THE FUTURE OF TRANSPORT

PUBLISHED PROJECT REPORT PPR2023

Skid resistance benchmark surveys 2022

Stuart Brittain

Report details

Report prepared for:	National Highways, SES		
Project/customer reference:	SPaTS 2: T0098		
Copyright:	© TRL Limited		
Report date:	10/01/2023		
Report status/version:	1.0		
Quality approval:			
Minal Jose (Project Manager)	**M Jose**	Martin Greene (Technical Reviewer)	**M Greene**

Disclaimer

Executive summary

As part of its process for managing skid resistance on the Strategic Road network (SRN), National Highways undertakes single annual skid resistance surveys (SASS). These surveys are carried out over the course of the summer and are split over three survey periods (early, middle and late). It is known that skid resistance varies during the year and between years and the survey data is corrected by the application of correction factors called the "Local Equilibrium Correction Factors" (LECF). To monitor the ongoing trends in skid resistance levels, National Highways established a series of benchmark sites. These sites are surveyed in all three of the survey periods during the survey season. The data collected is then examined for within year and between year trends in the skid resistance levels. This report discusses the analysis of the survey data collected in 2022, and compares the results of the analysis to those from earlier years.

Initially, in 2002, 39 sites were selected as benchmark sites, with two additional sites added in 2008 and a further two in 2009. The initial 39 sites contain mainly asphalt surfaces and the additional four contain mainly concrete surfaces.

One site (site 32) was removed from the long-term reference benchmark site list (sites which have a full survey history and have had no treatment since 2002) during the 2022 analysis. Currently 10 of the original 39 sites are suitable for use in the investigation of trends since 2002. An approach proposed in the analysis of the 2011 data and amended in 2020 to increase the amount of data used, resulted in 411 individual 100m lengths being suitable for use in the investigation of skid resistance trends over the last 10 years.

Comparison of the mean summer skid coefficient (MSSC) values from the benchmark sites suggests that 2022 was an "very low skid resistance" year in comparison to the average of the previous three years or when considering all of the years in the analysis. It should also be noted that this particularly low value in 2022 will cause the seasonally corrected data in 2023 (CSC) to be lower likely resulting in a notable increase in lengths identified as requiring an investigation under CS228 in 2023. In addition, the minimum value of the skid resistance values appears to have occurred around the middle/late survey period boundary in 2022.

For the 2022 survey, the between run variation of the data from the concrete sites (4.21 SR) was higher than the expected variation of repeat skid resistance measurements on a given day under the same weather conditions (3 SR). However, the variation of skid resistance over the year is seen to be different to that for the asphalt sites, and therefore the practice of applying an LECF of 1 to the concrete lengths should continue (as there is not sufficient length to calculate robust stand-alone LECFs for concrete surfaces). It has been noted that the average SR value for the concrete lengths has been low for the last three years, and as such it was recommended that this is further investigated by analysing the network data for concrete lengths.

An investigation into different geographic groupings of the benchmark sites was undertaken and this found that there might be a difference in the seasonal variation of skid resistance when moving south to north across England. However, it was not possible to come to a clear conclusion on this and as such this should be further investigated and built upon in future benchmark sites analyses.

Table of Contents

1 Introduction

1.1 Background

As part of its process for managing skid resistance on the Strategic Road network (SRN), National Highways undertakes single annual skid resistance surveys (SASS). These surveys are carried out over the course of the summer and are split over three survey periods (early, middle and late). It is known that skid resistance varies during the year and between years and the survey data is corrected by the application of correction factors called the “Local Equilibrium Correction Factors” (LECF). Further details on the surveys and how LECFs are calculated can be found in the skidding resistance part of the DMRB (DMRB CS 228)

In order to investigate long term trends in skid resistance values, National Highways established a series of benchmark sites. These benchmark sites have three surveys in each survey season (one in each survey period) in addition to the routine annual skid resistance survey. These additional surveys allow for the investigation of trends in skid resistance within and between years.

The first of the benchmark site surveys occurred in 2002 and they have been carried out in each year since. Initially there were 39 benchmark sites selected using the following criteria:

1. The site should be well defined (i.e. easily locatable)
2. Safe to test at 50km/h
3. Traffic delays or parked vehicles unlikely
4. Straight and level
5. Typical road surfacings (excluding concrete)
6. Surfacing in good condition

As part of the investigation into the seasonal correction values generated for the network (Donbavand & Brittain, 2007), it was found that concrete did not appear to behave in the same way as asphalt surfaces with regards to seasonal variation. National Highways therefore decided that some concrete sites should be added to the benchmark site investigations. Two sites were added in 2008 (labelled 40 and 41) and a further two were added in 2009 (labelled 42 and 43).

