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The performance of quieter surfaces over time

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Transport Research Laboratory

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The performance of quieter surfaces over time

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Executive summary

The Highways Agency implements the Government's noise policy of mitigating the effects of noise, where practicable, arising from traffic on the Strategic Road Network (SRN). This includes the provision of noise mitigation, both on new and existing roads, to provide long term noise benefits to residents affected by road traffic noise arising from their use. Quieter surfaces, first introduced in 1999, have been one of the key measures used by the Agency in order to manage and reduce noise impacts where possible. However, very little is known about the long term acoustic performance of these surfaces, which is essential when considering the sustainability of this type of mitigation. This work focuses on this need through the collection and analysis of appropriate long term data.

As well as providing information on which to form appropriate long term surfacing corrections to be used in noise assessments, the data are designed to assist the Agency's response to the Environmental Noise Directive. In addition the feasibility and practicality of using the principles of the acoustic classification system, defined as part of the European SILVIA programme, on the SRN have been investigated.

The acoustic performance of low noise surfaces (together with a Hot Rolled Asphalt (HRA) and an Exposed Aggregate Concrete (EAC) surface) have been assessed over a three year measurement programme through the collection of data from Statistical Pass-By (SPB), Close Proximity (CPX) and traffic noise surveys.

The results of these surveys, together with an examination of historical data, show that:

- On average, the acoustic performance of low noise surfaces deteriorates at a rate of 4.5 dB(A) over 10 years compared to a deterioration of 2 dB(A) over 10 years for HRA and EAC
- On average, low noise surfaces outperform the reference HRA surface by between 4 and 6 dB(A) when new and outperform HRA by between 1 and 3 dB(A) after 10 years
- New low noise surfaces can provide acoustic benefits of between 3 and 8 dB(A) over a new HRA surface.

There was found to be no correlation between the acoustic performance of the surface and the amount of traffic on the road. Some correlation with texture depth was noted but the variations in texture depth, lack of information on negative/positive texture and limited number of suitably old (>10 years) surfaces means that these data should be treated with some caution.

From the results of this work it is recommended that Annex 4 of HA 213/08 be amended to state that for an existing HRA surface a correction of +1 dB(A) is applied in place of 0 dB(A). This approach is likely to be cautionary but more realistic than the current approach, given the age of HRA surfaces on the SRN.

There is scope to consider a reduction in the correction specified for new low noise surfaces, since the average Road Surface Index (RSI) for new low noise surfaces at the sites examined in this study is approximately -5 dB(A). There is however a large spread in these data and if most low noise surfaces on the SRN were to be constructed using a 14 mm aggregate size for example a correction of -3.5 dB(A) may be considered an appropriate, albeit conservative, estimate.

The average acoustic performance of a generic low noise surface in the first 10 years of its life may be estimated by:

$$\text{Surface Correction} = \text{RSI} + 0.45 \times (\text{Age of Surface})\ \text{dB(A)}$$

where the age of the surface is interpreted as the time since the RSI was measured in years. If the RSI from the Highway Authority Product Approval Scheme (HAPAS) certification for the surface is not known it may be replaced by -5.5 in the equation; in

this instance the age of the surface would then equate to the time elapsed since the surface was laid.

It is recommended that the noise level to be reached for a HAPAS certificate to be awarded is reduced. It is recommended that a cautionary approach be taken and the current level of -2.5 dB(A) be reduced to -3.5 dB(A). This would also align better with the corrections used in HA213/08 for new low noise surfaces and although this level is currently met by almost all new surfaces, it will act to ensure that acoustic performance remains a consideration in designing surfaces.

In addition to the continued assessment of low noise surfaces using a 6 mm aggregate size to gain a larger data set, it is also recommended that a series of SPB measurements be undertaken on several HRA surfaces to confirm the relationship found in this study and better inform a more appropriate surface correction for an old HRA surface. Although no longer laid there is still a significant amount of HRA on the SRN and an understanding of its acoustic behaviour will better define the benefit received from introducing low noise surfaces.

The trialling of the acoustic classification defined in the SILVIA programme has proven relatively successful but only covers short test sections where low noise surfaces have been laid for only a few hundred metres. It would therefore be constructive to conduct an in-depth trial of the method over longer test sections in order to fully assess the methodology and assess the implications of using such a classification system for conformity of production.

Another issue to resolve prior to the introduction of the Conformity of Production assessment methodology concerns the approach taken if section(s) of the low noise surface fail to meet the defined tolerance since this was considered outside the scope of the work conducted as part of the SILVIA programme.

1 Introduction

1.1 Background

The Highways Agency implements the Government's noise policy of mitigating the effects of noise, where practicable, arising from traffic on the Strategic Road Network (SRN). This includes the provision of noise mitigation, both on new and existing roads, to provide long term noise benefits to residents affected by road traffic noise arising from their use. Quieter surfaces, first introduced in 1999, have been one of the key measures used by the Agency in order to manage and reduce noise impacts where possible. However, very little is known about the long term acoustic performance of these surfaces, which is essential when considering the sustainability of this type of mitigation. This work focuses on this need through the collection and analysis of appropriate long term data.

Since the implementation of the Environmental Noise Directive (END) (EC, 2002) into UK legislation through the Environmental Noise (England) Regulations 2006 (as amended 2009), there has been a renewed emphasis on long term noise management from major sources within EU member states, such as that from road traffic using the SRN. Therefore, as well as providing information on which to form appropriate long term surfacing corrections to be used in noise assessments, the data from this project are designed to assist the Agency's response to the END. Through understanding the longer term acoustic performance of surfaces, this information can be used in future END noise mapping and action plan rounds to inform accurate and effective noise mitigation strategies for the management of noise across the SRN.

Additionally, the SILVIA project, *"Sustainable Road Surfaces for Traffic Noise Control"* (Morgan, 2006), was initiated with the aim of making it possible to derive the full noise control benefits from quieter road surfaces (hereafter referred to as low noise surfaces). One of the outputs from the project, which was part funded by the European Union (EU) under the European Commission (EC) 5th Framework Programme, was the development of an acoustic classification system which addresses acoustic labelling, Conformity of Production (CoP) assessment and routine monitoring over the lifetime of the surface (Padmos *et. al.*, 2005). At present, the acoustic classification of low noise surfaces in the UK is restricted to Statistical Pass-By (SPB) measurements, expressed in terms of the Road Surface Influence (RSI)[1], for labelling and procurement purposes within the Highway Authority Product Approval Scheme (HAPAS). This provides no indication of the long term acoustic performance of the surface and indeed whether the surfacing is providing a consistent noise reduction along its length. The SILVIA acoustic classification system provides a means of addressing such shortcomings and the output from this work is used to test the feasibility and practicality of using the principles of the SILVIA system on the SRN.

1.2 Approach

The purpose of this project is to collate and gather data on the acoustic performance of low noise surfaces over time in order to fulfil the following objectives:

- Evaluate the acoustic performance over time of different aggregate size low noise surfaces
- Examine whether the results can be used to inform what surface corrections are used when undertaking noise predictions using the methodology in the Calculation of Road Traffic Noise (CRTN) (DoT and the Welsh Office, 1988)
- Examine the relationship between any changes in noise level with changes in texture and traffic conditions

[1] The RSI provides an acoustic comparison relative to a UK reference surface, see Section 2.1.

- Evaluate the feasibility and practical implications of using the principles of the SILVIA acoustic classification systems.

Data were collected over a three year programme in which SPB, traffic noise and Close Proximity (CPX) noise measurements were carried out at a number of locations across the SRN where low noise surfaces have been laid. Suitable locations were identified in 2007 and surveys were carried out in 2007, 2008 and 2009. At some of the locations historic data were available to allow an evaluation of performance over a period longer than three years.

A brief explanation of the survey procedures and the SILVIA acoustic classification system is given in Chapter 2. A comprehensive explanation of the SILVIA procedures can be found in (Padmos *et. al.*, 2005). A summary of the measurement locations to be included within the project and details of the measurements programme are presented in Chapter 3. The results from the measurement surveys of 2007, 2008 and 2009 are presented in Chapter 4. Chapter 5 provides a comprehensive analysis of the collected data including:

- An examination of the measured data together with historical data in order to derive the trend in performance of low noise surfaces over their lifetime
- An assessment of available traffic and surface texture data in order to attempt to explain the influence of these parameters on the acoustic performance of the surfaces
- Advice on updating the noise modelling section of Department for Transport's Design Manual for Roads and Bridges (DMRB), hereafter referred to as HA213/08 (Department of Transport, 2008), to reflect surface age and condition
- A review of the methodology for calculating RSI in HAPAS, taking into account the average structural life of a surface
- A review of the feasibility and practicality of using the principles of the SILVIA acoustic classification system on the SRN.

2 Measurement and classification methods

This chapter describes the method of measurements carried out at selected sites for assessing the acoustic performance of road surfaces.

2.1 Statistical pass-by (SPB)

The SPB measurement is probably the most frequently used procedure for assessing the influence of road surfaces on vehicle noise emissions. It is a relatively simple procedure, and the results produced can be directly applied to the surfacing correction used during traffic noise predictions.

It is also the method used by the Highways Agency for noise classification within their product approval scheme (HAPAS). The methodology followed as part of this work is largely described in ISO 11819-1 (ISO, 1997), however the reference speeds and RSI values discussed below are those defined in Appendix 8 of the HAPAS guidelines document for the assessment and certification of thin surfaces for highways (British Board of Agrément, 2008).

During an SPB measurement, the maximum pass-by noise levels and speeds of individual vehicles selected from the traffic stream at a reference distance of 7.5 m from the centre of the vehicle lane are measured. The traffic population is classified as follows:

- L - light vehicles including passenger cars and car derived vans, excluding vehicles towing trailers or caravans
- H_1 - commercial trucks with 2 axles and greater than 3.5 tonnes unladen weight
- H_2 - commercial trucks with more than 2 axles and greater than 3.5 tonnes unladen weight.

To provide statistically robust results a sample size of at least 100 L vehicles and at least 80 trucks with a minimum of 30 H_1 and 30 H_2 vehicles are required. For each vehicle category, a linear regression equation is derived between the maximum pass-by noise level, L_{Amax} and the logarithm of the vehicle speed (km/h). For each vehicle category, the estimated noise level, $L_{Amax,v}$ for a given reference speed, v km/h, is derived from the regression equation. The values of $L_{Amax,v}$ for each vehicle category are used as input to the following equations to provide an estimate of the RSI:

For medium speed roads[2]:

$$RSI_M = 10\log_{10}\left(11.8\times10^{\frac{L_{veh,L}}{10}} + 0.629\times10^{\frac{L_{veh,H1}}{10}} + 0.157\times10^{\frac{L_{veh,H2}}{10}}\right) - 92.3 \quad (2.1)$$

where $L_{veh,L}$, $L_{veh,H1}$ and $L_{veh,H2}$ are the respective values of $L_{Amax,v}$ for vehicle categories L H_1 and H_2 at speed v = 80, 70 and 70 km/h, respectively.

For high speed roads[3]:

$$RSI_H = 10\log_{10}\left(7.8\times10^{\frac{L_{veh,L}}{10}} + 0.578\times10^{\frac{L_{veh,H1}}{10}} + 10^{\frac{L_{veh,H2}}{10}}\right) - 95.9 \quad (2.2)$$

where $L_{veh,L}$, $L_{veh,H1}$ and $L_{veh,H2}$ are the respective values of $L_{Amax,v}$ for vehicle categories L H_1 and H_2 at speed v = 110, 90 and 90 km/h, respectively.

For a road speed category, the RSI value provides an estimate of the difference in traffic noise levels for typical traffic conditions on a test surface with that from similar traffic on a reference surface. A reference surface is one for which no surface correction is required in CRTN; for high speed roads this corresponds to a bituminous surface with a

[2] Defined in ISO 11819-1 as roads for which traffic normally operates at an average speed of 65 km/h to 99 km/h.

[3] Defined in ISO 11819-1 as roads for which cars normally operate at an average speed of 100 km/h or more.

texture depth of 2 mm and in practice is generally considered as having the same acoustic performance as a 20 mm Hot Rolled Asphalt (HRA) surface.

With this in mind it is worth clarifying the terminology used in this report when comparing different RSI values. An RSI of -5 dB(A) will be referred to as being 'lower than' an RSI of -2 dB(A) since it directly reflects a lower traffic noise at the reference speed even though the surface itself may be thought of as having a 'higher' noise performance.

For light vehicles, noise levels are influenced by variations in temperature. To reduce this variability, noise levels for light vehicles are normalised according to the following equation:

$$CorrectedL_{veh,L} = Measured\ L_{veh,L} + 0.03 \times \left[(0.7 \times T_{surface} + T_{air})/2 - 20 \right] \quad (2.3)$$

where $T_{surface}$ is the temperature of the road surface and T_{air} is the air temperature, both in ˚C.

2.2 Traffic noise

Traffic noise surveys are often used to assist in environmental noise assessments where noise from road traffic and the potential entitlement of affected households to noise insulation under the Noise Insulation Regulations (NIR) are issues. These noise surveys are often used to assist in the validation of noise maps produced using CRTN. Therefore, in order to help examine the accuracy of applying the measured RSI values to the CRTN methodology, some traffic noise surveys were carried out.

These surveys were conducted at a selection of sites where SPB measurements had been carried out and where the road surface of each lane across both carriageways was of the same type and age. This was a necessary restriction since the addition of RSI values to the CRTN calculation is applicable for the entire road width.

2.3 Close proximity (CPX)

The CPX method described in ISO 11819-2 (ISO, 2000) is designed to assess the acoustic properties of road surfaces by measuring the rolling noise of a set of standard reference tyres at two microphone positions located close to the tyre/road contact patch. These reference tyres and microphones are surrounded by a soundproof enclosure to minimise the effects of noise from other sources.

Noise measurements are taken at two microphones mounted at 20 cm from the tyre side wall, 20 cm in front and behind the centre of the contact patch and 10 cm above the road surface. During the measurements the tyre is allowed to roll freely at a constant speed over the road surface and the noise level at the microphones positions are sampled using suitable instrumentation. The recorded noise levels are averaged over 20 m sections and over the two microphones.

Since the standard was first published, the set of reference tyres has been replaced. The measurements carried out in the 2008 and 2009 surveys used the ASTM standard reference test tyre (a Uniroyal Tigerpaw 225/60/R16, specified in ASTM F2493-06 (ASTM, 2006)). This tyre has been selected as a reference tyre for CPX measurements and shown to produce noise levels typical of car tyres on a range of different surfaces (Schwanen *et al.*, 2007, Schwanen *et al.*, 2008).

TRITON is TRL's purpose built CPX tyre/road noise investigation vehicle (Figure 2.1). It is currently the only CPX system operating in the UK. The vehicle is based around a truck chassis and has a specially designed semi-anechoic and soundproof chamber which encloses a dedicated test wheel and an array of microphones.

The test wheel runs in the nearside wheel track, unlike some current CPX trailers in use in Europe where the test wheel runs in the middle of the lane. A wide range of passenger car and light van tyres can be fitted to the test wheel which may be subjected to a range of loading conditions.

The vehicle is designed to travel at the maximum speeds permitted on public roads.

Figure 2.1: TRITON when collecting data

2.4 SILVIA classification procedure

The noise classification system developed within the SILVIA project is split into two parts, namely labelling procedures and Conformity of Production (CoP) (Padmos et. al., 2005), which are discussed separately in sections 2.4.1 and 2.4.2 respectively.

Additionally the procedures outlined as part of the SILVIA project cover two labelling procedures, one involving both SPB and CPX measurements and the other involving SPB measurements together with measurements of intrinsic properties of the road surface such as texture and sound absorption. The first method is preferred and is the method that is discussed below and assessed in Chapter 5.

2.4.1 Labelling procedure

The acoustic labelling procedure is based around the assessment of trial sections of the road surface which are intended to provide reference noise levels, relative to which the CoP methodology can be applied on equivalent surfaces at other locations.

A trial length is defined as part of the road surface between 100 and 1000 m from which the trial section of 100 m will be selected. In order to define the trial section CPX measurements are taken every 20 m over the trial length and the trial section can then be any 100 m section of the trial length for which all CPX measurements lie within 0.5 dB(A) peak-to-peak[4] of the average CPX index for the trial length.

A SPB measurement for each vehicle category is then taken midway along the selected 100 m trial section and two labels for the trial section are defined as follows:

- $LABEL1_{SPB}$ — The average $L_{Amax,m,vref}$ value for each vehicle category m at a selected reference speed v_{ref} km/h
- $LABEL1_{CPX}$ — The average CPX index value for the trial section.

[4] This requires that the maximum level measured over the 100 m is within 0.5 dB(A) of the minimum level measured.

2.4.2 Conformity of Production (CoP)

Conformity of Production is the method by which the acoustic performance of a surface, that has been open to traffic for at least two months, is assessed. The quality and uniformity of the road surface with respect to noise is determined through CPX measurements conducted along the whole length of road. The road is then divided into 100 m sections and the CPX index for each section determined as the average of the CPX values for the five 20 m segments within the 100 m section. Each section is then assessed in turn against the following criteria:

$$CPXI \leq LABEL1_{CPX} + 1.5\ dB(A) \qquad (2.4)$$

It is also indicated that supplementary checks may be made using the SPB method with the condition that:

$$L_{Amax,m,vref} \leq LABEL1_{SPB} + 1.5\ dB(A) \qquad (2.5)$$

The primary quality control method for the surface is the CPX method since the SPB method only addresses a very localised section of the surface.

