead M, Morris L and Stait RE (2010) The performance of quieter surfaces over time. Published Project report 485. Crowthorne, UK: Transport Research Laboratory

REF 11. British Board of Agrement (2008) Guidelines document for the assessment and certification of thin surfaces for highways (SG 308256). Garston, UK: British Board of Agrement

REF 12. ISO (2001) BS EN ISO 11819-1:2001, Acoustics – Measurement of the influence of road surfaces on traffic noise – Part 1: Statistical Pass-By method. Geneva, Switzerland: International Organisation for Standardisation

REF 13. Peeters B (2004) Review of data needs for road noise source modelling, IMA02TR-040603-MP01

REF 14. TML, TNO, University of Ghent, University of Leeds (2005), Review of the suitability of traffic models for noise modelling, IMA02TR-050112-TML10

REF 15. Trow J, Shilton S (2005), Uncertainty Analysis of the Harmonoise Road Source Emission Levels, Forum Acusticum 2005

REF 16. M+P (2020) Road Traffic Noise Modelling: Development of a Methodology to Define Category 5 Vehicles, NO0255

Appendix A Coefficient tables

A.1 Core coefficients

The values of the coefficients in equations (**1**), (**2**), (**6**), (**7**) and (**8**), for the vehicle categories presented in Table 2, are given in Table 3 to Table 9.

Table 3: Category 1C

Coefficient	Value																										
	25 Hz	31 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
A_R	83.0	87.0	90.0	91.0	91.0	89.0	86.0	84.0	84.0	85.0	84.0	84.0	86.0	91.0	94.0	97.0	100	99.0	96.0	92.0	88.0	81.8	78.7	74.9	71.8	69.1	65.6
B_R	25.0	27.0	33.4	36.7	37.0	37.5	37.5	41.2	42.3	41.8	38.6	35.5	32.9	30.0	30.0	30.0	31.0	32.0	32.0	30.0	34.0	38.6	39.6	40.0	39.9	40.2	40.3
A_P	81	80	81	85	87	87	86	87	87	87	89	88	87	86	85	82	83	86	87	86	84	82	80	77	75	73	70
B_P	8	8	8	8	8	8	8	6	6	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
C_P	4	4	4	4	4	4	4	7	7	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Table 4: Category 1V

Coefficient	Value																										
	25 Hz	31 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
A_R	83.0	87.0	90.0	91.0	91.0	89.0	86.0	84.0	84.0	85.0	84.0	84.0	86.0	91.0	94.0	97.0	100	99.0	96.0	92.0	88.0	81.8	78.7	74.9	71.8	69.1	65.6
B_R	25.0	27.0	33.4	36.7	37.0	37.5	37.5	41.2	42.3	41.8	38.6	35.5	32.9	30.0	30.0	30.0	31.0	32.0	32.0	30.0	34.0	38.6	39.6	40.0	39.9	40.2	40.3
A_P	81	80	81	85	87	87	86	87	88	88	90	89	88	87	85	82	83	86	87	86	84	82	80	77	75	73	70
B_P	8	8	8	8	8	8	8	6	6	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
C_P	4	4	4	4	4	4	4	7	7	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Table 5: Category 1CE

Coefficient	Value																										
	25 Hz	31 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
A_R	83.0	87.0	90.0	91.0	91.0	89.0	86.0	84.0	84.0	85.0	84.0	84.0	86.0	91.0	94.0	97.0	100	99.0	96.0	92.0	88.0	81.8	78.7	74.9	71.8	69.1	65.6
B_R	25.0	27.0	33.4	36.7	37.0	37.5	37.5	41.2	42.3	41.8	38.6	35.5	32.9	30.0	30.0	30.0	31.0	32.0	32.0	30.0	34.0	38.6	39.6	40.0	39.9	40.2	40.3
A_P	75	73	73	76	77	79	79	81	79	78	80	75	70	66	65	63	63	66	67	68	67	66	65	62	59	57	54
B_P	8	8	8	8	8	8	8	6	6	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
C_P	4	4	4	4	4	4	4	7	7	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Table 6: Category 2

Coefficient	Value																										
	25 Hz	31 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
A_R	95.0	96.0	95.0	92.0	91.0	90.0	90.0	92.0	92.0	92.0	94.0	96.0	99.0	101	102	103	102	98.0	95.0	91.0	87.0	84.0	81.0	79.0	78.0	77.0	75.0
B_R	23.8	28.4	31.1	35.4	35.9	36.7	36.3	35.9	38.1	36.5	33.5	30.6	27.7	21.9	23.8	28.4	31.1	35.4	35.0	35.0	35.0	35.0	36.0	36.0	36.0	36.0	36.0
A_P	92.1	92.5	94.1	94.5	92.4	92	91.0	91.9	91	93.4	94.4	94.2	93.0	90.8	92.1	92.5	94.1	94.5	92.4	90.1	87.6	85.8	83.8	81.4	80	77.2	75.4
B_P	6.5	6.5	6.5	6.5	6.5	6.5	6.5	5	5.5	6	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
C_P	5	5	5	5	5	5	5	9	9	9	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Table 7: Category 3