The expected distribution of skid resistance (shown diagrammatically in Figure 1.1) means that skid resistance should be at similar levels in the early and late period surveys with the middle period producing slightly lower results. However, during the analysis of the 2005 benchmark site data it was found that the late surveys did not appear to return to levels similar to the early surveys. It was decided that an additional very late survey (i.e. after the late period survey) would be conducted in 2006 to see if the skid resistance values returned to the levels seen in the early period. This additional survey was also conducted in 2007, 2008 and 2009. A review of the data from the additional very late surveys suggested that the skid resistance was returning to levels seen in the early period during the very late period. Based on these findings, National Highways decided that the survey season should be modified so that the late surveys would produce similar results to the early surveys. The modified survey periods were first used for the 2010 surveys and the survey periods are shown in Table 1.1. Analyses undertaken since 2010 have shown that the revised dates for the survey periods continue to remain suitable.

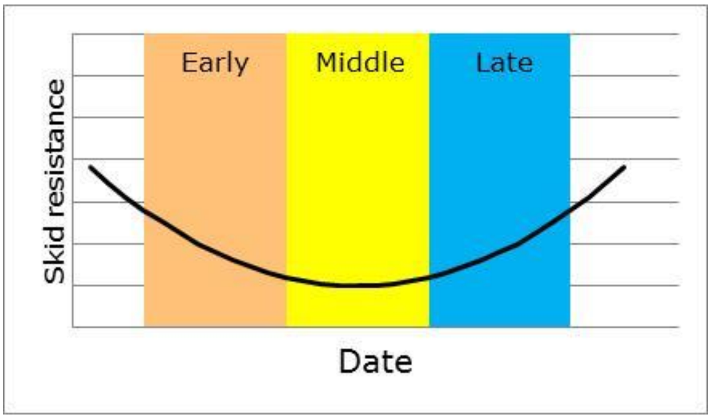

Figure 1.1: Expected seasonal variation of skid resistance over the summer

Table 1.1: Dates for the skid resistance survey periods

	Prior to 2010	2010 onwards
Early start	1st May	1st May
Early end	20th June	27th June
Middle start	21st June	28th June
Middle end	10th August	24th August
Late start	11th August	25th August
Late end	30th September	20th October
Very Late[1] start	1st October	n/a
Very late end	31st October	n/a

1.2 Directory of benchmark sites

The location and condition of each benchmark site is detailed within the directory of benchmark sites. The directory is a spreadsheet which contains schematics and summaries of the operators' notes to illustrate the surface changes and condition of each site. This directory is updated after each survey period to reflect the changes observed. The location information from the directory is reproduced in Table A.1 of Appendix A.

[1] The Very Late period was included in the surveys conducted in 2006 to 2009

2 Analysis process

2.1 Development of 10 year rolling analysis

During the analysis of the 2011 skid resistance benchmark sites data (Brittain, 2012) it was proposed that the analysis process should be amended. Prior to the amendment, the process involved examining the data from all of the sites which had not had any treatment or other anomaly since the start of the benchmark site programme in 2002. Using this approach meant that, for the report on the 2011 data, only 21 of the 39 sites could be used in the main analysis.

To increase the amount of data included in the main analysis, a new approach was formulated which would only exclude the lengths maintained, rather than removing the whole site. In addition, a new cut-off date for identifying sites with anomalies or resurfaced lengths would be set at 2010 rather than 2002. This new date was selected in part due to availability of the data in a format suitable for this analysis, and partly due to the change in the survey periods which occurred in 2010.

In the analysis of the 2019 skid resistance benchmark sites data (Brittain, 2020) it was proposed that this analysis should be further refined to use a rolling 10 year analysis, i.e. for the analysis of the 2022 surveys, data from 2013 to 2022 would be used. The results from this analysis, incorporating the data from the 2022 surveys, are given in section 4.

2.2 Combining 10 year rolling analyses

Over time, the 10 year rolling analysis approach will result in overlapping sets of 10 year analyses. Therefore, to provide an indication of trends going back to 2010 a method of providing values normalised to the current analysis from years before the current 10 year window was developed prior to the 2022 analysis.

The first step of this process is to determine the normalisation factor. This is calculated by dividing the average SR value for the earliest survey year in the current analysis by the average of the values obtained in previous analyses (which themselves are the average values of the included lengths) for the same survey year. This normalisation factor is then multiplied by the average SR values obtained for the earlier survey analyses (either directly measured or the normalised values) to generate the normalised value. This process is then repeated to produce normalised values back to 2010. An example illustrating this process is given in Figure 2.1.

	Average SR for 2013 analysis year	Average SR for 2014 analysis year	Average SR for 2015 analysis year	Average SR for 2016 analysis year	Average SR for 2017 analysis year	Average SR for 2018 analysis year	Average SR for 2019 analysis year	Average SR for 2020 analysis year	Average SR for 2021 analysis year
2010 survey year	I	II	III	IV	V	VI	VII	a	b
2011 survey year	VIII	IX	X	XI	XII	XIII	XIV	XV	c
2012 survey year	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV
2013 survey year	…	…	…	…	…	…	…	…	…
2014 survey year	-	…	…	…	…	…	…	…	…
2015 survey year	-	-	…	…	…	…	…	…	…

Where:

$$a = \frac{XV}{Average(VIII\ to\ XIV)} \times Average(I\ to\ VII)$$

$$b = \frac{XXIV}{Average(XVI\ to\ XXIII)} \times Average(I\ to\ a)$$

$$c = \frac{XXIV}{Average(XVI\ to\ XXIII)} \times Average(VIII\ to\ XV)$$

Figure 2.1: Overview of process for calculating normalised values for examination of trends since 2010

2.3 Examination of trends going back to 2002

So that it is still possible to examine trends going back to 2002, an analysis based on the original approach was also undertaken and is reported in Appendix B.