The feasibility and practicality of using these assessment procedures on the SRN is discussed in 5.4.2.

3 Site selection

This chapter describes the method and the criteria that were applied to the selection of the measurement locations and testing sites at which the measurement surveys were carried out. Section 3.1 outlines the requirements and properties of the survey sites, Section 3.2 discusses practical considerations made in choosing the sites and Section 3.3 presents the location, surface type and age of each site at which SPB measurements were carried out. Note that while SPB measurements were carried out at all identified sites, traffic noise surveys and CPX measurements were only carried out at some of the selected locations. These locations, a subset of the sites presented in Section 3.3, are described in Sections 3.4 and 3.5 respectively.

3.1 Site requirements

The measurement sites were selected in order to capture low noise surfaces on the SRN with a variety of aggregate sizes and ages. It was also important to balance this requirement with the need to conduct several SPB measurements on each type of surface in order to provide a more robust set of results. A total of 26 sites with low noise surfaces were identified and these are presented in Section 3.3.

Two additional SPB sites were selected, to be undertaken on a Hot Rolled Asphalt (HRA) surface and an Exposed Aggregate Concrete (EAC) surface. The reason for each of these surfaces being included is given below:

- *Hot Rolled Asphalt (HRA):* Although this surface is no longer laid on the SRN, there is still much HRA material on the network (72% in 2001; McRobbie *et. al.,* 2004). HRA has similar acoustic properties to the reference surface used for evaluating the acoustic performance of low noise surfaces in the UK. A measurement on such a surface would provide very useful information about the performance of this reference surface over time.
- *Exposed Aggregate Concrete (EAC):* While classified as a 'concrete surface' despite its random texture, EAC is no longer laid on the SRN. Although an initial assessment of the acoustic performance of EAC compared with HRA found similarities between the surfaces when new (Hewitt *et al*, 1997), later comparisons of their performance over time have shown some acoustic benefits compared with HRA (Chandler *et al*, 2003). With the structural lifetime of EAC likely to be much longer than that of a low noise surface (Morgan, 2006), it is possible that after, for example 15 years, an EAC surface may have a lower noise level than a thin surface.

3.2 Site selection method

In order to fulfil the objectives of the project it was necessary to select measurement locations with sites where the surface is greater than five years old and previous data are available, and also sites where the surface was new (<2 years old).

3.2.1 Sites with previous data

For sites where previous data were available, the sites were selected from three sources. These were where measurements have been undertaken by TRL on previous Highways Agency projects, on projects for the EC (e.g. Imagine and SILVIA) and locations where measurements have been undertaken for surfacing contractors.

3.2.2 New measurement sites

In selecting measurement sites where the surface was new (i.e. <2 years old), contacts with surfacing contractors and an ongoing project with the Highways Agency[5] were utilised.

3.2.3 Site selection considerations

In choosing suitable sites for SPB measurements, consideration was given to the practical aspects of undertaking the noise measurements. These were the requirements for traffic management, safety of the workforce, the traffic conditions on the road and any planned or perceived re-surfacing work. In addition any restrictions, such as no hard shoulder closures being permitted, were also considered.

For the selection of sites to trial the SILVIA methodology, consideration was also given to the possibility of collecting as much data from one location as possible (i.e. the test surfaces being on one continuous section of road).

3.3 SPB sites

The following section gives details of the all the measurement sites. A total of 28 sites were selected and SPB measurements were carried out at all of these. Low noise surfaces were laid at 26 sites: 5 sites with 6 mm maximum stone size aggregate, 10 sites with 10 mm maximum stone size aggregate and 11 sites with 14 mm maximum stone size aggregate. In addition a 20 mm HRA and an exposed aggregate surface (EAC) were selected for comparison purposes.

The location of these measurement sites is shown in Figure 3.1. Section 3.3.1 sorts these locations by aggregate size and summarises the location and age of the surface. Photographs of each of the site locations can be found in Appendix A and further sites details such as GPS co-ordinates and marker post references for each of the sites can be found in Appendix B.

Section 3.3.2 provides a summary of the types and ages of the selected surfaces.

[5] The HA/QPA/RBA Collaborative Research Programme.

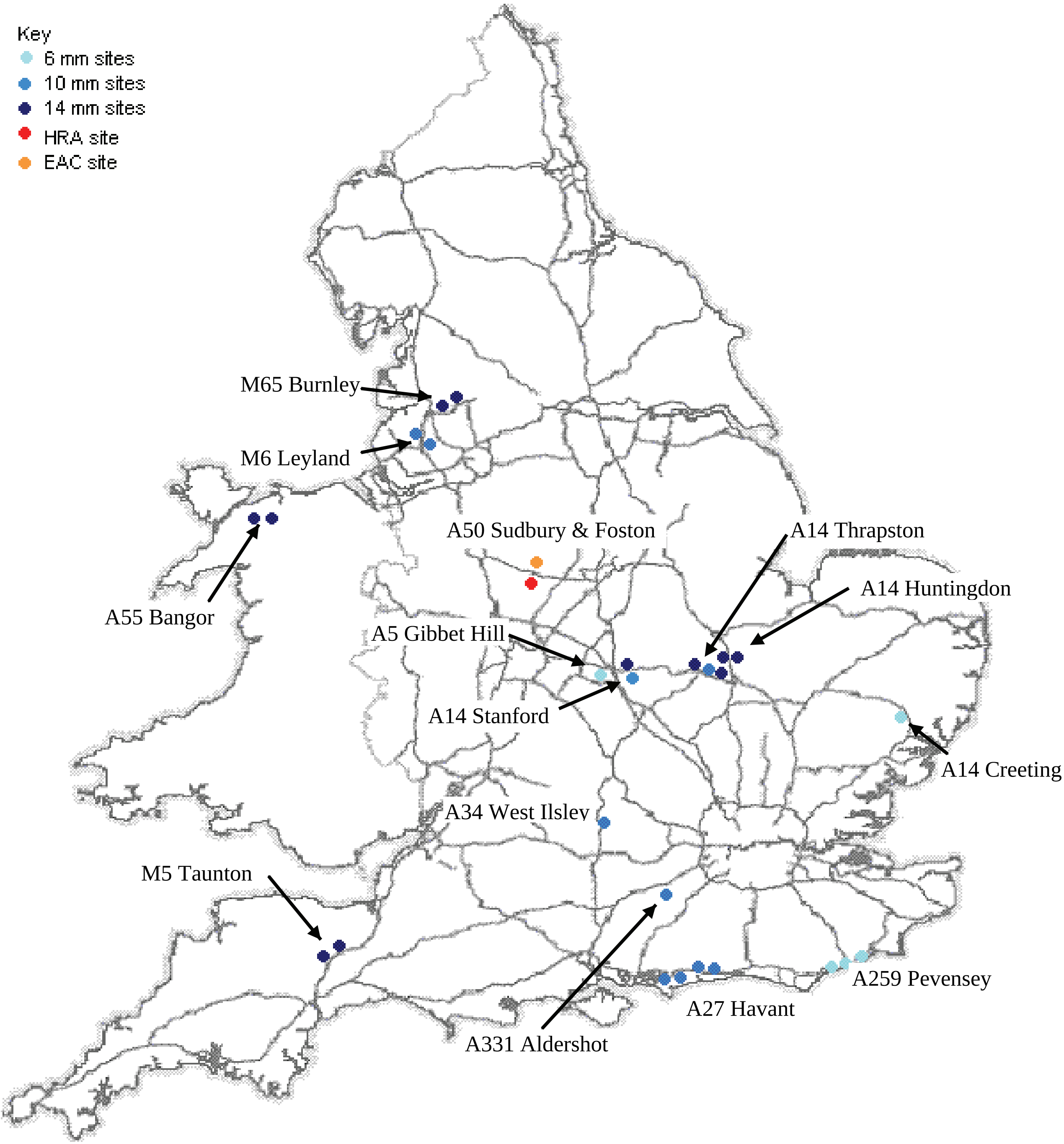


Figure 3.1: Location of measurement sites

3.3.1 *Site locations*

The tables below shows the sites selected for this study, grouped by stone size or surface type. For the exact locations of the numbered sites see Appendix B.

Table 3.1: 6mm measurement sites

Road	Description of location / site	Date laid
A259	Pevensey - Site 1 W/B	Nov-03
A259	Pevensey - Site 2 W/B	Oct-04
A259	Pevensey - Site 3 W/B	Nov-03
A5	Gibbet Hill - Site 1 N/B	Dec-05
A14	Creeting St Mary- Site 1 N/B	Jun-06

Table 3.2: 10mm measurement sites

Road	Description of location / site	Date laid
M6	Leyland - Site 1 N/B	Jun-99
M6	Leyland - Site 2 S/B	Jun-99
A331	Aldershot - Site 1 S/B	Mar-00
A34	West Ilsley - Site 1 S/B	Mar-00
A27	Havant - Site 1 W/B	Mar-05
A27	Havant - Site 2 W/B	Mar-05
A27	Havant - Site 3 E/B	Sep-05
A27	Havant - Site 4 W/B	Sep-05
A14	Thrapston - Site 2 E/B	Sep-06
A14	Stanford - Site 1 W/B	Aug-07

Table 3.3: 14mm measurement sites

Road	Description of location/site	Date laid
A14	Huntingdon - Site 1 S/B	Feb-99
A14	Huntingdon - Site 2 N/B	Feb-99
M65	Burnley - Site 1 E/B	Aug-99
M65	Burnley - Site 2 E/B	Aug-99
M5	Taunton - Site 1 N/B	Feb-01
M5	Taunton - Site 2 N/B	Feb-01
A55	Bangor - Site 1 E/B	Feb-05
A55	Bangor - Site 2 E/B	Feb-05
A14	Thrapston - Site 1 E/B	Sep-06
A14	Thrapston - Site 3 E/B	Sep-06
A14	Stanford - Site 2 E/B	Aug-07

Table 3.4: HRA/EAC measurement sites

Road	Description of location/site	Surface type	Date laid
A50	Sudbury - Site 1 W/B	HRA	Aug-95
A50	Foston - Site 1 E/B	EAC	Aug-95

3.3.2 Site summary

A summary of the aggregate size and age of the identified surfaces is given in Table 3.5.

Although the number of sites selected differs slightly from an ideal spread of data, it was considered that this would still allow sufficient data to be collected to achieve the project objectives. It should also be noted that the ages as categorised in Table 3.5 are relative to 2007 when their selection was finalised, so that, for example, some of the 6 mm sites were over 5 years old at the time of the 2009 survey. That fact that the use of the 6 mm aggregate size is still not widespread is also evident from the number of new sites identified where, out of a total of only five locations investigated, only two were found to be suitable for SPB measurements.

Table 3.5: Summary of number of sites selected

Aggregate size	Age[1]	Number of locations	Total number of sites selected
6mm	< 2 years	2	2
6mm	2-5 years	1	3
6mm	> 5 years	0	0
10mm	< 2 years	2	2
10mm	2-5 years	2	4
10mm	> 5 years	3	4
14mm	< 2 years	2	3
14mm	2-5 years	1	2
14mm	> 5 years	3	6
Additional surfaces	> 5 years	2	2[2]
Total		18	28

[1] Relative to 2007.
[2] Both these sites were 12 years old in 2007.

3.4 Traffic noise sites

Table 3.6 shows details of the sites where traffic noise measurements were conducted. These sites were selected where the surface was laid across the entire width of the carriageway.

A total of 30 minutes of traffic noise was recorded at each site. During each recording a traffic count of the total flow was taken with vehicles classified as either 'light' i.e. cars and car-based vans less than 3.5 tonnes or 'heavy' i.e. commercial vehicles exceeding 3.5 tonnes; motorcycles were classified as 'light' vehicles. In some instances a sample of vehicle speeds were also recorded and used to determine average traffic speeds during each measurement period; in other cases the average traffic speed was obtained from the closest Motorway Incident Detection And Signalling (MIDAS) loop.

Measurements were carried out only when the road surface was dry and under light wind conditions i.e. wind speeds less than 5 m/s.

Table 3.6: Details of traffic noise survey sites

Maximum Stone size, (mm)	Road	Description of location / site	Date laid
14mm	A14	Huntingdon Site 1 S/B	Feb-99
14mm	A14	Huntingdon Site 2 N/B	Feb-99
14mm	A14	Stanford Site 2 E/B - MP 4/2	Aug-07
20mm	A50	Sudbury Site 4 W/B - MP 103/3	Aug-95

3.5 CPX sites

It was required that at one site of each of the three main aggregate sizes (6 mm, 10 mm, 14 mm – i.e. a minimum of 3 sites in total), tests in accordance with the general principles of the SILVIA procedures for acoustic labelling, conformity of production and routine monitoring should be undertaken.

CPX measurements were therefore conducted at two suitable locations on the A14 which consisted of a number of test surfaces, four of which corresponded to SPB measurement sites and these sites are shown in Table 3.7. These measurements were made in order to examine the uniformity of the low noise surfaces for each aggregate size and assess their compliance with the tolerances defined in the SILVIA CoP methodology (Padmos et. al., 2005).

Table 3.7: Details of CPX sites

Maximum stone size	Road	Description of location / site	Marker post	Date laid
6 mm	A14	Creeting St Mary Site 1 N/B	17/20	Jun-06
10 mm	A14	Thrapston Site 2 E/B	56/8	Sep-06
14 mm	A14	Thrapston Site 1 E/B	55/6	Sep-06
14 mm	A14	Thrapston Site 3 E/B	56/9	Sep-06

3.5.1 6 mm – Creeting St. Mary

This trial section contained lengths of a 6, 10 and 14 mm surface; however the topography of the site only allowed SPB measurements to be undertaken alongside the 6 mm surface. Therefore this site was used in order to trial the SILVIA CoP methodology for a 6 mm surface.

A graphical representation of the location is given in Figure 3.2 and details of the surfaces are given in Table 3.8. CPX measurements were taken on the 6 mm trial surface in 2008 and on three trial sections in 2009. The results of these surveys are presented in Section 4.3.1 and discussed in relation to the SILVIA CoP in Section 5.4.2.

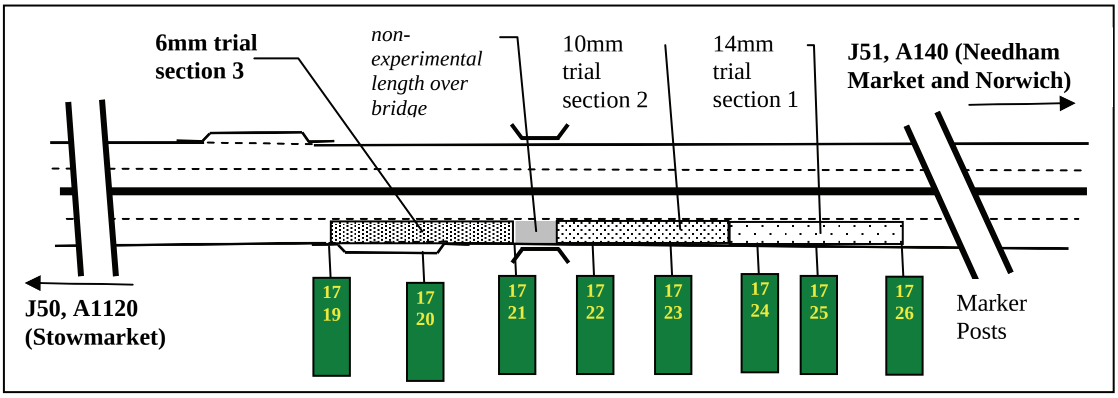


Figure 3.2: 6 mm CPX measurement location - Creeting St. Mary

Table 3.8 Trial sections on A14, Creeting St. Mary

Section	MP position	Stone size	Length
1	17/260 – 17/235	14 mm	~250 m
2	17/235 – 17/215	10 mm	~200 m
-	17/215 – 17/210	infill over bridge	50 m
3	17/210 – 17/190	6 mm	~300 m

3.5.2 10 mm and 14 mm - Thrapston

The six test surfaces at Thrapston are shown in Figure 3.3 and cover a three kilometre trial section consisting of two 6, 10 and 14 mm surfaces. It is only possible to undertake SPB measurements at locations alongside lay-bys; therefore only the 14 mm surfaces and the second 10 mm surface were used to trial the SILVIA CoP methodology.

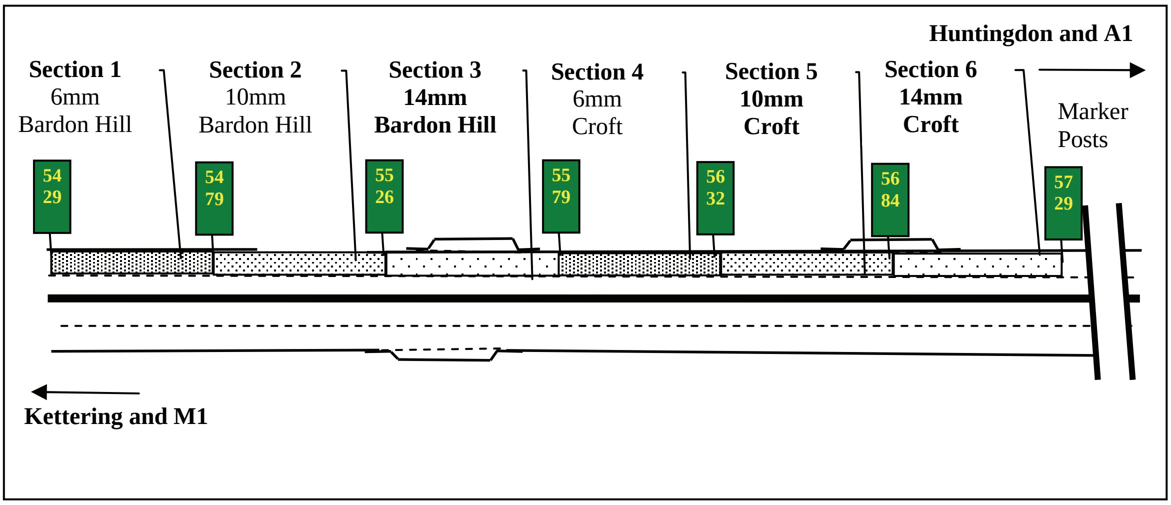


Figure 3.3: 10 mm and 14 mm measurement location - Thrapston

Table 3.9 below provides details of each surface at Thrapston. CPX measurements were taken on trial sections 3-6 in 2008 and on all trial sections in 2009. The results of these measurements are presented in Section 4.3.2 and discussed in relation to the SILVIA CoP in Section 5.4.2.