Coefficient	Value																										
	25 Hz	31 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
A_R	97.3	98	95.6	93.2	91.9	90.0	91.0	91.0	92.0	93.0	94.0	97.0	101	104	105	104	102	97.5	93.0	89.0	85.5	84.1	82.2	79.8	78.6	77.5	76.8
B_R	25.9	30.4	32.3	36.5	36.8	38.0	36.8	32.8	36.0	34.6	32.7	29.3	26.4	26.0	28.0	30.4	32.3	36.5	36.8	38.0	36.8	38.5	38.9	38.5	40.2	40.8	41.0
A_P	96.8	95.1	95.8	95	92.7	91.2	90.0	93.0	95.0	95.0	97.0	97.2	95.8	95.9	96.8	95.1	95.8	95	92.7	91.2	88.7	87.6	87.2	84.2	82.7	79.7	77.6
B_P	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C_P	5	5	5	5	5	5	5	9	9	9	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Table 8: Category 4a

Coefficient	Value																										
	25 Hz	31 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
A_R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B_R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A_P	89.9	91.8	91.2	92.4	95	94.1	92.9	85.6	81.6	81.4	85.5	86.3	87.9	88.7	89.9	91.8	91.2	92.4	95	94.1	92.9	90.4	89.1	87.4	84.9	84.4	82.2
B_P	12.3	13.9	16.6	17.2	17.9	19.3	20.6	17.3	14.5	5	14.6	9.9	9.7	12.7	12.3	13.9	16.6	17.2	17.9	19.3	20.6	19.9	20.8	20.5	21	21	19.3
C_P	4	4	4	4	4	4	4	7	7	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Table 9: Category 4b

Coefficient	Value																										
	25 Hz	31 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
A_R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B_R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A_P	89.4	89.9	90.1	89.7	89.8	88.2	86.5	93.2	90	88.4	87.6	87.7	87	87.4	89.4	89.9	90.1	89.7	89.8	88.2	86.5	85.8	85.1	85.1	82.7	81.7	80.4
B_P	10.8	11.4	11.4	11.7	13.4	11.6	12.2	4.8	7.3	11.3	10.6	13.9	13.5	11	10.8	11.4	11.4	11.7	13.4	11.6	12.2	10.9	10.5	12	12	12	12
C_P	4	4	4	4	4	4	4	7	7	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

A.2 Road surface corrections

The coefficients for the road surface corrections, given by equations (**3**) and (**4**), are provided in Table 10 for category 1 vehicles and Table 11 for category 2 and 3 vehicles. Corrections are only applied in the 1/3rd octave bands between 250 Hz and 4 kHz. Corrections in other 1/3rd octave bands are set to zero.

Table 10: Category 1

Road Surface	α													β
	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25kHz	1.6 kHz	2 kHz	2.5 kHz	3.15kHz	4 kHz	
HRA 20mm	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	0
TSCS 6mm	-1	-1	-1	-2	-3	-3	-6	-6.5	-6.5	-6.5	-5	-4	-3	-6
TSCS 10mm	-1	-1	-1	-2	-3	-3	-6	-6.5	-6.5	-6.5	-5	-4	-3	-6
TSCS 14mm	0	0	0	0	-1	-2	-4	-4.5	-4.5	-4.5	-3	-2	-1	-6
Surface Dressing	0.5	0.5	0.5	-1	-2	-3	-2	1	2	2	1	0.5	0.5	0
Brushed Concrete	0	1	2	1	0	0	0	0	1	2	2	2	2	0
LDG Concrete	-4	-3	-2	-3	-4	-4	-4	-4	-3	-2	-2	-2	-2	0

Table 11: Category 2 and 3

Road Surface	α													β
	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25kHz	1.6 kHz	2 kHz	2.5 kHz	3.15kHz	4 kHz	
HRA 20mm	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	0
TSCS 6mm	-1	-1	-1	-2	-3	-4	-6	-6.5	-6.5	-6.5	-5	-4	-3	-4
TSCS 10mm	-1	-1	-1	-2	-3	-4	-6	-6.5	-6.5	-6.5	-5	-4	-3	-4
TSCS 14mm	0	0	-2	-3	-4	-3	-3	-4	-4.5	-4.5	-3	-2	-1	-4
Surface Dressing	0.5	0.5	0.5	-1	0	1	2	3	4	4	3	2	1	0
Brushed Concrete	0	1	2	1	0	1	1	1	2	3	3	3	3	0
LDG Concrete	-4	-3	-2	-3	-4	-3	-3	-3	-2	-1	-1	-1	-1	0

A.3 Temperature corrections

Coefficients for adjusting the rolling noise to account for the local air temperature, the value *K* in equation (**5**), are given in Table 12. The values in the table are applicable to vehicles in category 1. For vehicles in categories 2 and 3, *K* should be set to half the value. No correction is applied to vehicles in category 4.

Table 12: Coefficients for the temperature correction for category 1 vehicles

	Porosity		
Mean Profile Depth	**<5%**	**5-15%**	**>15%**
<0.5 mm	0.04	0.06	0.08
0.5-1.5 mm	0.08	0.07	0.06
>1.5 mm	0.12	0.08	0.03

aecom.com