Consideration was given to merging this data into the combined analysis discussed in section 2.2. However, the change in survey periods prior to the 2010 surveys and the different approaches to the datasets meant that this did not appear to be a suitable approach.

Over time the original approach for processing the benchmark sites is becoming less robust due to the reduction in the number of sites that are suitable for inclusion in the analysis. Therefore, the appropriateness of this analysis will be reviewed annually, and will be removed when it is no longer deemed sufficiently robust. The review of the 2022 data found that it is still suitable to report the trends going back to 2002.

3 Survey issues

3.1 Alignment of data

Prior to 2021, the survey contractor provided data with markers entered using push button entry. When using these markers to align the data, it was found that the resulting alignments were, in general, good. It is, however, sometimes necessary to shift the locations of the markers by up to 50m (based on a visual analysis of the patterns in the data).

For the review of the 2021 surveys the data was manually aligned (using the graph shapes and OSGR data). This work identified that it would be better to use fitting tools to automatically identify the marker position using the OSGR data. This should ensure a good starting point for the alignment process. This was introduced for the 2022 surveys and the fitting was carried out using the software provided by National Highways (Machine Survey Pre-processor or MSP) to survey contractors to fit data for the SASS of the network. After fitting, the data was reviewed manually to identify if any small changes to the alignment would be necessary.

To run the fitting process, route files are required which contain OSGR coordinates of specified points in the survey. These were created prior to the 2022 analysis using the nodes from National Highways network sections. The use of National highways network sections will make it easier to extract the matching construction records (and other useful data) from National Highways pavement management system. However, because the network definition can change over time, the route files will need to be reviewed annually and updated as appropriate. In addition, some of the sites might start and finish partway through sections; as such, a record will be kept of these offsets and applied to the fitted data before manually checking the alignment.

3.2 Issues and observations from surveys

For the 2022 survey data, six sites (5, 8, 11, 21, 31 and 32) had issues identified from the data, the construction records in National Highways' pavement management system (HAPMS, soon to be replaced with P-AMS), the video and/or from the operator's notes (recorded in the directory of benchmark sites).

3.2.1 Site 5

For the late survey this site was surveyed on the opposite carriageway and as such the 2022 survey of this site has been marked invalid.

3.2.2 Site 8

On examination of the 2022 survey data from site 8 it could be seen that there was some additional variability to the data in the first 150m. The survey operator's notes identified that there were potholes/ravelling during the Early survey. Examination of the survey data (shown in Figure 3.1) shows that the length deteriorates by the time of the middle survey. The survey operator's notes identifies that a new surface was then in place by the time of the late survey over this length (at the time of this report this maintenance was not recorded in HAPMS). Therefore, the first part of the site has been marked as invalid for the 2022 survey.