Table 3.9: Trial section on A14, Thrapston

Section	MP position	Stone size	Length
1	54/290 – 54/789	6 mm	500 m
2	54/789 – 55/264	10 mm	500 m
3	55/264 – 55/788	14 mm	500 m
4	55/788 – 56/326	6 mm	500 m
5	56/326 – 56/836	10 mm	500 m
6	56/836 – 57/290	14 mm	500 m

Although the surfaces at these two locations are older than the age stipulated for labelling purposes in SILVIA (2 months) they do have a number of benefits:

- The surfaces are among those selected for SPB measurements
- These trial sections are included in the HA / QPA / RBA collaborative research programme and so the results of this project could feed into that project if necessary
- The location of the surfaces within the trial sections allow potentially useful information to be measured on the other surfaces within the trial section. For example, there is a 6 mm surface within the trail section at Thrapston
- The aim of this part of the project is to trial the SILVIA methodology, so the age of the surface, although a factor is not that important.

One test tyre was used for the CPX measurements. This was an ASTM tyre that has been recommended for use by Working Group (WG) 33.

4 Measurement survey results

This chapter presents and discusses the results of the 2007, 2008 and 2009 measurement surveys carried out as part of this project. A limited set of SPB measurements were carried out in September and October 2007 and a full set of SPB and traffic noise measurements were carried out from May to June 2008 and from June to September 2009. The CPX measurements were carried out in September 2008 and September 2009.

The analysis of these data, together with historic noise measurements, traffic flow and surface texture is presented in Chapter 5.

4.1 SPB measurements

This section presents the SPB results from the 2007, 2008 and 2009 surveys; for a complete list of all SPB results available for each surface dating back to when they were laid see Appendix C. For each surface in the following sections the RSI for high speed roads, RSI_H, has been calculated from the SPB results according to equation (2.2).

4.1.1 6 mm surfaces

The results of the SPB measurements carried out at each site with a 6 mm low noise surface are shown in Table 4.1.

Table 4.1: Results of SPB measurements at 6 mm sites

Road	Site	Date surface laid	2007 RSI_H dB(A)	2008 RSI_H dB(A)	2009 RSI_H dB(A)
A259	Pevensey - Site 1	Nov-03	--	-3.8	-4.3
A259	Pevensey - Site 2	Oct-04	--	-2.5*	-1.9*
A259	Pevensey - Site 3	Nov-03	--	-5.2	-5.9
A5	Gibbet Island - Site 1	Dec-05	-7.5	-8.7	-7.5
A14	Creeting St Mary- Site 1	Jun-06	-6.5	-5.8	-5.0

*Result not included in analysis

It should be noted that the data collected from all three sites along the A259 do not fall within the HAPAS tolerances for a high speed road category. The reference speeds for high speed roads are encompassed in the data set however so these results are included in the data set examined in Section 5.1.

The second site at Pevensey is not ideally suited to an SPB measurement since there is too much vegetation to allow a microphone to be placed at the standard 7.5 m from the centre of the vehicle lane. As such the 2008 measurements were taken at 5 m and extrapolated out to the standard 7.5 m and the measurements in 2009 were taken at a slightly different position along the surface. Also, perhaps as a result of these issues, the results for this site appear to be considerably higher than those for the other 6 mm surfaces of a similar age and as such they are not included in the analysis of Chapter 5.

A possible explanation for the lower RSI at Site 3 in 2009 is that the traffic cones marking the microphone location were placed closer to the road in 2009 which can lead to traffic pulling closer to the centre of the road and therefore passing by slightly further from the microphone.

4.1.2 10 mm surfaces

The results of the SPB measurements carried out at each site with a 10 mm low noise surface are shown in Table 4.2.

Table 4.2: Results of SPB measurements at 10 mm sites

Road	Site	Date surface laid	2007 RSI_H dB(A)	2008 RSI_H dB(A)	2009 RSI_H dB(A)
M6	Leyland - Site 1	Jun-99	--	-2.5	-1.7
M6	Leyland - Site 2	Jun-99	--	-1.5	-2.1
A331	Aldershot - Site 1	Mar-00	--	-2.2	-1.5
A34	West Ilsley - Site 1	Mar-00	--	-1.6*	-2.3
A27	Havant - Site 1	Mar-05	--	-5.9	-6.2
A27	Havant - Site 2	Sep-05	--	-6.0	-6.1
A27	Havant - Site 3	Mar-05	--	-5.9	-5.2
A27	Havant - Site 4	Sep-05	--	-6.1	-6.9*
A14	Thrapston - Site 2	Sep-06	-4.9	-4.7	-6.6
A14	Stanford - Site 1	Aug-07	-7.2	-7.7	-6.2

*Result not included in analysis

A damp road surface can lead to artificially high RSI values being measured because water retained in the negative texture of the surface reduces its noise reducing properties. The HAPAS guidelines therefore state that measurements should be conducted relative to a dry road surface. The surface at the West Ilsley site in 2008 was however slightly damp and this is likely the cause of the relatively high RSI value recorded. This result is therefore removed from the analysis of Chapter 5.

The relatively low RSI value for Havant Site 4 in 2009 may be partially explained by the fact that this site had become heavily overgrown by this time and as a result there were a lot of trees and bushes surrounding the microphone, potentially increasing the absorption of the peak vehicle noise. Although it is unlikely that the vegetation would have made a large difference to the levels the relatively low RSI and is nevertheless removed from the analysis of Chapter 5.

The relatively low RSI value at Thrapston Site 2 in 2009 is harder to explain although it may be noted that these measurements were taken close to the end of the laid surface, see Section 3.5.2, where the noise level has been found to be very variable, see Section 4.3.

4.1.3 14 mm surfaces

The results of the SPB measurements carried out at each site with a 14 mm low noise surface are shown in Table 4.3.

Ongoing road works at the M5 Taunton sites in 2009 presented only a very small time window in which to conduct SPB measurements and as such Site 2 was not completed.

The low RSI at Thrapston Site 1 in 2009 is likely partly due to the fact that measurements were taken in a slightly different position within the lay-by in 2009 and the acoustic variability of the surface in this region is very high, see Section 4.3.

Nevertheless the result is still somewhat of an outlier with respect to the 14 mm surfaces and is therefore omitted from the analysis of Chapter 5.

Table 4.3: Results of SPB measurements at 14 mm sites

Road	Site	Date surface laid	2007 RSI_H dB(A)	2008 RSI_H dB(A)	2009 RSI_H dB(A)
A14	Huntingdon - Site 1	Feb-99	-0.2	+0.5	-0.6
A14	Huntingdon - Site 2	Feb-99	0.5	-0.3	-0.3
M65	Burnley - Site 1	Aug-99	--	-0.5	+0.3
M65	Burnley - Site 2	Aug-99	--	-0.8	+0.1
M5	Taunton - Site 1	Feb-01	--	-1.1	-2.6
M5	Taunton - Site 2	Feb-01	--	-1.2	--
A55	Bangor - Site 1	Feb-05	--	-3.3	-2.0
A55	Bangor - Site 2	Feb-05	--	-4.6	-3.5
A14	Thrapston - Site 1	Sep-06	-4.5	-3.8	-5.7*
A14	Thrapston - Site 3	Sep-06	-3.5	-3.8	-3.7
A14	Stanford - Site 2	Aug-07	-3.6	-3.0	-3.1

*Result not included in analysis

4.1.4 HRA/EAC surfaces

The results of the SPB measurements carried out at the HRA and EAC sites are shown in Table 4.4.

Although the result for the EAC surface in 2009 is slightly lower than in 2008 these results do not differ greatly from what may be expected.

Table 4.4: Results of SPB measurements at HRA and EAC sites

Road	Site	Surface type	Date surface laid	2007 RSI_H dB(A)	2008 RSI_H dB(A)	2009 RSI_H dB(A)
A50	Sudbury - Site 1	HRA	Aug-95	+1.7	+1.6	+2.1
A50	Foston - Site 1	EAC	Aug-95	--	-0.4	-0.7

4.2 Traffic noise measurements

Table 4.5 shows the results from traffic noise surveys carried out alongside 4 sites at the same microphone positions where the SPB measurements were conducted. Recall, from Section 3.4, that these sites were selected where the low noise surfaces was laid across the entire width of the carriageway.

The noise results were derived from averaging the data collected during two 15 minute recordings. During the traffic noise surveys traffic counts were also conducted. These data are also presented in Table 4.5 together with mean traffic speeds, obtained from the closest Motorway Incident Detection And Signalling (MIDAS) loop, for the appropriate road section for that hour.

These traffic data, together with the RSI values obtained from the measurement surveys, have been used to predict the measured noise levels using CRTN and these results are presented in the final column of Table 4.5. Although the predicted noise levels are generally slightly lower than the measured levels, when looking at the confidence with which the predictions lie with 3 dB(A) of the measurements, they compare favourably with the accuracy of CRTN when it was first validated (Delaney et al, 1976). The traffic noise levels at these sites in 2008 and 2009 are broadly similar.

Table 4.5: Results of traffic noise measurements

Year	Maximum stone size (mm)	Road	Site	Average hourly traffic data			Measured traffic noise index $L_{A10,1h}$ dB(A)	CRTN noise index $L_{A10,1h}$ dB(A)
				Flow veh/h	%H	Speed km/h		
2008	14mm	A14	Huntingdon Site 1	3096	18.5	104	85.3	84.9
	14mm	A14	Huntingdon Site 2	2520	27.8	101	85.8	83.9
	14mm	A14	Stanford Site 2	2748	33.9	109	83.3	82.7
	20mm	A50	Sudbury Site 1	2952	25.3	106	87.8	86.6
2009	14mm	A14	Huntingdon Site 1	2664	26.0	102	85.0	83.8
	14mm	A14	Huntingdon Site 2	3184	13.4	102	85.0	83.5
	14mm	A14	Stanford Site 2	2512	30.7	103	83.0	81.5
	20mm	A50	Sudbury - Site 1	2666	23.5	108	89.0	86.7

4.3 CPX measurements

CPX measurements were carried out at 50 and 80 km/h in 2008 and 2009 at the sites identified in Section 3.5. Two runs were made in the nearside wheel-track of the nearside lane over the total length of the road section and the presented results comprise the average value from these runs.

A summary of indicative levels close to the locations of the SPB measurements is presented in Table 4.6. However great care must be taken on interpreting these numbers since, as was mentioned in Section 4.1, the SPB measurements were, in some cases, conducted in slightly different locations and the acoustic variability of the measured surfaces is significant. A more detailed look at the complete surface lengths is therefore reported in Sections 4.3.1 and 4.3.2.

The interpretation of these results with respect to the SILVIA CoP methodology is discussed in Section 5.4.2.

Table 4.6: Results of CPX measurements

Stone size (mm)	Site	Surface type	Date surface laid	2008 CPX dB(A)		2009 CPX dB(A)	
				50 km/h	80 km/h	50 km/h	80 km/h
6mm	A14 Creeting St Mary - Site 1	Axophone	Jun-06	93.0	98.6	94.1	100.4
10mm	A14 Thrapston - Site 2	Superflex	Sep-06	92.5	99.1	93.1	99.6
14mm	A14 Thrapston - Site 1	Hitex	Sep-06	94.1	99.7	93.6	99.2
14mm	A14 Thrapston - Site 3	Hitex	Sep-06	95.4	101.8	95.5	102

4.3.1 6 mm – Creeting St. Mary

The CPX results at 80 km/h from the Creeting St. Mary site can be viewed in Figure 4.1. The approximate position of the SPB measurements is indicated by the vertical dotted line and the deterioration of the acoustic performance of the surface in this region is clearly visible.

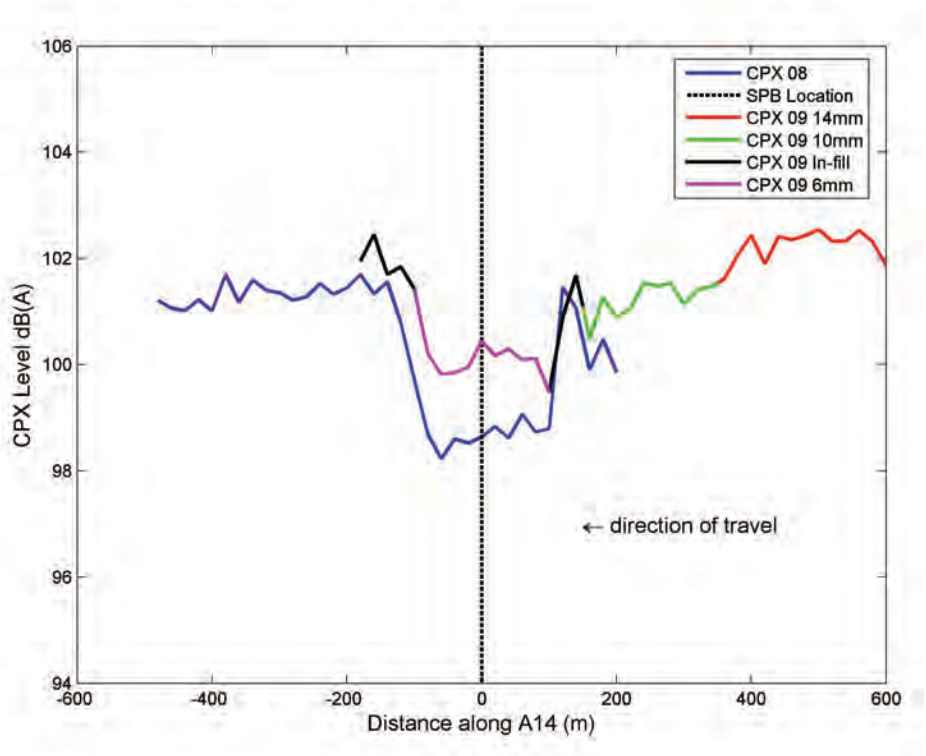


Figure 4.1: CPX results Creeting St. Mary '08 and '09, 80 km/h

Note the rapid change in performance of the surface near the edges of the 6 mm section. This had a definite effect on the results at one of the Thrapston sites where two different surfaces were measured in the same lay-by. The results at 50 km/h showed exactly the same trends.

4.3.2 10 mm and 14 mm – Thrapston

The CPX results at 80 km/h from the three Thrapston sites are shown in Figure 4.2. The first vertical dotted line indicates the position of the SPB measurements in 2009. In 2008 similar measurements were taken further along the lay-by where it can be seen that the road surface had a poorer acoustic performance. This helps to explain the lower RSI that was recorded in 2009 as discussed in Section 4.1.3.

Looking at the second SPB measurement site it can be seen that the performance of the surface in this region is highly variable which may help explain the comparatively lower RSI recorded in 2009 as mentioned in Section 4.1.2.

The SPB results for the third site were fairly similar and this is borne out when comparing the red and blue curves close to the third dotted line in Figure 4.2.

Overall it can be seen that there has been some deterioration in the 6 mm section (which was not one of the identified sites for this programme of work) but other than this the 2008 and 2009 results are very similar. With respect to the 10 mm and 14 mm surfaces the differences between measurements taken in 2008 and 2009 are smaller than the variability in CPX level along each section for any given year.