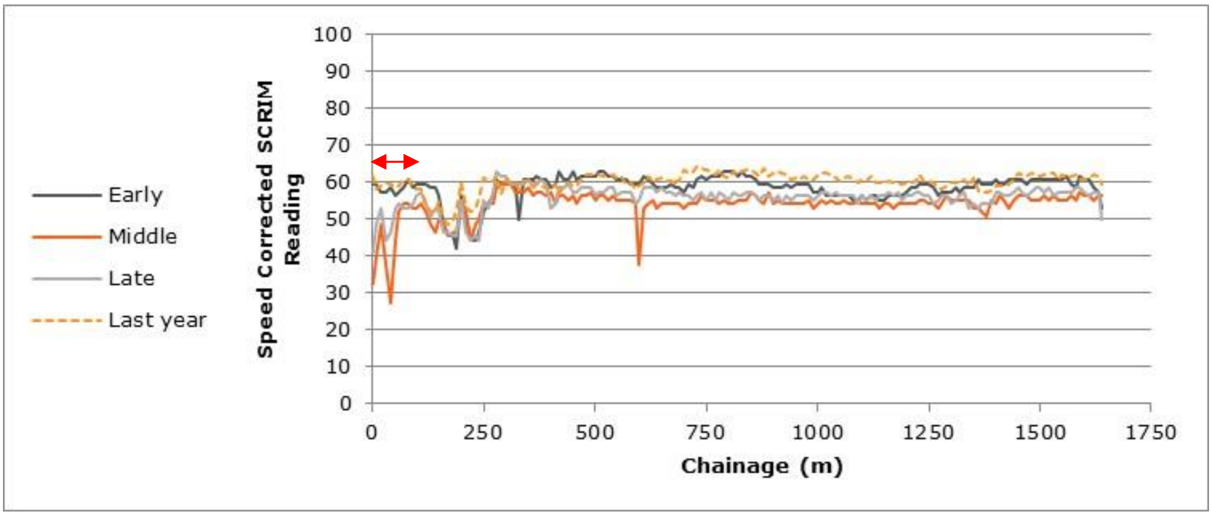

Figure 3.1: Skid resistance values from the 2022 survey for site 8

3.2.3 Site 11

During analysis of the 2022 data from site 11 it was noted that there was a spike in the 2022 surveys just before 750m that was not present in the previous years' surveys. No feature was identified at this point in the operator's notes, nor is there a record of maintenance of this length in HAPMS. However, this feature is quite distinct and is visible in all of the 2022 surveys. Therefore, this length has been marked as changed and excluded from the analysis (it will be included again in 10 years assuming the future survey data matches).

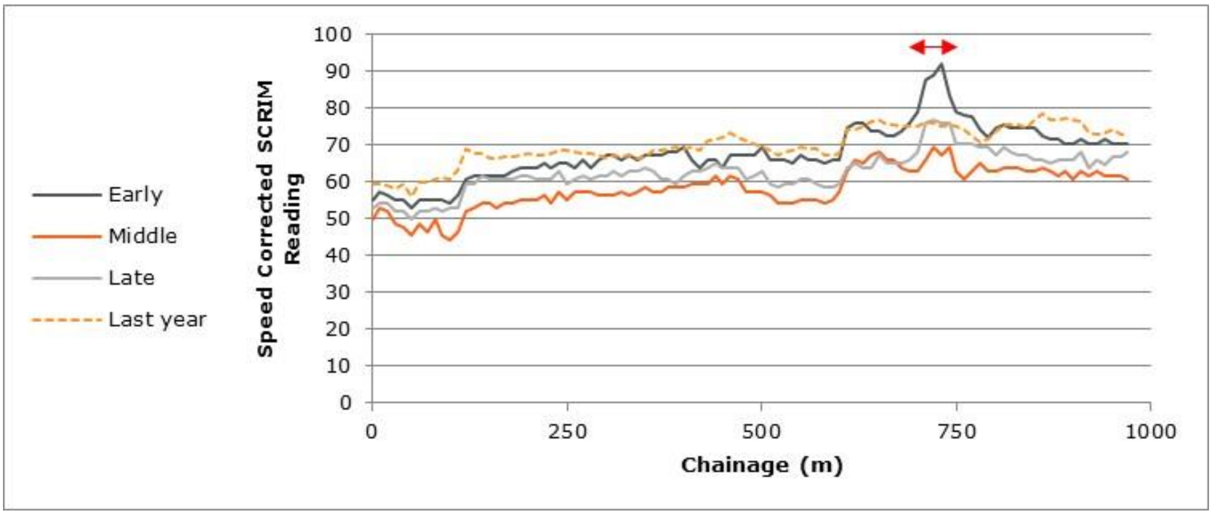

Figure 3.2: Skid resistance values from the 2022 survey for site 11

3.2.4 Site 21

The 2022 data from site 21 showed two new features, one around 1300m and one around 1700m. The construction records in HAPMS for this site showed maintenance of these lengths in November 2021 (i.e. between the 2021 and the 2022 surveys). The features were not recorded in the operator's notes (most likely the maintenance has blended in by the time of the survey). The length around 1300m has been marked as changed (to be re-included in 10 years). The length around 1700m was different between the 2022 surveys and has such been marked as invalid.

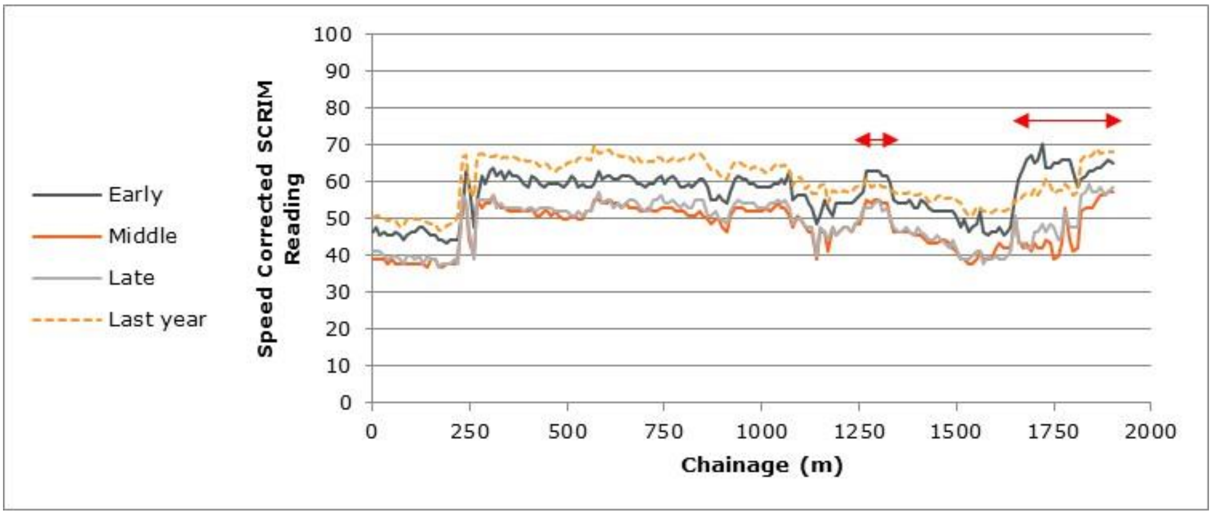

Figure 3.3: Skid resistance values from the 2022 survey for site 21

3.2.5 Site 31

On examination of the site 31 data it could be seen that the first 120m was variable between the 2022 surveys. In addition, from the end of this length to 210m there was a feature in the data which was present in the 2022 surveys but not the 2021 surveys. The HAPMS construction records include maintenance of this length in February 2022 (no feature noted in the survey notes). Due to these features the first length (to 120m) was marked as invalid, and the next length (to 210m) was marked as changed.

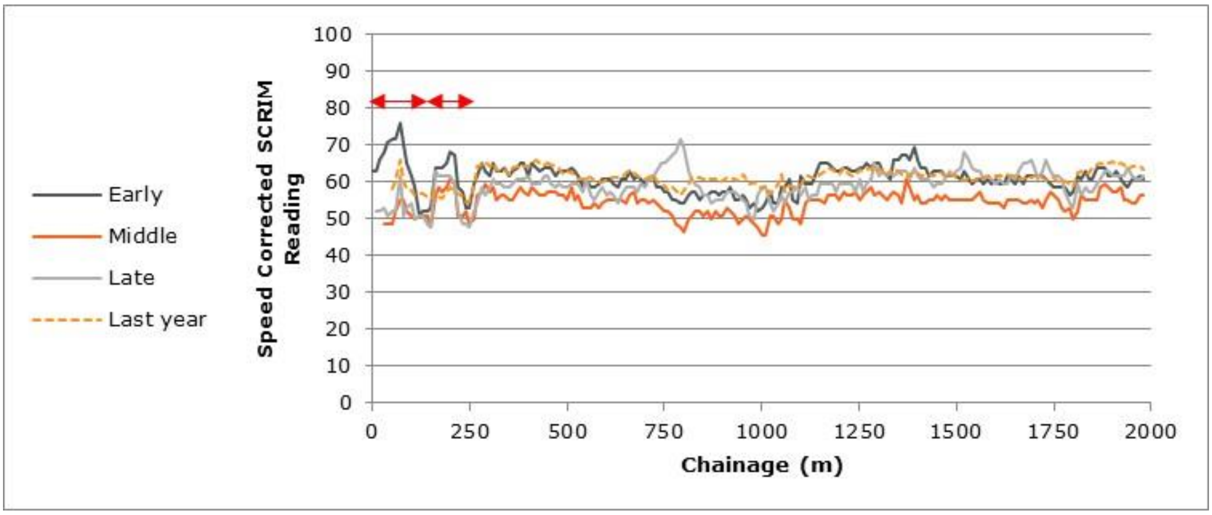

Figure 3.4: Skid resistance values from the 2022 survey for site 31

3.2.6 Site 32

The 2022 data for Site 32 showed anomalies in the early survey data at the start and end of the site. No maintenance was recorded on this site in HAPMS and no features were recorded in the operator’s notes. It is not known whether these features were caused by maintenance or some contamination or other feature of that survey. However, as the data is clearly different from the other surveys the lengths have been marked as invalid.