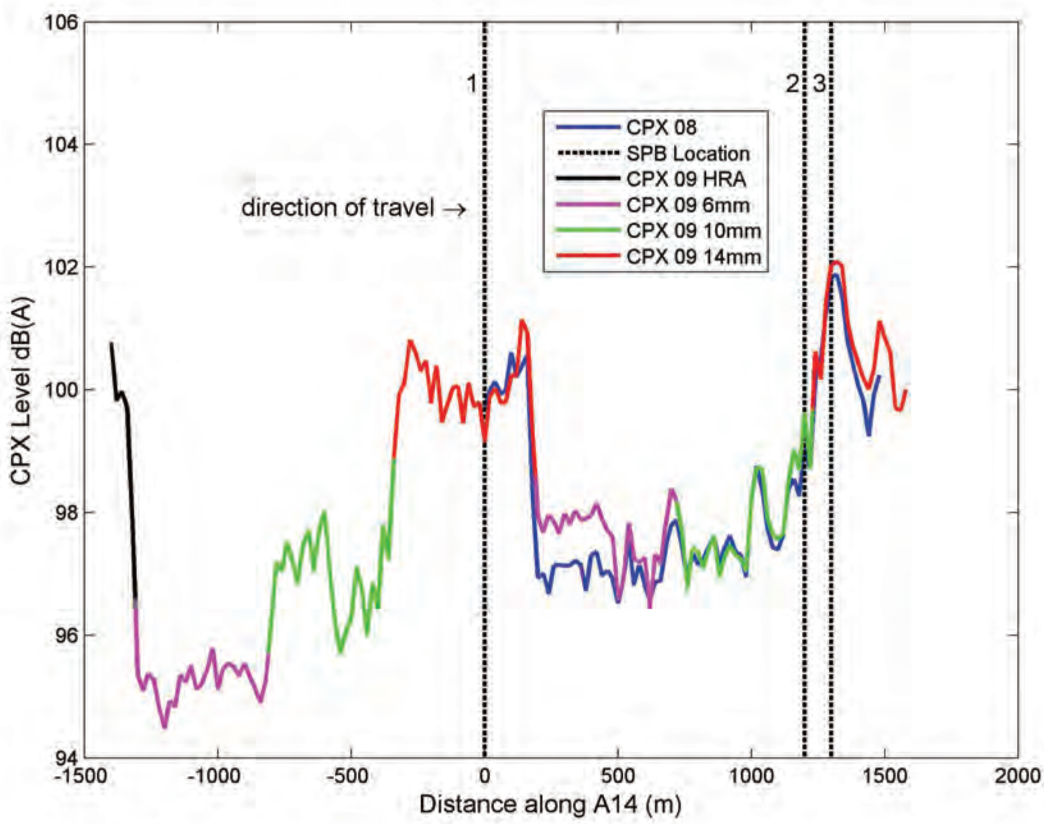


Figure 4.2: CPX results Thrapston '08 and '09, 80 km/h

5 Assessment of low noise surfaces over time

This chapter brings together the data collected as part of this project with historical data, traffic data and information on surface texture in order to review a number of issues concerning the assessment of low noise surfaces over time. Section 5.1 looks at all the information on RSI available for each site in the measurement study and examines the deterioration of the acoustic performance of thin surfaces over time. Section 5.2 collates available traffic and surface texture information for some of the sites in order to help explain the causes of the change in performance of the surfaces. How the trends found in Section 5.1 may be incorporated as additional advice on noise assessments in DMRB is looked at in Section 5.3. Finally Section 5.4 discusses possible additions to the HAPAS methodology in order to derive RSI values that act as a closer representation of the acoustic performance of the surface over its lifetime and the feasibility of utilising the SILVIA CoP methodology on the SRN.

5.1 Acoustic performance over time

The following sections plot the high speed RSI values for all the site locations in this study, sorted by stone size and surface type, together with a best fit line representing the average acoustic performance. It may be noted that consideration was given to higher order polynomial best fit curves but it was found that the mean deterioration in acoustic performance across all surface types and ages was relatively linear.

5.1.1 6 mm surfaces

All RSI data relating to the sites with a 6 mm surface are plotted against the age of the surface in Figure 5.1.

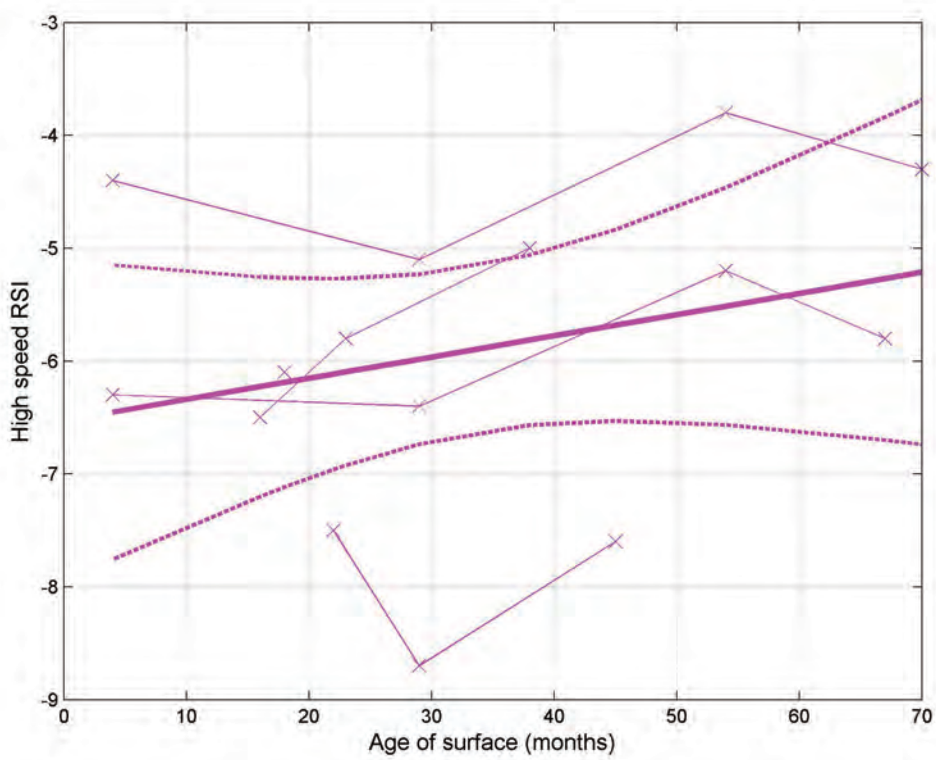


Figure 5.1: Plot of RSI_H values for 6 mm surfaces against age, with best fit line and 95% confidence interval

The bold lines in the graph represent the best fit line and the dashed lines the 95% confidence intervals for the data. The thin lines join RSI values relating to the same location. The trend in Figure 5.1 suggests relatively slow deterioration of 6 mm surfaces of the order of 1 dB(A) over 5 years. There are not enough data for this type of surface however to be confident of this result; if the omitted RSI values from Pevensey Site 2, see Section 4.1.1, had been included the gradient of the best fit line would be much steeper. It was also found, when looking at the CPX data in Section 4.3, that the deterioration in acoustic performance of 6 mm surfaces over one year was greater than that measured for 10 mm or 14 mm surfaces.

It can also be seen from Figure 5.1 that no RSI data exist for 6 mm surfaces over 6 years old and therefore the long term behaviour of these surfaces is unknown.

5.1.2 10 mm surfaces

All RSI data relating to the sites with a 10 mm surface are plotted against the age of the surface in Figure 5.2. As in Figure 5.1 the bold lines in the graph represent the best fit line and 95% confidence interval for the data and the thin lines join RSI values relating to the same location.

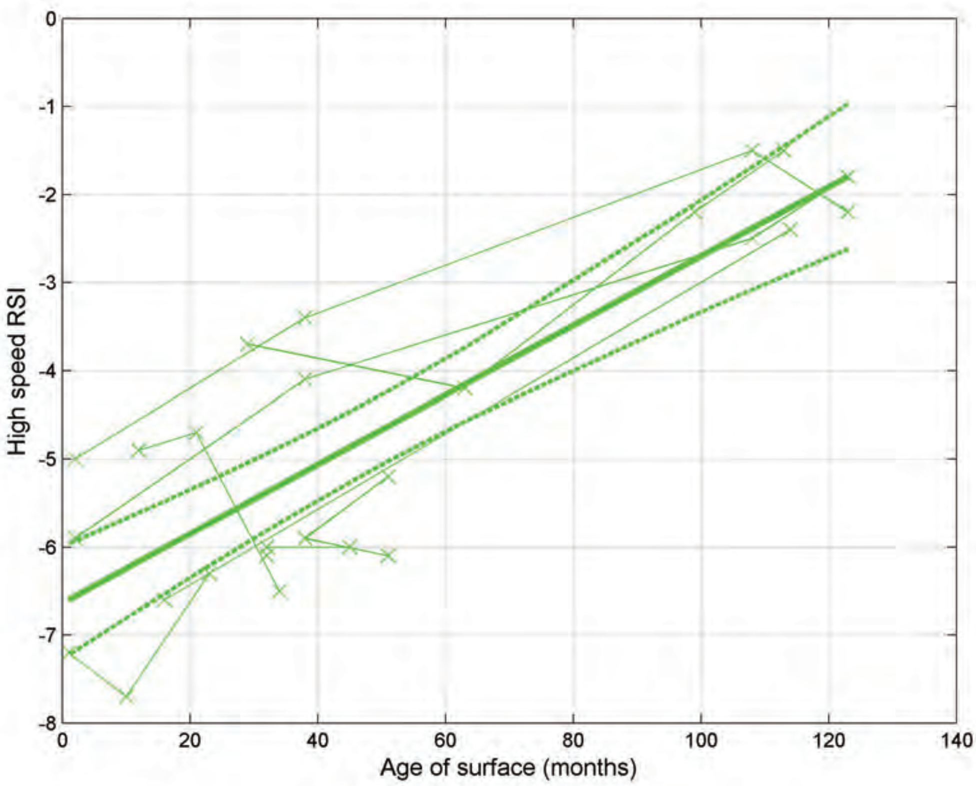


Figure 5.2: Plot of RSI_H values for 10 mm surfaces against age, with best fit line and 95% confidence interval

There are more data available for 10 mm surfaces than 6 mm surfaces and the data include RSI values on surfaces up to 10 years old. On examining the results a relatively reliable trend of a 1 dB(A) deterioration every two years emerges. There is an absence of data for surfaces between 6 and 8 years old but there is no real reason to imagine that the current trend would be altered in this period.

It should be noted that other forms of polynomial best fit curves have been investigated in order to explain the relationship between acoustic performance and age but it was found that a linear deterioration over time was the best fit for the current data set. At this stage the data does not suggest a turning point at which the acoustic performance is relatively constant over time.

5.1.3 14 mm surfaces

All RSI data relating to the sites with a 14 mm surface are plotted against the age of the surface in Figure 5.3. As in the previous figures the bold lines in the graph represent the best fit line and 95% confidence interval for the data and the thin lines join RSI values relating to the same location.

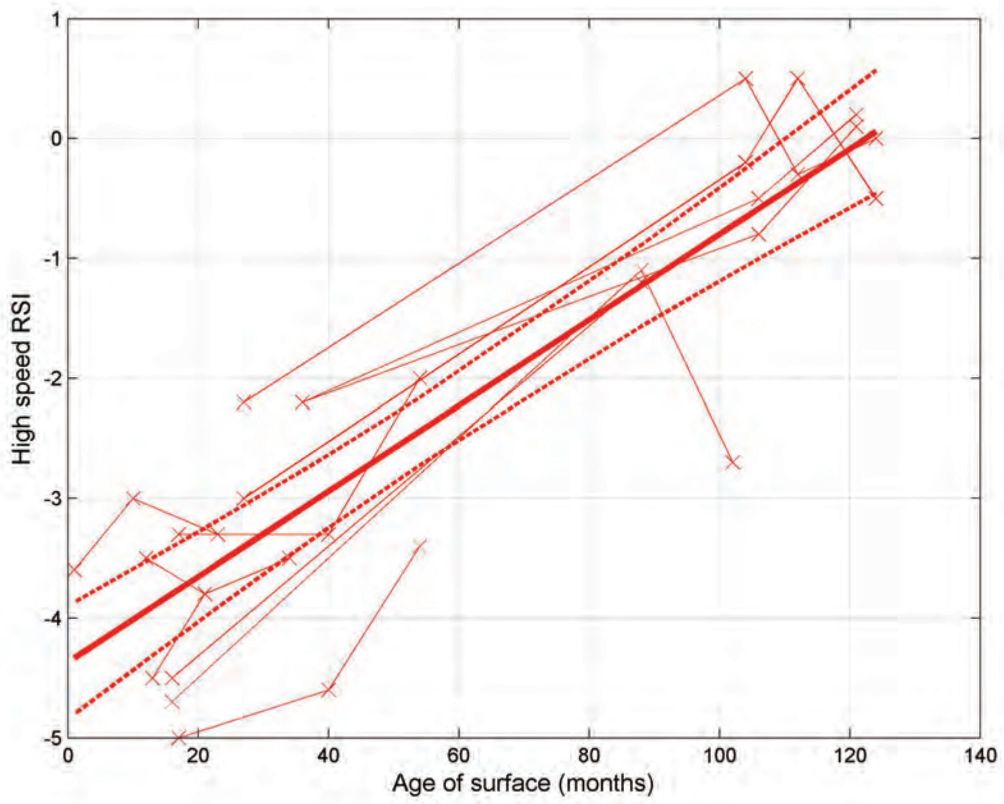


Figure 5.3: Plot of RSI_H values for 14 mm surfaces against age, with best fit line and 95% confidence interval

Overall the results for 14 mm surfaces show a similar trend to the 10 mm surfaces, of a 1 dB(A) deterioration every two years, albeit with an equivalent RSI about 2 dB(A) higher. The 2009 survey on the M5 produced a RSI 1.5 dB(A) lower than in 2008 and the value of -2.6 dB(A) for a surface 102 months old stands out as somewhat of an outlier in Figure 5.3. However, as has been seen in Figure 4.2, this 1.5 dB(A) difference may be expected from longitudinal variations in the laying of the surface and therefore error bars of at least this magnitude must be considered when viewing the data.

5.1.4 HRA/EAC surfaces

All RSI data relating to the sites with a HRA or EAC surface are plotted against the age of the surface in Figure 5.4. As in the previous figures the bold lines in the graph represent the best fit line and 95% confidence interval for the data and the thin lines join RSI values relating to the same location.

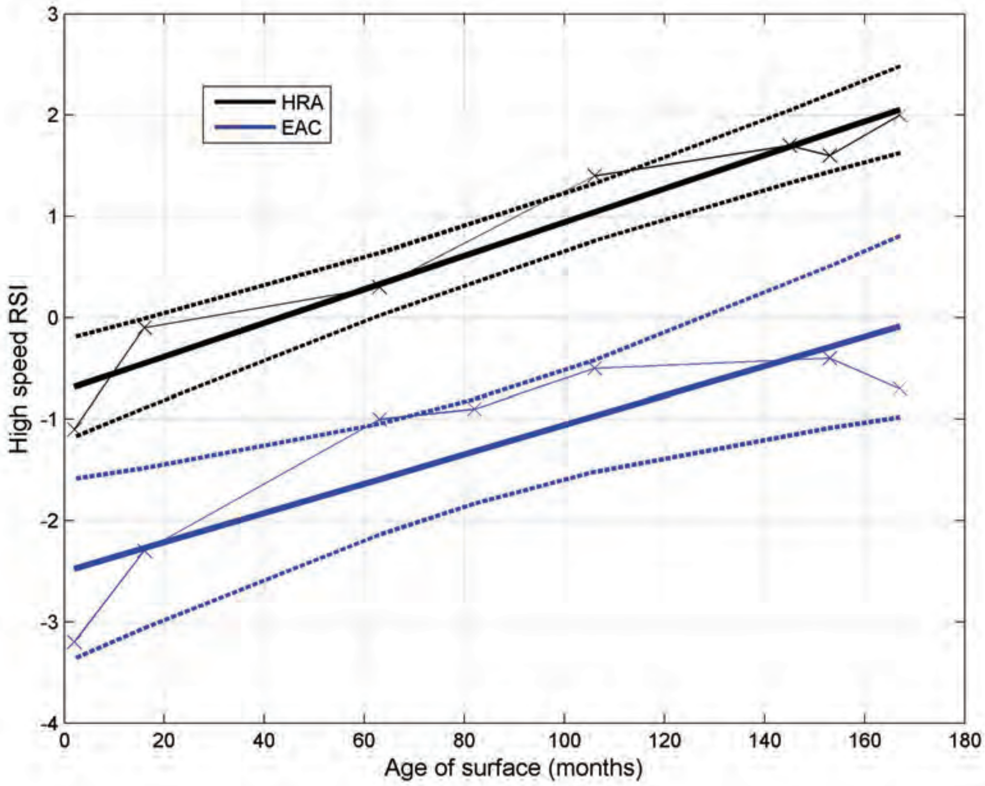


Figure 5.4: Plot of RSI_H values for HRA and EAC surfaces against age, with best fit lines and 95% confidence intervals

These results indicate an approximate deterioration of 1 dB(A) every 5 years illustrating that HRA and EAC surfaces have a stronger acoustic durability than low noise surfaces. It is also important to note that the RSI scale is a nominal comparison with a new HRA surface and therefore replacing an old HRA surface with a low noise surface will result in a greater acoustic benefit than indicated by the RSI of the low noise surface. Although the trends illustrated in Figure 5.4 are quite strong, it should be cautioned that these results only relate to one test location.

5.1.5 All surfaces

The RSI data for all surfaces discussed in the previous sections are summarised in Figure 5.5. Here the performance of each surface type may be compared to one another and it can be seen that, when new, low noise surfaces provide on average between 4 and 6 dB(A) benefit over the tested HRA. Despite the improved acoustic durability of HRA the low noise surfaces still outperform the tested HRA by 1 to 3 dB(A) after 10 years.

As mentioned in Section 5.1.1 there are not enough data to rely on the apparent durability of 6 mm surfaces as illustrated in Figure 5.5; it is entirely feasible that given further measurements the mean deterioration of 6 mm surfaces will match that of the 10 mm and 14 mm surfaces.