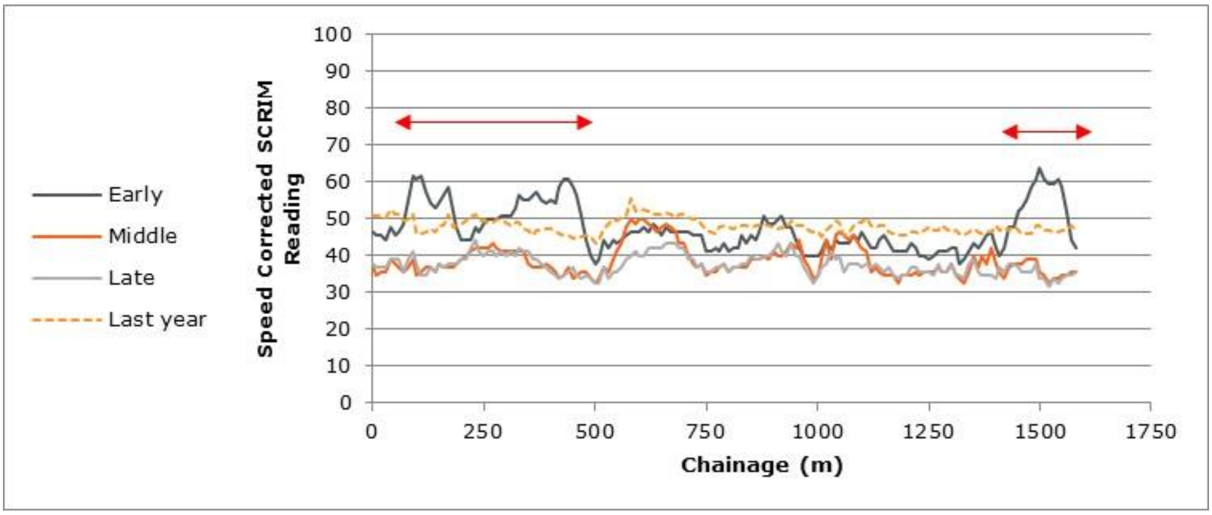

Figure 3.5: Skid resistance values from the 2022 survey for site 32

3.2.7 Summary of issues and observations from surveys

A summary of all the sites which have had any anomalies since the start of the benchmark site programme, which has resulted in them being removed from the long term reference benchmark sites, is shown in Table 3.1. Site 38 in 2019 is shown in grey italics as it has not been removed but should be removed if any additional issues are found.

If a benchmark site has undergone treatment, is missing surveys or otherwise unsuitable during the analysis period then it can no longer be considered as part of the long term reference set (i.e. used to calculate the average trend in MSSC since 2002). The analysis of the long term reference set is provided in Appendix B.

Table 3.1: Summary of issues and observations

Site Numbers	Year	Comments
5	2005	Resurfaced in 2005
4	2007	The late run in 2007 was carried out in lane 2 instead of lane 1
7, 15, 23 and 33	2007	Resurfaced in 2007
10, 16, 20, 22, 23 and 30	2008	These sites were resurfaced in 2008. Note site 23 was resurfaced in 2007 and 2008
2, 4, 21, 30 and 37	2009	Resurfaced in 2009. Note site 30 received patching treatment in 2008 and 2009
5	2010	Unable to align 2010 data
28	2010	Road works during early 2010 survey
21	2010	Patch(es) between 2009 and 2010 surveys

Site Numbers	Year	Comments
34	2010	Difference between the early start point and the mid/late start point
41	2010	Unexplained difference in SR between the early and the mid/late survey
4	2011	New surfacing between the 2010 and 2011 surveys
11	2011	Unable to align 2011 data
10 and 30	2012	Resurfaced between 2011 and 2012
5	2012	First 500m of site missing from early and late surveys
39	2012	Invalid data for part of the testing and resurfaced between 2011 and 2012
26	2014	Was not surveyed
28	2014	Was not surveyed in the late period
15	2015	Majority of site was resurfaced between the early and middle surveys
20	2015	Majority of site was resurfaced between the middle and late surveys
29	2015	First half of the site was resurfaced between the early and middle surveys
2	2016	The site was resurfaced between 250 and 500m
3 and 7	2016	The whole site has been resurfaced.
6	2017	Site resurfaced between 780 and 2875m between early and middle surveys
33	2017	Whole site resurfaced before the early survey
4, 17, 18 and 23	2018	Treatment to parts of the sites
34	2018	Hard shoulder surveyed instead of lane 1 for the middle and late surveys
22 and 29	2019	Length resurfaced at end of site
23	2019	Surveys undertaken on hard shoulder due to road works
28	2019	Length resurfaced at the start of the site
38	*2019*	*Short length maintained at end of site (should not be removed from long term analysis at this stage)*
19	2020	No middle survey
8 and 35	2021	Last third of site resurfaced
31	*2022*	*Short length maintained at start of site (should not be removed from long term analysis at this stage)*
32	2022	Anomalies at start and of the site in the Early survey

One site (32) was removed from the long term reference benchmark sites this year. The maintenance on site 31 was deemed short enough to keep this site in the list for the time being. There are currently 10 long term reference benchmark sites and these are listed in Table 3.2.

Table 3.2: Reference benchmark sites

Site	Road
1	A30
9	A23
12	A12
13	A47
14	A1
25	M40
27	A616
31	M6
36	M6
38	A1

An approach proposed in the analysis of the 2011 data (and amended following a review of the 2019 data) to increase the amount of collected data used, enabled skid resistance trends of individual 100m lengths to be analysed from 2013 onwards.

For the 2022 surveys, following the removal of unsuitable lengths, 305 (of 627) individual 100m lengths were available for the investigation of skid resistance trends over 10 years for the asphalt sites and 106 (of 109) 100m lengths for the concrete sites. This is an increase of 17 for the asphalt sites and 2 for the concrete sites in comparison to last year's analysis.

3.2.8 All lane running

Some parts of the National Highways network are being converted to all lane running (ALR) which is resulting in the lane one changing position (to where the hard shoulder was). To date only two sites have been affected by changing to ALR.

The first is site 26 (on the M1). The first survey on this site on the new lane 1 was in 2015. As such this site is currently excluded from the analysis and will be re-included in 2025 (due to the 10 year rolling analysis approach discussed in section 4.1).

The second is site 23 (on the M6) which is in the process of being converted into ALR. This site was surveyed in lane 2 due to road works in 2020. The 2021 survey was in the current lane 1 (the hard shoulder was blocked off for road works). Therefore, this site is currently excluded from the analysis. It is expected that this site will be re-included in the analysis of the 2032 data.

4 Results from the 2022 surveys (10yr rolling analysis)

4.1 Average SR and between survey variation

The process implemented to examine data may in some years result in some of the sites reducing to very short lengths. These shorter sites should not have as much input into the overall benchmark statistics as longer sites. To allow a sensible weighting of the data, each site is split into 100m lengths, with the average values for each 100m length being averaged together to produce the overall average for the benchmark sites. The results from the 2022 surveys are given in Table 4.1.

Using this process means that the lengths used in the benchmark site analysis change each year, and as such the data provided in previous years' reports will not always be directly comparable to that in the current year's report. This is because some lengths will be excluded in the current analysis which were not previously excluded. In addition, lengths that were excluded as a result of the data collected 11 years ago would be brought back in for this analysis. To provide a comparison to the results of this year's analysis, the data from the preceding 9 years have been reprocessed using the same lengths used for the 2022 analysis; this analysis is presented in Appendix C.

Utilising 100m averages for this analysis also allows for the investigation of between run variation using the criteria from the accreditation trials for sideway-force skid resistance devices (TRL, 2020) as a comparison; i.e. if the road conditions remain the same, the upper limit on the acceptable between run standard deviation is 3 SR. This means that if seasonal variation is occurring then it would be expected that the variation between the early, middle and late runs would be larger than 3 SR. Note, the between run standard deviations have been averaged together using the root mean square approach (the standard approach for calculating averages of standard deviations).

For the 2022 data the between run standard deviation (BRSD) is above the 3 SR threshold for both the asphalt and the concrete sites. As seen in most previous analyses the BRSD for the asphalt sites was larger than for the concrete sites.

Table 4.1: 2022 survey data

Site	Number of 100m lengths	Early Avg. SR	Middle Avg. SR	Late Avg. SR	Between run standard deviation	Average
1	22	62.8	55.2	46.2	8.53	54.8
2	5	62.4	54.8	53.6	4.83	56.9
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	0	-	-	-	-	-
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	14	44.2	38.5	41.6	4.05	41.4
10	23	61.0	49.4	52.3	6.38	54.2
11	3	60.2	52.3	57.5	4.07	56.7
12	9	63.4	47.4	52.7	8.56	54.5
13	13	47.4	40.4	40.6	4.03	42.8
14	17	61.3	48.2	51.2	7.53	53.6
15	1	41.7	34.5	36.8	3.64	37.7
16	19	60.4	44.9	49.0	8.20	51.4
17	10	38.0	31.9	37.3	3.52	35.7
18	0	-	-	-	-	-
19	0	-	-	-	-	-
20	0	-	-	-	-	-
21	14	55.5	47.7	48.8	4.25	50.7
22	16	72.4	64.1	65.6	4.58	67.4
23	0	-	-	-	-	-
24	11	59.2	46.6	49.1	6.79	51.6
25	12	64.7	56.5	54.0	5.65	58.4
26	0	-	-	-	-	-
27	16	61.9	54.1	54.7	4.47	56.9
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	23	53.5	42.5	48.9	5.55	48.3
31	16	60.6	54.4	59.8	3.78	58.2
32	7	43.9	39.5	37.9	3.41	40.5
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	13	52.5	45.9	50.2	3.37	49.5
36	10	52.8	45.2	49.8	3.97	49.2
37	14	59.2	53.1	56.5	3.20	56.3
38	14	55.1	47.1	50.1	4.35	50.8
39	3	58.9	56.5	53.5	2.72	56.3
40	13	57.7	52.8	51.5	3.47	54.0
41	55	43.7	37.6	38.5	4.17	39.9
42	18	49.2	40.2	41.1	5.09	43.5
43	20	48.4	41.3	44.6	3.86	44.7
Asphalt 0-39	305	57.5	48.5	50.5	5.65	52.2
Concrete 40-43	106	47.2	40.6	41.7	4.21	43.2

A summary of between run standard deviations (BRSD) and the average SR values since 2013 are presented in Table 4.2 for the asphalt lengths and in Table 4.3 for the concrete lengths. The BRSD values are also shown in Figure 4.1, and the average SR values in Figure 4.2 (along with the trend lines for the data).