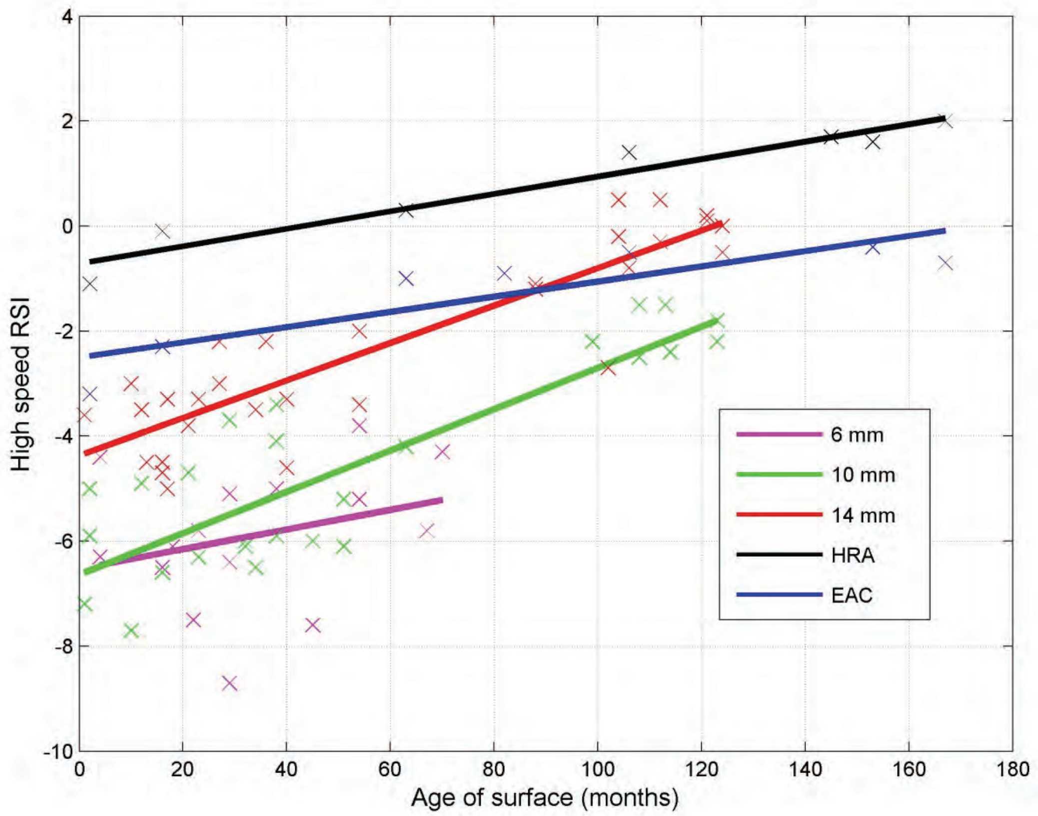


Figure 5.5: Summary of RSI data for all surfaces over time

5.2 Effect of traffic and surface texture

The results presented in Section 5.1 indicate a clear deterioration in the acoustic performance of low noise surfaces over time. However, they do not explain the causes of this deterioration in performance. To help explain the differences in deterioration between surfaces of the same aggregate size traffic and texture data for two 10 mm and two 14 mm surfaces are examined over the course of their lifetime in Sections 5.2.1 and 5.2.2 respectively.

5.2.1 10 mm sites – M6 and A34

The total monthly traffic flows, for the carriageway for which SPB measurements were conducted, for the Northbound M6 and Southbound A34 sites are shown in Figure 5.6. Note that the data are presented in terms of the age of the current 10 mm surface at each site and not for specific dates. It may be seen that the traffic during this period is greater on the M6 than the A34. Figure 5.7 plots the average Mean Texture Depth (MTD) stored in the Highways Agency Pavement Management System (HAPMS) from texture surveys taken along each section of road over the lifetime of the current surface. It can be seen that there is a gradual increase in texture over the lifetime of the surface at both sites which may imply that the acoustic performance of the surface was deteriorating. The large peak in MTD at the A34 site was the result of some localised surface degradation which has since been repaired. The corresponding peak in RSI can be seen in Figure 5.8 where the results of SPB measurements taken on the surfaces are shown. An increase of about 0.3 mm in mean texture depth, for both sites, can be seen to be concurrent with an increase in RSI of about 4.5 dB(A).

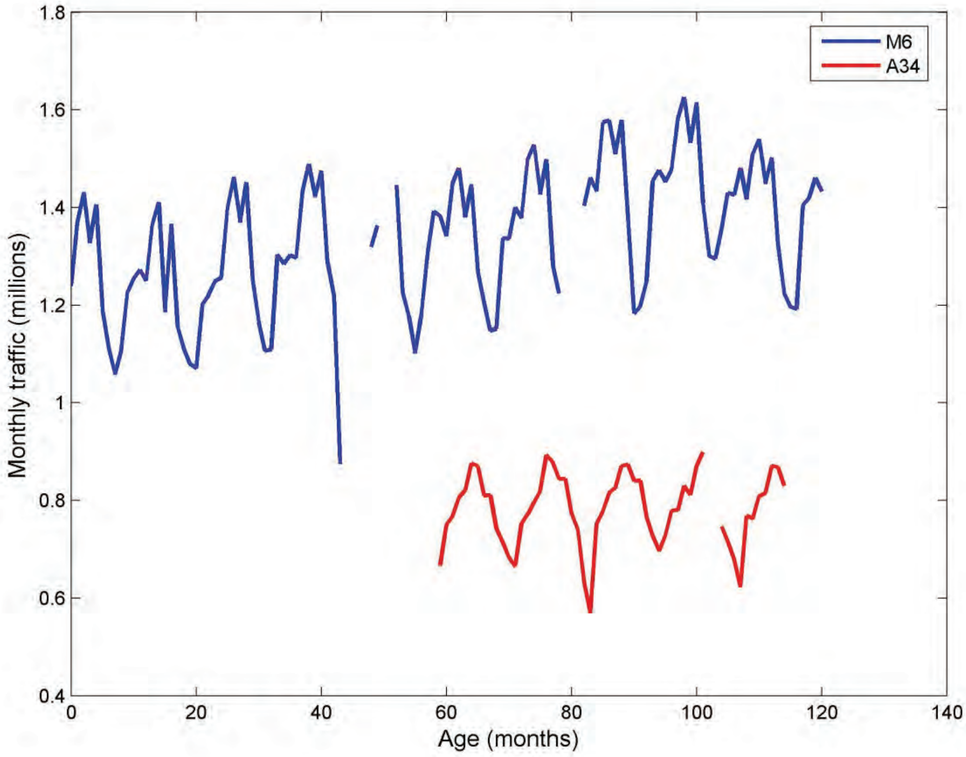


Figure 5.6: Monthly traffic at the M6 and A34 sites since the current 10 mm surface was laid

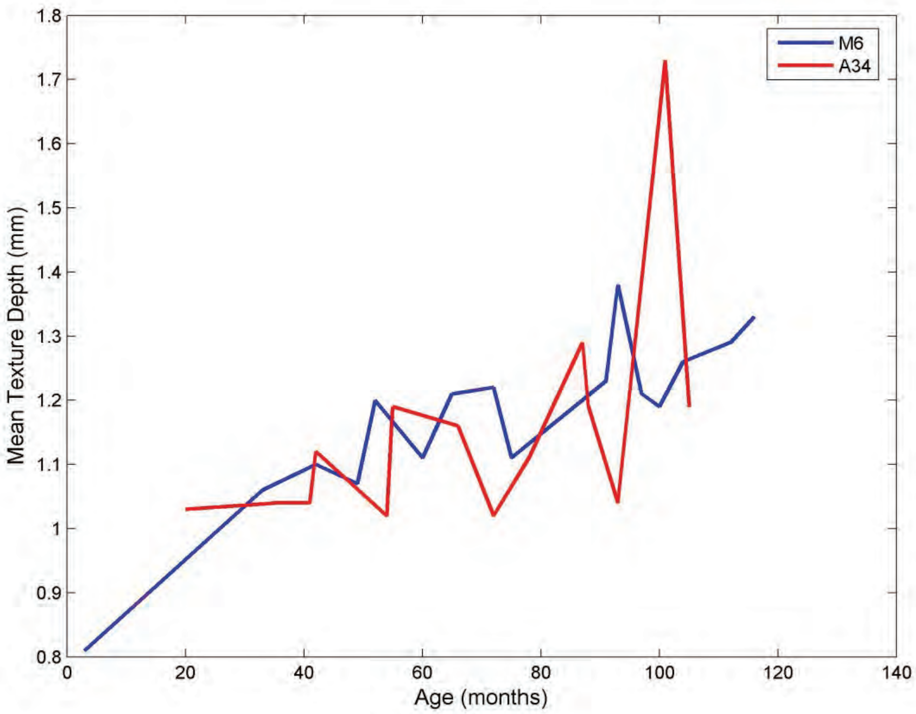


Figure 5.7: Average texture values for the M6 and A34 sites since the current 10 mm surface was laid

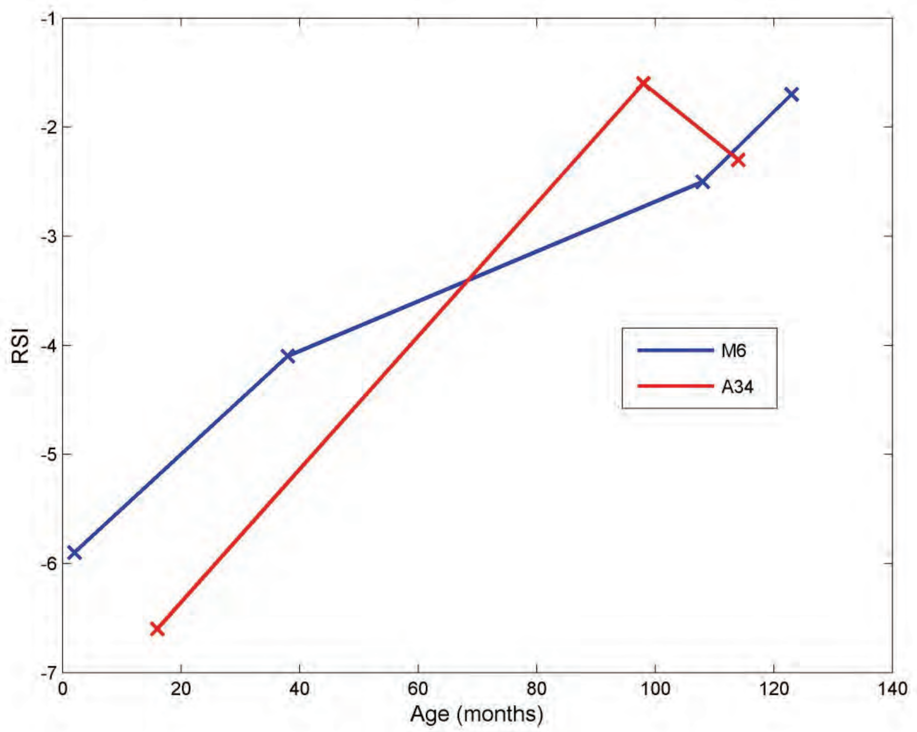


Figure 5.8: Measured RSI values for the M6 and A34 sites since the current 10 mm surface was laid

5.2.2 14 mm sites – M65 and M5

Similar results comparing data relating to the 14 mm surfaces at the first M65 and M5 sites are shown in Figure 5.9, Figure 5.10 and Figure 5.11. It can be seen that at these sites there is only a slight increase in average traffic flow and MTD over the lifetime of the surfaces even though the RSI values have largely increased over this period. The overall trend of an increase in MTD of about 0.15 mm and RSI of about 2 dB(A) however shows a similar correlation to the 10 mm sites looked at in Section 5.2.1.

Although the difference between the mean texture depths of the two 14 mm surfaces would suggest a larger difference in RSI according to the identified trends the larger traffic flow on the M5 may be contributing to further surface degradation not reflected in the average MTD.

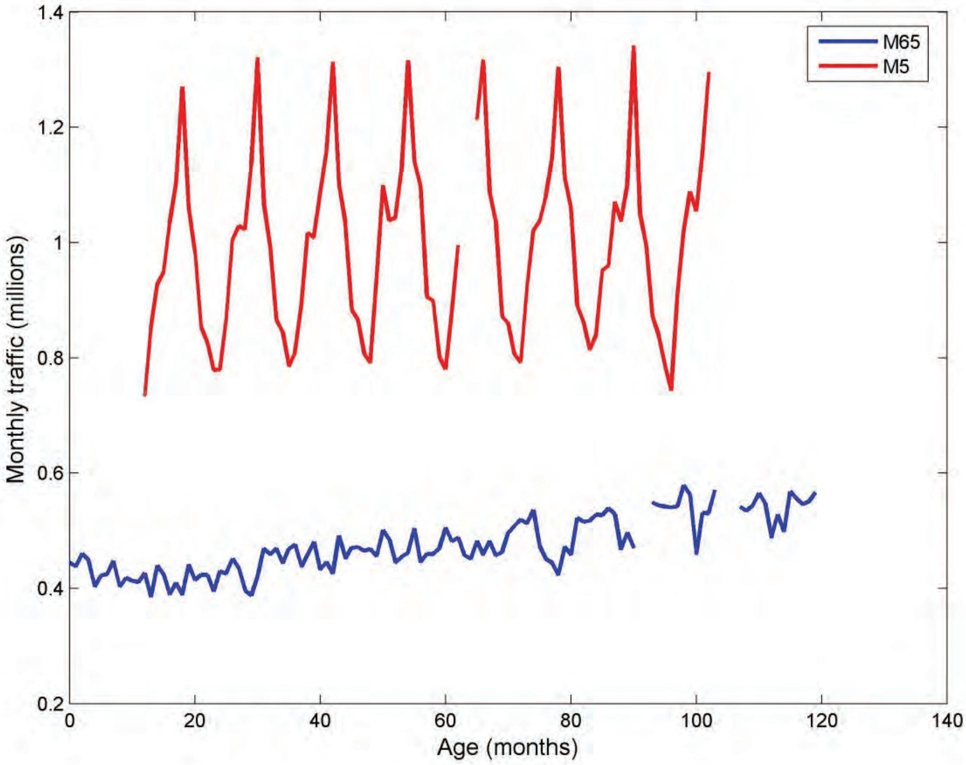


Figure 5.9: Monthly traffic at the M65 and M5 sites since the current 14 mm surface was laid

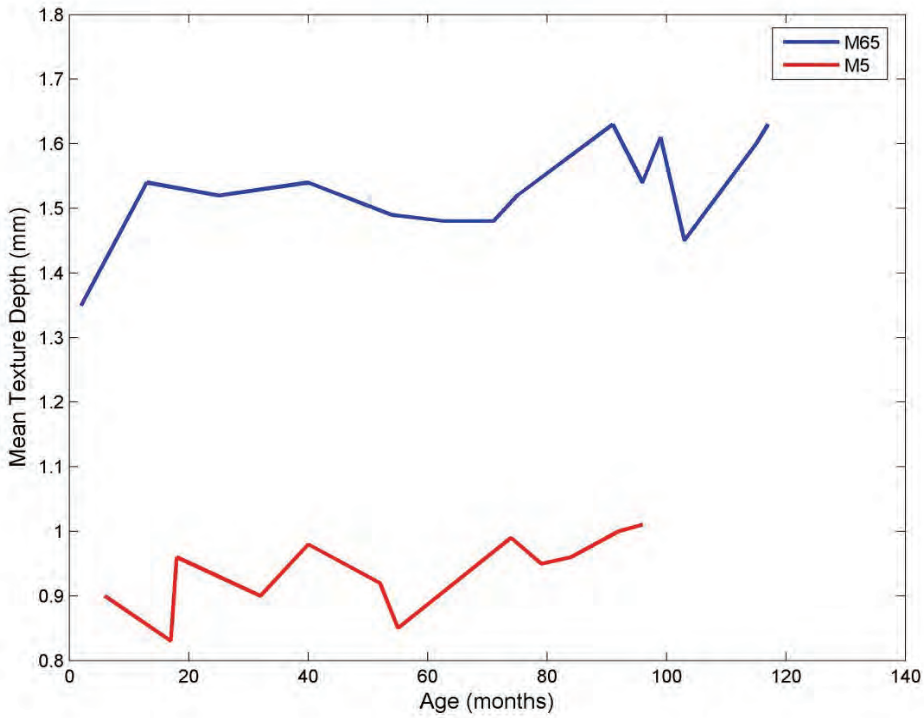


Figure 5.10: Average texture values for the M65 and M5 sites since the current 14 mm surface was laid

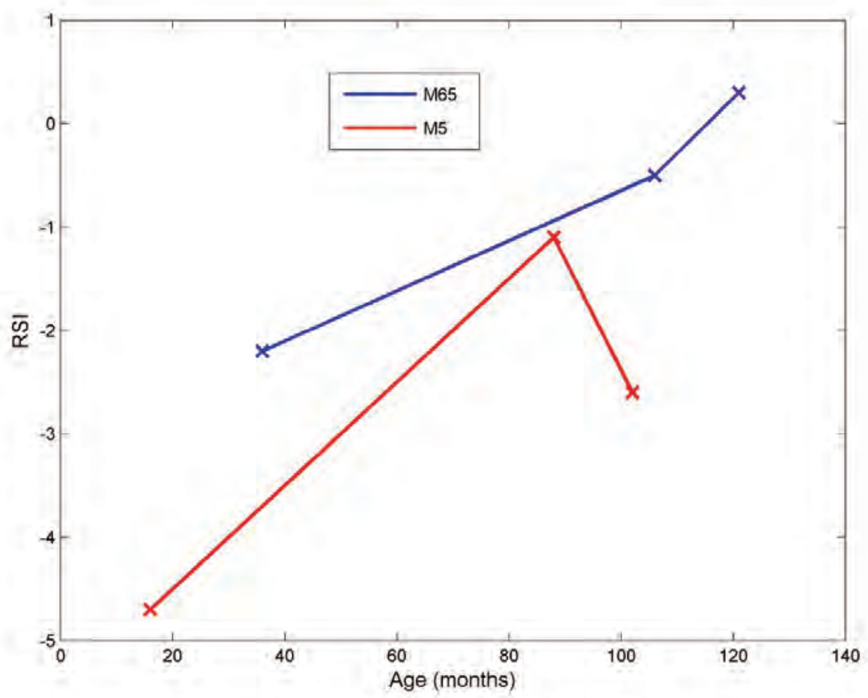


Figure 5.11: Measured RSI values for the M65 and M5 sites since the current 14 mm surface was laid

5.3 Classification of a low noise surface

5.3.1 Introduction

The acoustic performance of a road surface is an important input parameter when calculating the traffic noise level from a road. Using accurate input parameters is important when making decisions based on calculated noise levels. As this report has shown, the acoustic performance of surfaces can vary by up to 10 dB(A) depending upon type and stone size.

The current guidance on what surface correction to apply to noise calculations is found in CRTN and also Annex 4 of HA213/08. This information on surface corrections is required by the Highways Agency when undertaking environmental assessments and appraisals. More widely it is also used for the production of noise maps, such as those produced by Defra in response to the END. The guidance for undertaking assessment is given in HA213/08 and guidance for appraisal is given in WebTAG Unit 3.3.2 (DfT, 2009). Both these methods require the assessor to make assumptions about the road surface correction in the opening year of the scheme and normally the 15th year after opening.

Table 5.1 below shows the current surface corrections for assessment and appraisal scenarios that are recommended to be used, as defined in HA213/08.

Table 5.1: Surface corrections (dB) currently recommended for use during assessment and appraisal

Surface type	Assessment / Appraisal condition	
	Opening year	15th Year
Existing reference surface	0	0[1]
Existing low noise surface	-2.5	-3.5[2]
New reference surface[3]	n/a	n/a
New low noise surface	-3.5	-3.5

[1] For a surface on the SRN this situation is unlikely to exist, as by 15 years after opening the reference surface would normally have been re-surfaced with a low noise surface through general maintenance.
[2] This value is based on a future update to DMRB to reflect improvements in low noise surfaces; HA213/08 currently only states the -2.5 dB value for existing low noise surfaces.
[3] Included for completeness but not likely to exist due to current Highways Agency surfacing policy.

Only the new low noise surface in the opening year can currently be defined with any level of accuracy, although the results have shown even this could vary by a considerable amount between different surfaces. The surface correction for an existing surface in the opening year will, as expected, be very much dependant on the age of the surface. This will apply to the reference surface and also a low noise surface. In the 15th year the problem of not knowing the exact age of the surface still exists, but is really only applicable to a low noise surface as any HRA on the network would probably have been re-surfaced within a 15 year period. Data on the age of any surface can be very difficult to obtain, and currently could not be relied upon to consistently provide accurate information.

As the results from this research have shown, the noise reducing properties of a low noise surface deteriorate with time. There could therefore be a considerable difference between the actual RSI of a surface and what is assumed for any calculations. For example, an existing 14 mm surface could be 10 years old during an opening year calculation and the results from this project would indicate a surface correction of about 0 dB(A) is appropriate, yet a noise reduction of -2.5 dB(A) is still assumed. These potential differences have implications for the accuracy of noise assessments and appraisals undertaken by the Highways Agency. For low noise surfaces of a known age an age dependent road surface correction is recommended in Section 6.2. However, given uncertainties over the structural life of some current surfaces, it is unlikely that the age of the surface in the 15th year could be determined and therefore it is considered that only an appropriate 'average' could be used in this instance.

Section 5.3.2 examines how the results from this research could be used to better define a 'low noise surface' to one that takes into account long term acoustic performance. Section 5.3.3 discusses whether the reference surface should be re-defined to take into account the reduction in acoustic performance with age.

5.3.2 Definition of a low noise surface

A low noise surface is currently defined by the Highways Agency in the Manual of Contract Documents for Highway Works (MCHW) (Highways Agency, 2008). This defines a low noise surface as having an RSI of -2.5 dB(A) and a 'very quiet surfacing material' as having an RSI of -3.5 dB(A). It is this level of -2.5 dB(A) that the Highways Agency specifies a surface must have met in order to be applied extensively on the SRN and is generally considered to define a low noise surface.

The HAPAS system requires a surface to achieve an RSI of -2.5 dB(A) after a minimum period of one year from opening to traffic. However, this method of surface assessment does not take account of the long term performance of the surface.

It is noted that the Highways Agency does not replace its low noise surfaces on the basis of poor acoustic performance; therefore the lifetime of the surface applies to its structural lifetime.

The following derivation of a possible minimum acoustic performance over lifetime for a generic low noise surface (i.e. irrespective of aggregate size) is based on the following assumptions:

- Structural lifetime: An immediate problem is in defining the typical lifetime of the low noise surface as this varies greatly and is influenced by such factors as traffic flow and surface construction. The oldest surface used in the current study is the 10 mm surface at Leyland, which is just over 10 years old. Since very little information is available regarding the average lifetime of different low noise surfaces, a lifetime of 10 years will be assumed.
- Acoustic performance at end of lifetime: Ideally a low noise surface will maintain some benefit in acoustic performance over its lifetime relative to a reference surface. Therefore at the end of lifetime, the low noise surface should have an RSI less than or equal to 0 dB(A).
- Rate of acoustic performance deterioration: The gradient corresponding to the average of the slopes for the 10 mm and 14 mm surfaces is assumed.

Based on these assumptions, the possible minimum acoustic performance for a generic low noise surface is plotted in Figure 5.12. This line is very similar to that for the 14 mm surfaces best fit line and approximately 2 dB(A) above the 10 mm surfaces best fit line.

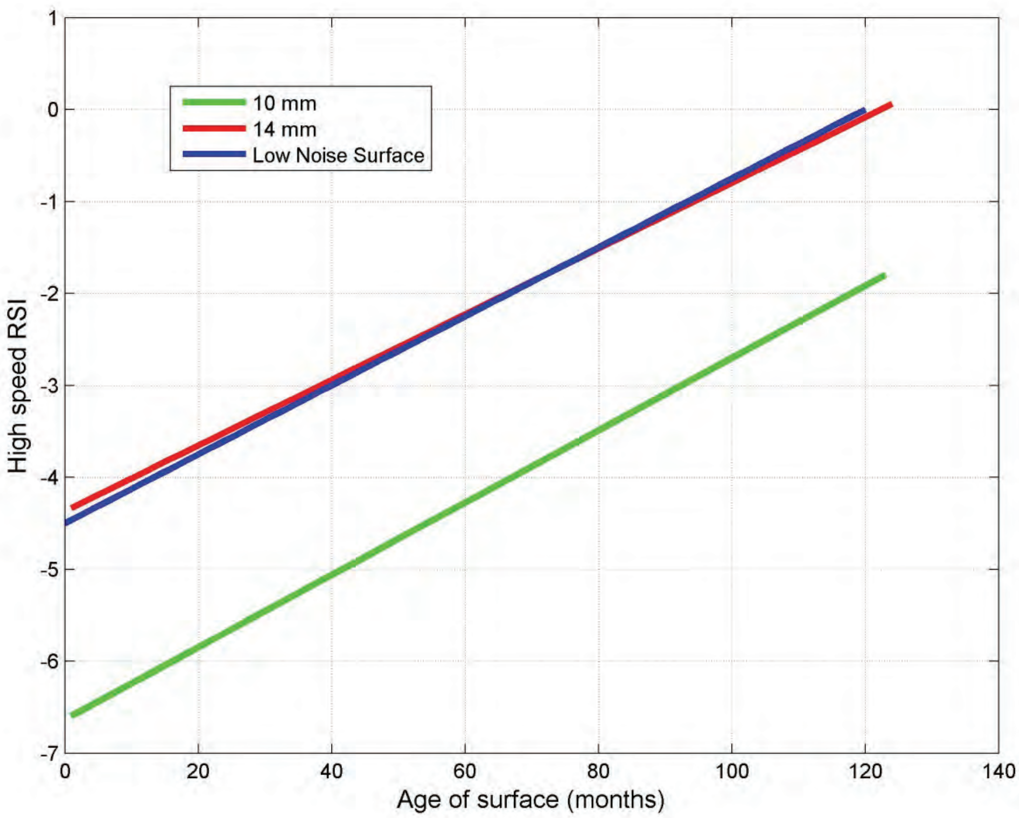


Figure 5.12: Best fit line for a surface that achieves a benefit in acoustic performance over its life

The 6 mm surface data have not been included in this since there are insufficient data to show how this type of surface performs over a 10 year period. This implies that, on average, most surfaces are already meeting whole life acoustic performance, which equates to meeting an RSI of −4.1 at 12 months. It may therefore be appropriate to define a low noise surface in terms of acoustic performance over an assumed average surface life.

5.3.3 Implications for the reference surface

The reference surface, more commonly known as Hot Rolled Asphalt (HRA), is no longer routinely laid on the SRN as it has been Highways Agency policy for at least 10 years to only resurface with a low noise surface. Due to this, the only situation where the acoustic performance of the reference surface is required is when a calculation is made for the opening year condition, where currently a correction of 0 dB(A) is used. However, any HRA surface on the SRN is likely to be at least 10 years old. It may therefore be appropriate to assign a correction value based upon the mid to long term performance of HRA.

As Figure 5.4 has shown, using a best fit line the HRA surface had an RSI of approximately +1.3 dB(A) after 10 years. After 14 years (the time over which the performance of the surface was studied), the RSI was approximately +2.2 dB(A).

Although only one HRA surface has been studied for this research, there is evidence that this surface type, after a number of years on the SRN, has a higher RSI than the 0 dB(A) that is currently used. As with low noise surfaces the exact life of an HRA surface is dependent upon a number of factors. Therefore, if the correction for the reference surface is changed, the level chosen would have to either be an average value or a cautionary approach adopted.

5.4 Certification of a low noise surface

5.4.1 Review of the HAPAS certification procedure

The results from this research have shown that most thin surfaces are already below the HAPAS certification level of -2.5 dB(A) after one year. As shown in Figure 5.5, many are even still below this level after five years. In order to drive for continuous improvement and seek to achieve long term acoustic performance, the requirement of the HAPAS test could be changed to consider long term performance and also reflect improvements in the acoustic performance of surfaces.

The results have shown that an RSI of -4.1 after 12 months is on the best fit line for a surface that would remain below a level of 0 dB(A) for 10 years. Examining the results from the actual measurements on the 6 mm and 10 mm surfaces, given in Figure 5.1 and Figure 5.2 respectively, an RSI of -4.1 is not exceeded for any measurements undertaken on a surface that is less than 12 months old. For the 14 mm surfaces there are very few actual measurements that have been undertaken on new surfaces; however, an RSI of -4.1 is just below the best fit line for 14 mm surfaces.

A sudden reduction in the requirements from -2.5 to -4.1 dB(A) may be considered too restrictive and therefore a cautionary approach of -3.5 dB(A) may be more appropriate, and this would align with both the definition of a very quiet surfacing material in MCHW and the current guidance in DMRB.

If the average life of a surface is assumed to be 10 years, another possibility could be to specify that the HAPAS test is undertaken at the midpoint in the life of the surface (i.e. five years). However, surfacing manufacturers often need a HAPAS certificate quickly in order to market such surfaces and it is considered they would be unwilling to adopt such a system.

The possibility of having a separate HAPAS level for each stone size of thin surface is not considered appropriate as it would be difficult to then apply this to assessment, since the exact stone size to be used in any potential new low noise surface is not likely to be known at the time of conducting an environmental assessment.

5.4.2 Feasibility of SILVIA CoP methodology

In Section 2.4 the SILVIA classification procedure was discussed as a proposed methodology for labelling and certifying the laying of low noise surfaces. Here the results from applying this procedure in practice are presented and discussed. It is important to first note the main differences between the proposed methodology and the measurements that were carried out as part of this work. These are as follows:

- Firstly it is intended that as part of the labelling procedure a dedicated test section is laid in order to derive an appropriate label which is then used in assessing 100 m sections of road. The measurements taken as part of this programme were all taken on surfaces already open to traffic on the SRN.
- Secondly the SILVIA methodology states that a SPB measurement be taken half way along a test section that has already been defined through CPX measurements. In this study the CPX measurements were taken after the SPB was conducted and the test section was then retrospectively defined as the 100 m of road about the SPB location[6]
- Thirdly it is proposed that at SPB measurements are taken on at least two test sections, whereas due to site restrictions only one SPB measurement was taken at each location as part of this work.

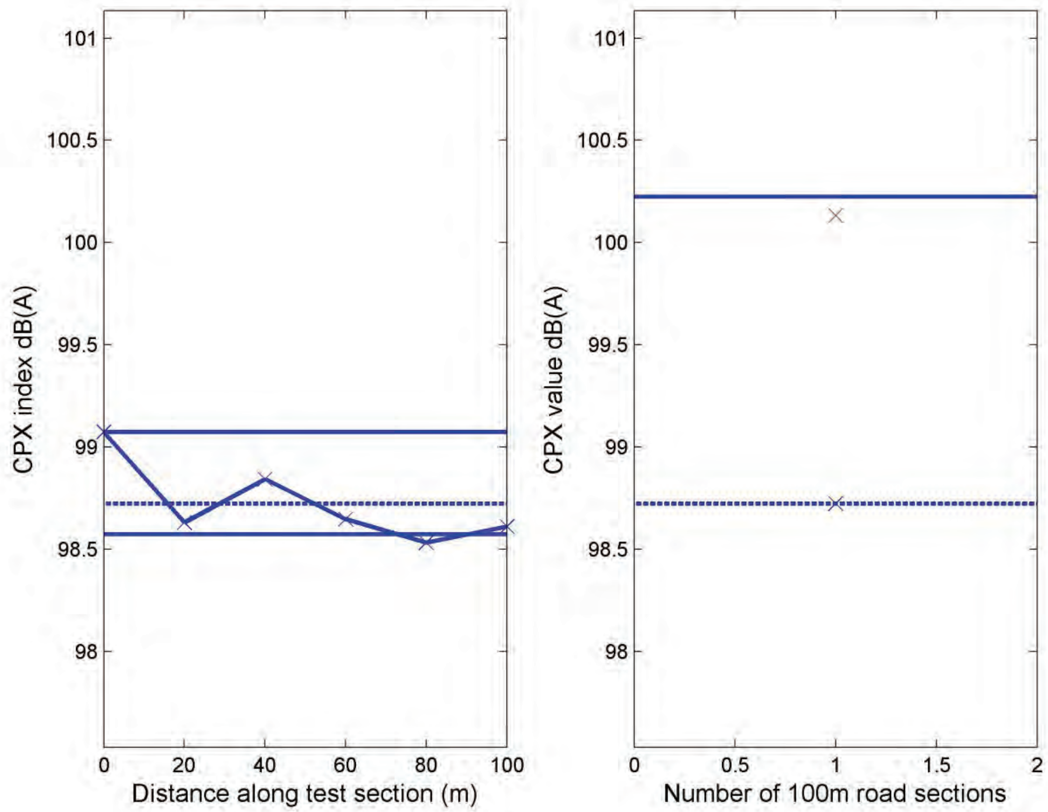
5.4.2.1 6 mm – Creeting St. Mary

Recall from Section 2.4 that the SILVIA surface classification procedure is divided into two parts: labelling and CoP. The 2008 results from the 100 m labelling section are shown in Figure 5.13a. The tolerance recommended in (Padmos et. al., 2005), for the labelling section, states that all values should be within 0.5 dB(A) of each other and this is represented in the graph by the bold horizontal lines. It can be seen that the values from the section about the SPB site at Creeting St. Mary only narrowly fail to meet this condition. The dotted line represents the average CPX index, used when assessing the CoP.

For the CoP assessment the 6 mm surface is divided into 100 m sections excluding the first and last 50 m since, as was shown in Section 4.3, the acoustic properties of the surface can vary considerably in these regions. It is noted that the current revision of 11819-2 recommends ignoring the first 10-20 m to allow any deviation in surface quality caused by the commencement of paving to be excluded from the measurement data.

At the Creeting St. Mary site this restriction results in only one 100 m section and the average CPX index from the 2008 and 2009 surveys are shown in Figure 5.13b as a blue and red cross respectively. The bold blue line represents the upper tolerance of 1.5 dB(A) above the mean CPX value from the labelling section as defined in the SILVIA CoP methodology for surfaces open to traffic. It can be seen that the average CPX values for both the 2008 and 2009 surveys fall within this tolerance.

[6] Where there is a discrepancy between the exact measurement points of the 2008 and 2009 surveys, see Section 4.1, the position of the 2008 SPB measurements is used.

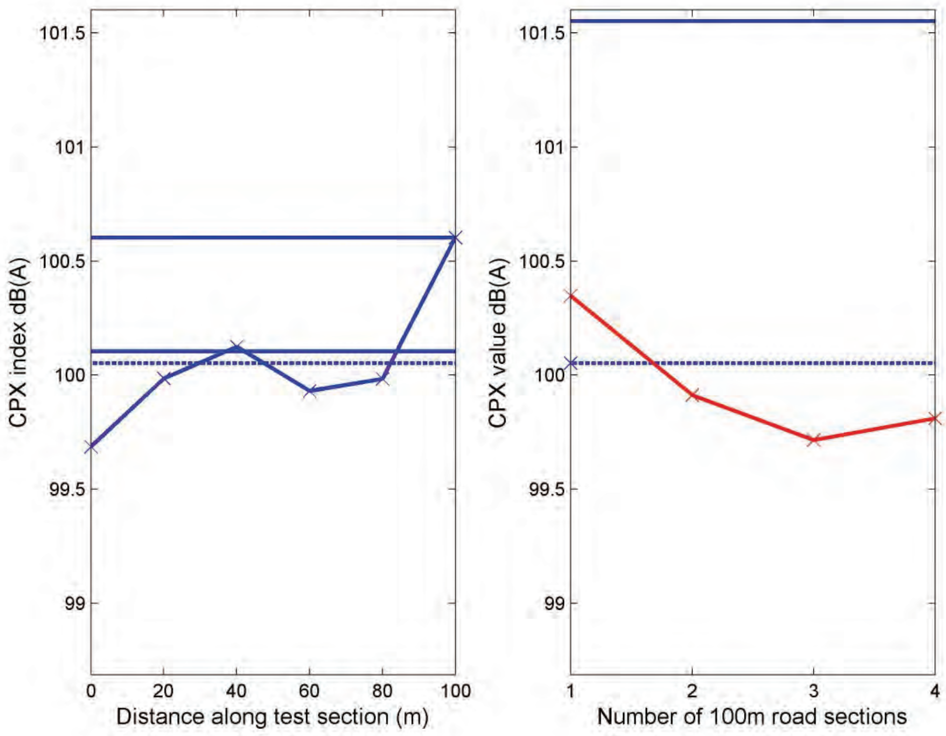


(a) labelling assessment (b) CoP assessment

Figure 5.13: CPX indices measured at Creeting St. Mary, 6 mm

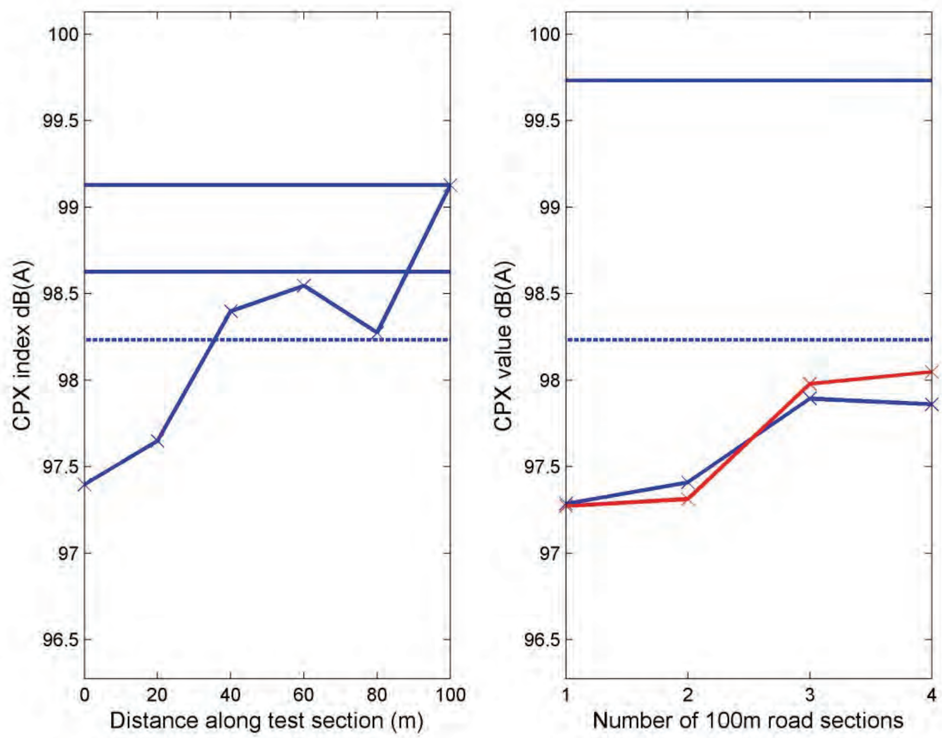
5.4.2.2 10 mm and 14 mm – Thrapston

The CPX measurements taken in 2008 and 2009 at the Thrapston sites have been processed in the same manner as those in Section 5.4.2.1 and are shown in Figure 5.14, Figure 5.15 and Figure 5.16.



(a) labelling assessment (b) CoP assessment

Figure 5.14: CPX indices measured at Thrapston Site 1, 14 mm

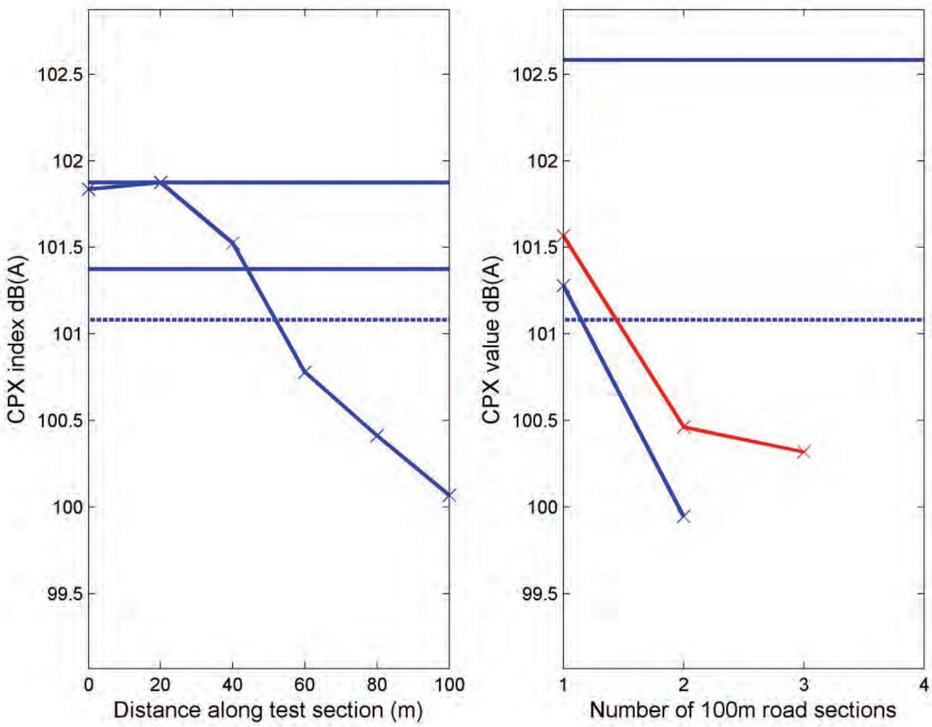


(a) labelling assessment (b) CoP assessment

Figure 5.15: CPX indices measured at Thrapston Site 2, 10 mm

Examining the results from the first 14 mm surface at Thrapston, shown in Figure 5.14, it can be seen that the recommended tolerance for the labelling section is not met by the 100 m section about the SPB location where the peak-to-peak variation is about 1 dB(A). The 1.5 dB(A) tolerance proposed as part of the CoP methodology is however comfortably met for measurements taken in both 2008 and 2009. Note that results in 2008 were recorded over a shorter length of this section and therefore data only exist for one 100 m section represented by the blue cross on the left hand side of the right hand graph in Figure 5.14.

The variation in acoustic performance of the 10 mm surface at the second site at Thrapston was such that the peak-to-peak variation of the selected test section was over 1.5 dB(A). This exceeds the variation in the average values of all the 100 m sections at this site as can be seen in Figure 5.15. It may also be noted that the average CPX value about the SPB location exceeds the average values of the 100 m sections for this stretch of low noise surface. This may be explained by reference to Figure 4.2 where it can be seen that the SPB measurements were taken at the end of this stretch of 10 mm surface, just before where the final 14 mm surface is laid. As a result the CPX values about the SPB location are higher than those measured along the rest of the surface and this is reflected in Figure 5.15.



(a) labelling assessment (b) CoP assessment

Figure 5.16: CPX indices measured at Thrapston Site 3, 14 mm

Finally Figure 5.16 presents the results with respect to the second 14 mm surface at Thrapston. At this site the SPB measurements were taken at the start of the 14 mm section and the fall in CPX values along the test section reflects the properties of this part of the surface as presented in Figure 4.2. As with the previous sites the CoP tolerance is achieved with respect to both years' measurements.

It should be stressed that this is a limited study of four very short (<500 m) sections of low noise surface on the SRN and more data would be required for definitive conclusions to be drawn. Nevertheless the results from this work suggest that:

- The 0.5 dB(A) peak-to-peak labelling tolerance is unlikely to be achieved if the test section is taken from the SRN
- Test sections should not be located near the start or end of the length of the surface in question since results are very variable in this region and can have peak-to-peak differences of close to 2 dB(A) across 100 m (Figure 5.15and Figure 5.16)
- Assuming test sections are suitably located a peak-to-peak tolerance of 1 dB(A) may be achievable (Figure 5.13 and Figure 5.14)
- The 1.5 dB(A) tolerance defined as part of the CoP methodology is readily achievable.

6 Conclusions and recommendations

6.1 Project summary

The acoustic performance of low noise surfaces (together with an HRA and an EAC surface) have been assessed over a three year measurement programme from 2007 to 2009 through the collection of data from SPB, CPX and traffic noise surveys.

The results of the SPB measurements, in terms of high speed RSI, together with historical data are summarised in Figure 5.5. These results show that:

- On average, the acoustic performance of low noise surfaces deteriorates at a rate of 4.5 dB(A) over 10 years compared to a deterioration of 2 dB over 10 years for HRA and EAC
- On average, low noise surfaces outperform the reference HRA surface by between 4 and 6 dB(A) when new and outperform HRA by between 1 and 3 dB(A) after 10 years. However it should be cautioned that only one HRA surface has been tested.
- Taking into account the manner in which the low noise surface was constructed and laid and the stone size used, new low noise surfaces can provide acoustic benefits of between 3 and 8 dB(A) over a new HRA surface.

An examination of traffic and surface texture data over the life of some of the low noise surfaces, discussed in Section 5.2, showed no correlation between the acoustic performance of the surface and the traffic on the road. There is some correlation with texture depth but the variations in texture depth, lack of information on negative/positive texture and limited number of suitably old (>10 years) surfaces means that these data should be treated with some caution.

The traffic noise measurements are summarised in Table 4.5 and show that using the RSI derived from the SPB measurements as a correction to the basic noise level in a CRTN calculation gives reasonably good agreement between measured and predicted noise levels.

The results of the CPX measurements are shown in Figure 4.1 and Figure 4.2 which illustrate the not insignificant variation in acoustic performance of low noise surfaces along their length. On average there was found to be a 1 dB(A) variation in the CPX index over just a few hundred metres of a low noise surface. The results also highlighted the relatively poor acoustic performance provided near the start and end of test sections. From the, somewhat limited, dataset some acoustic deterioration can be observed over the course of a year, especially on the 6 mm surfaces.

An examination of the CPX results with respect to the implementation of the SILVIA acoustic labelling procedure, discussed in Section 5.4.2, showed that:

- Measurements taken along selected 100 m test sections varied by up to 1 dB(A) except where the test section was near the start or end of the surface in which variations of up to 2 dB(A) were recorded
- The CoP tolerance, that each 100 m section of the surface must be no more than 1.5 dB(A) above the index value derived from the test section, was met at all sites.

6.2 Potential impacts

The results of this work have implications for the corrections applied for low noise surfaces in noise mapping exercises, HAPAS certification and the use of the CoP methodology proposed as part of the SILVIA programme. Recommendations relating to these issues are discussed below.

From the results of Section 5.1.4 it is recommended that Annex 4 of HA 213/08 be amended to state that for an existing HRA surface a correction of +1 dB(A) is applied in place of 0 dB(A). This recommendation is supported by the measurement of a high speed RSI of +0.9 dB(A) for an 82 month old HRA surface reported in (Chandler et. al., 2003). This approach is likely to be cautionary but more realistic than the current approach, given the age of HRA surfaces on the SRN. If this is adopted, the wording of some documents (e.g. MCHW) would need to be checked to ensure that phrases such as 'in relation to the reference surface' are clear.

This proposed change would essentially only influence calculations undertaken to represent noise levels in the opening year since it is unlikely there would be any HRA on the network by the 15th year. The impact of this will mainly be on assessments where the noise level in the opening year is calculated and then compared with other conditions. With the surface correction for the reference surface being increased by 1 dB(A) this will have the effect of making the impact of any scheme appear more beneficial.

From the results of Section 5.1 (see Figure 5.5) it can be seen that the proposed correction of -3.5 dB(A) (see Table 5.1) already represents a good approximation of the average benefit of an existing low noise surface that has been part of the SRN for 5 years. It is therefore recommended that no further adjustments to this correction are required at present. There is scope for reduction in the proposed correction for new low noise surfaces since the average RSI for new low noise surfaces at the sites examined in this study is approximately -5 dB(A). There is however a large spread in these data and if it was found that most low noise surfaces on the SRN used a 14 mm aggregate size for example the existing correction of -3.5 dB(A) may be considered an appropriate, albeit conservative, estimate.

If the age and aggregate size of the low noise surface is known then the best fit lines shown in Figure 5.5, for 10 mm and 14 mm stone sizes, may be considered as constructive estimates of the potential acoustic benefit of the surface. An estimate for the average acoustic performance of a generic low noise surface in the first 10 years of its life may be derived from an average of these lines. This results in the following formula for estimating the acoustic benefit of a low noise surface:

$$\text{Surface Correction} = RSI + 0.45 \times (\text{Age of Surface})\ dB(A) \qquad (6.1)$$

where the age of the surface is interpreted as the time since the RSI was measured in years. If the RSI from the Highway Authority Product Approval Scheme (HAPAS) certification for the surface is not known it may be replaced by -5.5 in the equation; in this instance the age of the surface would then equate to the time elapsed since the surface was laid.

It is recommended that the noise level to be reached for a HAPAS certificate to be awarded is reduced. Using the whole life acoustic performance approach, adopted in Section 5.3.2, this level could be set to -4.1 dB(A) in order for the acoustic performance of a surface to be of benefit for 10 years. However, it is recommended that a cautionary approach of -3.5 dB(A) be adopted as this would also align better with that used in HA213/08 for new low noise surfaces. Although this level is currently met by almost all new surfaces, it will act to ensure that acoustic performance remains a consideration in designing surfaces.

6.3 Future assessment

Although a relatively large dataset on low noise surfaces has been collected as part of this work there are several key deficiencies in the data which have prevented stronger recommendations from being made in Section 6.2. As such focussed approaches to continued monitoring of the impact and behaviour of low noise surfaces are discussed in this section.

In addition to the continued assessment of some low noise surfaces it is recommended that a series of SPB measurements be undertaken on several HRA surfaces to confirm the relationship found in this study and better inform a more appropriate surface correction for an old HRA surface. Although no longer laid there is still a significant amount of HRA on the SRN and an understanding of its acoustic behaviour will better define the benefit received from introducing low noise surfaces. This will improve the accuracy of many ‘opening year’ assessments and may, for example, explain recent reports of greater than expected noise reductions from low noise surfaces (Pease, 2009). If possible SPB measurements should be taken at a location where measurements have been undertaken previously in order to compare with the long term performance from this study.

With respect to low noise surfaces the 10 mm and 14 mm datasets are relatively robust and cover at least a 10 year span in total, however the 6 mm dataset contains some large variations between surfaces and only covers a 6 year span in total which is considered to be shorter than the intended life of the surface. It is therefore recommended that further measurements are required at sites with low noise surfaces using a 6 mm stone size to better understand their long term acoustic deterioration. These data will be especially important if reduced costs result in 6 mm surfaces becoming increasingly common.

The definition of a low noise surface, discussed in Section 5.3.2, the results of which were used to help recommend changes to HAPAS noise certification, assumed an average life of a low noise surface to be 10 years. It is recommended that data are collected on the actual life of low noise surfaces in order to better define the expected life and hence the requirements for HAPAS certification and long term acoustic performance. If it is found that the life of a low noise surface is greater than 10 years then further data on 10 mm and 14 mm surfaces will also be required.

The trialling of the CoP methodology defined in the SILVIA programme has proven relatively successful but only covers short test sections where low noise surfaces have been laid for only a few hundred metres. There were also some differences in the way in which the measurements were carried out, as outlined in Section 5.4.2. Given these differences and the variability in CPX index of the tested surfaces over these short distances it would therefore be constructive to conduct an in-depth trial of the method over longer test sections. This would have the advantage of providing greater flexibility in the location of a suitable labelling section and provide the opportunity to conduct two distinct SPB measurements as defined in the methodology, although labelling sections will still be restricted to areas such as lay-bys where SPB measurements can be conducted. It would also mean that labelling sections could be selected away from areas where it has been shown that the acoustic variability can be large such as where the surface starts or ends.

None of the labelling sections of the SRN defined as part of this work met the stringent 0.5 dB(A) peak-to-peak tolerance defined as part of the methodology so it is anticipated that, even with longer test sections, this tolerance would need to be relaxed to 1-1.5 dB(A) if labelling sections were to be taken from the SRN. The CoP tolerance was met by all test sections however indicating that this tolerance is readily achievable and could potentially be obeyed on longer sections of road.

Another issue to resolve prior to the introduction of the CoP methodology concerns the approach taken if section(s) of the low noise surface fail to meet the defined tolerance since this was considered outside the scope of the work conducted as part of the SILVIA programme.

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Appendix A Site photographs

Figure A1: A259 Pevensey Site 1

Figure A2: A259 Pevensey Site 2

Figure A3: A259 Pevensey Site 3

Figure A4: A5 Gibbet Hill Site 1

Figure A5: A14 Creeting St. Mary Site 1

Figure A6: M6 Leyland Site 1

Figure A7: M6 Leyland Site 2

Figure A8: A331 Aldershot Site 1

Figure A9: A34 West Ilsley Site 1

Figure A10: A27 Havant Site 1

Figure A11: A27 Havant Site 2

Figure A12: A27 Havant Site 3

Figure A13: A27 Havant Site 4

Figure A14: A14 Thrapston Site 2

Figure A15: A14 Stanford Site 1

Figure A16: A14 Huntingdon Site 1

Figure A17: A14 Huntingdon Site 2

Figure A18: M65 Burnley Site 1

Figure A19: M65 Burnley Site 2

Figure A20: M5 Taunton Site 1

Figure A21: M5 Taunton Site 2

Figure A22: A55 Bangor Site 1

Figure A23: A55 Bangor Site 2

Figure A24: A14 Thrapston Site 1

Figure A25: A14 Thrapston Site 3

Figure A26: A14 Stanford Site 2

Figure A27: A50 Sudbury HRA Site 1

Figure A28: A50 Foston EAC Site 1

Appendix B Site locations

All measurement sites are shown in Table B1 below. These have been selected after site visits made during September 2007. A photograph of each site can be found in Appendix A.

Table B1: Selected measurement sites

Stone size	Road	Location	Direction of travel	Other site details	Site number	Date surface laid
6mm	A259	Pevensey	West	N 50° 50.410' E 00° 22.260'	1	November 2003
	A259	Pevensey	West	N 50° 50.210' E 00° 22.020'	2	November 2003
	A259	Pevensey	West	N 50° 50.270' E 00° 22.090'	3	October 2004
	A5	Gibbet Hill	North	N 52° 26.000' W 01° 14.201'	1	December 2005
	A14	Creeting St Mary	West	MP 17/20 N 52° 10.299' E 01° 03.168'	1	June 2006
10mm	M6	Leyland	North	MP 339/2 N 53° 40.641' W 02° 41.076'	1	June 1999
	M6	Leyland	South	MP 339/2 N 53° 40.461' W 02° 41.070'	2	June 1999
	A331	Aldershot	South	MP 4/9 +60m N 51° 16.240' W 00° 44.050'	1	March 2000
	A34	West Ilsley	South	MP 56/98 N 51° 32.101' W 01° 17.706'	1	March 2000
	A27	Havant	West	MP 58/0 N 50° 51.414' W 00° 54.891'	1	March 2005
	A27	Havant	West	MP 55/8 N 50° 51.176' W 00° 56.672'	2	March 2005
	A27	Havant	East	MP 63/7 N 50° 50.940' W 00° 50.325'	3	September 2005
	A27	Havant	West	MP 60/8 N 50° 51.367' W 00° 52.639'	4	September 2005
	A14	Thrapston	East	MP 56/8 N 52° 21.784' W 00° 25.362'	2	September 2006

Stone size	Road	Location	Direction of travel	Other site details	Site number	Date surface laid
	A14	Stanford	West	MP 4/6 N 52° 23.600' W 01° 07.077'	1	August 2007
14mm	A14	Huntingdon	South	MP 115/8 N 52° 21.176' W 00° 13.576'	1	February 1999
	A14	Huntingdon	North	MP 115/6 N 52° 21.125' W 00° 13.554'	2	February 1999
	M65	Burnley	East	MP 28/6 N 53° 46.978' W 02° 18.549'	1	August 1999
	M65	Burnley	East	MP 28/9 N 53° 46.580' W 02° 18.440'	2	August 1999
	M5	Taunton	North	MP 210/79 N 50° 59.511' W 03° 05.780'	1	February 2001
	M5	Taunton	North	MP 210/44 N 50° 59.576' W 03° 05.600'	2	February 2001
	A55	Bangor	East	MP 41/4 N 53° 13.280' W 04° 03.230'	1	February 2005
	A55	Bangor	East	MP 42/8 N 53° 13.560' W 04° 01.450'	2	February 2005
	A14	Thrapston	East	MP 55/6 N 52° 21.904' W 00° 26.332'	1	September 2006
	A14	Thrapston	East	MP 56/9 N 52° 21.773' W 00° 25.301'	3	September 2006
	A14	Stanford	East	MP 4/2 N 52° 23.623' W 01° 07.117'	2	August 2007
HRA	A50	Sudbury	West	MP 103/3 N 52° 53.088' W 01° 44.210'	1	August 1995
EAC	A50	Foston	East	MP 99/4 N 52° 52.882' W 01° 40.523'	1	August 1995

Appendix C RSI summary tables

Table C1 gives the year that each surface was laid (highlighted in green) and also the results from any previous SPB measurements, given as RSI levels. These levels are intended only as indications, as some levels are temperature corrected and others are not. It is unlikely that any level would change by more than 0.1 as a result of this.

Table C1: Site details of age and previous SPB measurements results

Stone size	Road/Site	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
6mm	A259 Pevensey Site 1										-4.4		-5.1		-3.8	-4.3
	A259 Pevensey Site 2												-6.1		-2.5	-1.9
	A259 Pevensey Site 3										-6.3		-6.4		-5.2	-5.9
	A5 Gibbet Hill													-7.5	-8.7	-7.5
	A14 Creeting St Mary													-6.5	-5.8	-5.0
10mm	M6 Leyland Site 1					-5.9			-4.2						-2.5	-1.7
	M6 Leyland Site 2					-5			-3.5						-1.5	-2.1
	A331 Aldershot								-3.7			-4.3			-2.2	-1.5
	A34 West Ilsley							-6.8							-1.6	-2.3
	Havant Site 1														-5.9	-6.2
	Havant Site 2														-6.0	-6.1
	Havant Site 3														-5.9	-5.2
	Havant Site 4														-6.1	-6.9
	A14 Thrapston Site 2													-4.9	-4.7	-6.6
	A14 Stanford Site 1													-7.2	-7.7	-6.2
14mm	A14 Huntingdon Site 1							-3.0						-0.2	0.5	-0.6
	A14 Huntingdon Site 2							-2.2						0.5	-0.3	-0.3
	M65 Burnley Site 1								-2.2						-0.5	0.3

Stone size	Road / Site	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	M65 Burnley Site 2								-2.2						-0.8	0.1
	M5 Taunton Site 1								-4.7						-1.1	-2.6
	M5 Taunton Site 2								-4.5						-1.2	
	A55 Bangor Site 1												-3.3		-3.3	-2.0
	A55 Bangor Site 2												-5		-4.6	-3.5
	A14 Thrapston Site 1													-4.5	-3.8	-5.7
	A14 Thrapston Site 3													-3.5	-3.8	-3.7
	A14 Stanford Site 2													-3.6	-3.0	-3.1
20mm	A50 HRA Sudbury	-1.1	-0.1			0.3					1.4			1.7	1.6	2.1
	A50 EAC Foston	-3.2	-2.3			-1.0			-0.9		-0.5				-0.4	-0.7

Table C2 shows the reference noise levels and temperatures on which the RSI values are based.

Table C2: Summary of SPB data

Stone size	Location	Site	Measurement date	Age (months)	$L_{veh,L}$ dB(A)	$L_{veh,H1}$ dB(A)	$L_{veh,H2}$ dB(A)	Air temperature	Surface temperature	RSI
6mm	A259 Pevensey Westbound	1	March 2004	4	80.3	83.3	86.6	19.0	30.0	-4.4
			April 2006	29	79.6	82.9	85.9	19.0	30.0	-5.1
			May 2008	54	81.1	83.5	87.2	14.5	20.3	-3.8
			September 2009	70	80.5	83.0	86.7	20.3	25.7	-4.3
	A259 Pevensey Westbound	2	April 2006	18	78.5	81.7	84.9	19.0	30.0	-6.1
			May 2008	43	82.4	85.2	88.5	14	17.2	-2.5
			June 2009	56	83.5	85.8	87.2	26.5	35.4	-1.9
	A259	3	March 2004	4	78.5	81.7	84.3	19.0	30.0	-6.3

Stone size	Location	Site	Measurement date	Age (months)	$L_{veh,L}$ dB(A)	$L_{veh,H1}$ dB(A)	$L_{veh,H2}$ dB(A)	Air temperature	Surface temperature	RSI
10mm	Pevensey Westbound		April 2006	29	78.2	81.6	84.6	19.0	30.0	-6.4
			May 2008	54	79.6	82.1	85.8	16.7	24.9	-5.2
			June 2009	67	79.0	83.1	84.4	24.4	28.7	-5.9
	A5 Gibbet Hill Nortbound	1	October 2007	22	76.1	82.2	84.6	14.1	13.5	-7.5
			May 2008	29	75.5	79.6	82.9	19.5	25.3	-8.7
			September 2009	45	76.8	81.9	83.5	17.3	21.8	-7.5
	A14 Creeting St Mary Westbound	1	October 2007	16	77.4	82.9	85.5	14.8	15.2	-6.5
			May 2008	23	78.4	83.8	85.4	21.3	24.9	-5.8
			August 2009	38	79.4	83.6	86.1	26.0	32.6	-5.0
	M6 Leyland Northbound	1	August 1999	2	78.3	83.4	85.5	16.0	20.5	-5.9
			August 2002	38	80.8	84.3	86.1	22.0	26.5	-4.1
			June 2008	108	82.8	84.6	87.7	15.4	21.1	-2.5
			September 2009	123	83.6	85.3	88.1	16.0	17.0	-1.7
	M6 Leyland Southbound	2	August 1999	2	80.0	83.4	85.3	18.0	22.0	-5.0
			August 2002	38	81.6	84.9	86.6	23.5	27.0	-3.4
			June 2008	108	84.0	86.0	87.9	17.3	23.4	-1.5
			September 2009	123	83.2	84.5	87.7	18.0	21.1	-2.1
	A331 Aldershot Southbound	1	August 2002	29	81.3	84.2	86.8	19.5	21.0	-3.7
			June 2005	63	80.7	84.9	85.4	23.5	33.5	-4.2
			June 2008	99	82.9	84.9	87.9	23.8	29.7	-2.2
			August 2009	113	84.0	84.8	87.8	24.7	30.7	-1.5
	A34 West Ilsley	1	July 2001	16	78	81.8	83.9	27.0	39.0	-6.6
			May 2008	98	84.1	85.5	87.9	11.7	12.4	-1.6

Stone size	Location	Site	Measurement date	Age (months)	$L_{veh,L}$ dB(A)	$L_{veh,H1}$ dB(A)	$L_{veh,H2}$ dB(A)	Air temperature	Surface temperature	RSI
	Southbound		September 2009	114	83.1	84.7	87.1	15.7	19.2	-2.3
	A27 Havant Westbound	1	May 2008	38	78.8	82.2	85.1	18.6	22.8	-5.9
			June 2009	51	78.6	82.1	84.5	26.8	28.1	-6.2
	A27 Havant Eastbound	2	May 2008	32	78.3	83.0	85.1	21.3	30.3	-6.0
			June 2009	45	78.6	82.0	84.8	28.0	32.9	-6.1
	A27 Havant Westbound	3	May 2008	38	78.5	82.8	85.5	18.7	20.4	-5.9
			June 2009	51	76.6	82.4	85.6	18.7	54.0	-5.2
	A27 Havant Westbound	4	May 2008	32	78.4	83.0	84.7	21.5	27.8	-6.1
			September 2009	45	77.8	81.8	83.8	19.3	31.7	-6.9
	A14 Thrapston Eastbound	2	September 2007	12	79.7	83.9	86.3	11.6	13.9	-4.9
			June 2008	21	79.7	83.7	86.7	20.4	22.9	-4.7
			July 2009	34	77.7	82.1	84.8	27.0	33.6	-6.6
	A14 Stanford Westbound	1	September 2007	1	77.8	81.7	83.4	11.6	15.8	-7.2
			June 2008	10	77.1	80.9	83.1	13.8	20.3	-7.7
			July 2009	23	78.7	82.6	83.9	17.7	25.4	-6.2
14mm	A14 Huntingdon Southbound	1	May 2001	27	82.4	84.5	87.4	9.0	14.0	-3.0
			October 2007	104	85.5	86.4	88.9	17.6	21.8	-0.2
			June 2008	112	86.3	86.8	89.4	17.4	21.5	0.5
			June 2009	124	85.0	85.3	88.5	28.7	33.6	-0.6
	A14 Huntingdon Northbound	2	May 2001	27	83.2	85.1	87.6	16.5	20.5	-2.2
			October 2007	104	85.9	88.9	90.1	15.1	15.4	0.5
			June 2008	112	85.0	86.2	89.4	23.5	35.4	-0.3
			June 2009	124	85.3	85.8	89.2	30.3	40.4	-0.3

Stone size	Location	Site	Measurement date	Age (months)	$L_{veh,L}$ dB(A)	$L_{veh,H1}$ dB(A)	$L_{veh,H2}$ dB(A)	Air temperature	Surface temperature	RSI
	M65 Burnley Eastbound	1	August 2002	36	83.2	85	87.3	18.5	24.5	-2.2
			June 2008	106	85.3	86.0	88.0	20.4	26.0	-0.5
			September 2009	121	86.1	86.9	88.9	15.0	14.1	0.3
	M65 Burnley Eastbound	2	August 2002	36	83.2	85.2	87.5	17.0	21.5	-2.2
			June 2008	106	84.7	85.7	88.5	18.5	29.5	-0.8
			September 2009	121	85.7	86.5	89.2	20.0	23.3	0.1
	M5 Taunton Northbound	1	June 2002	16	80.6	83.5	85.0	17.5	24.5	-4.7
			June 2008	88	84.5	86.4	88.1	17.4	20.3	-1.1
			August 2009	102	82.7	84.8	86.9	19.7	24.4	-2.6
	M5 Taunton Northbound	2	June 2002	16	80.4	83.9	85.9	19.5	24.5	-4.5
			June 2008	88	84.3	85.6	88.1	22.7	27.0	-1.2
	A55 Bangor Eastbound	1	July 2006	17	82.2	83.2	85.7	23.6	27.5	-3.3
			June 2008	40	82.4	83.7	86.2	14.1	15.0	-3.3
			August 2009	54	83.5	85.1	87.3	21.6	28.3	-2.0
	A55 Bangor Eastbound	2	July 2006	17	80.4	82.1	84.3	25.7	30.6	-5.0
			June 2008	40	81.1	81.7	84.4	16.6	22.1	-4.6
			August 2009	54	81.9	83.5	86.3	22.3	30.3	-3.5
	A14 Thrapston Eastbound	1	October 2007	13	81.0	82.5	85.6	13.7	12.9	-4.5
			June 2008	21	81.6	83.5	85.7	20.0	25.3	-3.8
			July 2009	34	79.0	82.2	85.0	26.7	32.4	-5.7
	A14 Thrapston Eastbound	3	September 2007	12	81.9	82.8	86.7	15.3	11.7	-3.5
			June 2008	21	81.4	83.2	86.1	22.3	29.1	-3.8
			July 2009	34	81.4	83.2	86.8	31.3	38.4	-3.7

Stone size	Location	Site	Measurement date	Age (months)	$L_{veh,L}$ dB(A)	$L_{veh,H1}$ dB(A)	$L_{veh,H2}$ dB(A)	Air temperature	Surface temperature	RSI
	A14 Stanford Eastbound	2	September 2007	1	81.8	84.1	86.6	11.1	11.8	-3.6
			June 2008	10	82.2	85.1	87.3	13.6	18.0	-3.0
			July 2009	23	81.6	85.0	87.5	18.4	19.8	-3.1
20mm HRA	A50 Sudbury Westbound	1	October 1995	2	84.1	87.1	88.6	20.0	30.0	-1.1
			December 1996	16	85.2	87.0	89.8	20.0	30.0	-0.1
			November 2000	63	85.8	87.5	89.7	20.0	25.0	0.3
			June 2004	106	87.1	88.3	90.3	19.0	19.0	1.4
			September 2007	145	87.6	87.6	90.3	17.0	18.8	1.7
			May 2008	153	87.4	88.3	90.6	17.3	16.6	1.6
			July 2009	167	87.8	88.6	90.8	16.7	20.1	2.1
20mm EAC	A50 Foston Eastbound	1	October 1995	2	81.7	84.6	87.5	19.0	30.0	-3.2
			December 1996	16	82.7	86.6	87.5	19.0	30.0	-2.3
			November 2000	63	84.4	86.4	88.7	19.0	23.0	-1.0
			June 2002	82	84.9	86.4	88.4	9.9	11.1	-0.9
			June 2004	106	85.3	86.5	89.1	8.0	7.0	-0.5
			May 2008	153	85.1	86.5	88.8	20.8	22.4	-0.4
			July 2009	167	84.8	86.2	88.6	20.3	23.7	-0.7

Default values used (19,30 gives no temperature correction)

The performance of quieter surfaces over time

The Highways Agency implements the Government's noise policy of mitigating the effects of noise, where practicable, arising from traffic on the Strategic Road Network (SRN). Quieter surfaces have been one of the key measures used by the Agency in order to manage and reduce noise impacts where possible. However, very little is known about the long term acoustic performance of these surfaces, which is essential when considering the sustainability of this type of mitigation. This work focuses on this need through the collection and analysis of appropriate long term data.

As well as providing information on which to form appropriate long term surfacing corrections to be used in noise assessments, the data are designed to assist the Agency's response to the Environmental Noise Directive. In addition the feasibility and practicality of using the principles of the acoustic classification system, defined as part of the European SILVIA programme, on the SRN have been investigated.

The acoustic performance of low noise surfaces (together with a Hot Rolled Asphalt and an Exposed Aggregate Concrete surface) have been assessed over a three year measurement programme through the collection of data from Statistical Pass-By, Close Proximity and traffic noise surveys. These data have been analysed in conjunction with historical data to provide recommendations on the classification and performance of low noise surfaces over time.

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