Table 4.2: Summary of asphalt site data

Year	BRSD	Average SR
2013	3.50	54.9
2014	5.13	55.5
2015	5.16	57.9
2016	4.21	59.1
2017	6.27	57.2
2018	5.82	59.7
2019	4.93	59.5
2020	4.85	57.8
2021	6.30	58.1
2022	5.65	52.2
Average	5.25	57.2

Table 4.3: Summary of concrete site data

Year	BRSD	Average SR
2013	1.84	49.2
2014	3.50	49.5
2015	5.32	50.6
2016	2.19	53.8
2017	3.90	49.9
2018	4.55	51.8
2019	4.09	51.0
2020	3.21	46.7
2021	6.00	48.0
2022	4.21	43.2
Average	4.07	49.4

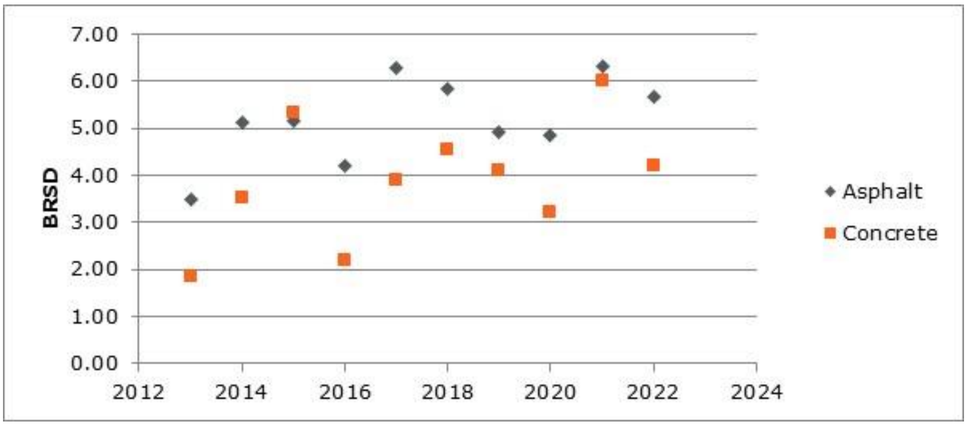

Figure 4.1: Average BRSD of Benchmark sites over 10 year analysis period

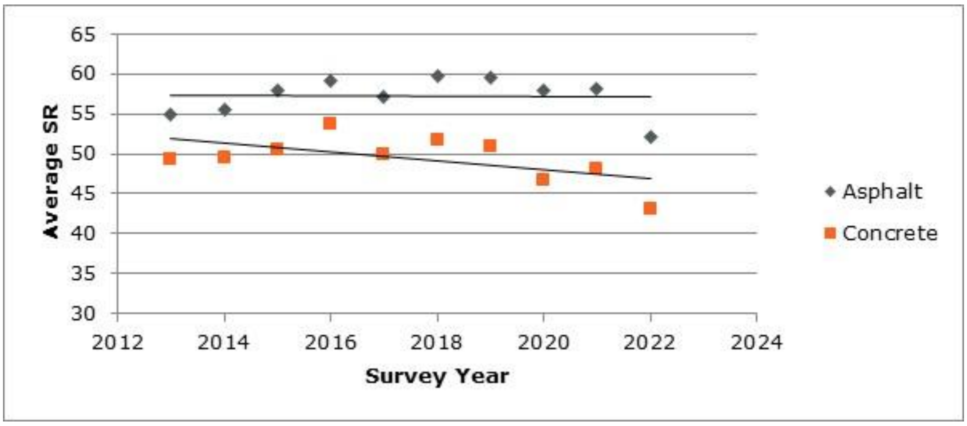

Figure 4.2: Average SR of Benchmark sites over 10 year analysis period

Table 4.2, Table 4.3 and Figure 4.1 show that the between run or between period standard deviation for the asphalt surfaces is highest for the 2017, 2018, 2019, 2021 2022 survey years, and lowest in 2013. In addition, it can be seen that for two of the ten years, the between period standard deviation for the concrete lengths is lower than the between run standard deviation criteria from the accreditation trials (3 SR). This suggests that the variation seen on the concrete sites in these years is likely to be mainly or solely caused by normal machine variation. This therefore suggests that for the other eight years the variation experienced includes other affects in addition to the typical machine variation.

Table 4.2, Table 4.3and Figure 4.2 suggest that, with the exception of the latest data set, the average SR value for the asphalt sites is fairly stable over time. Conversely the data suggests a possible downward trend in the SR values for concrete sites since 2019 (with the earlier data looking stable).

4.2 Expected distribution of SC for asphalt sites

In order to visualise the variation of Skid Coefficient (SC) throughout the course of the survey season the ratio of the MSSC value to the measured value (for each period and each 100m length) was calculated. This ratio is approximately equivalent to a Local Equilibrium Correction Factor (LECF) value (although strictly it is not, as it would only correct within year variation and it is being applied to 100m lengths). The average MSSC value for the complete 2022 dataset was then divided by these “LECF” values and combined with the survey dates to produce an estimate for the distribution of SC values.

Using this approach allows the current year’s data to be compared to previous years on a like for like basis. In particular, differences in average values between years and also within year trends can be investigated. The lines of best fit for the data for the last five years are shown in Figure 4.3.

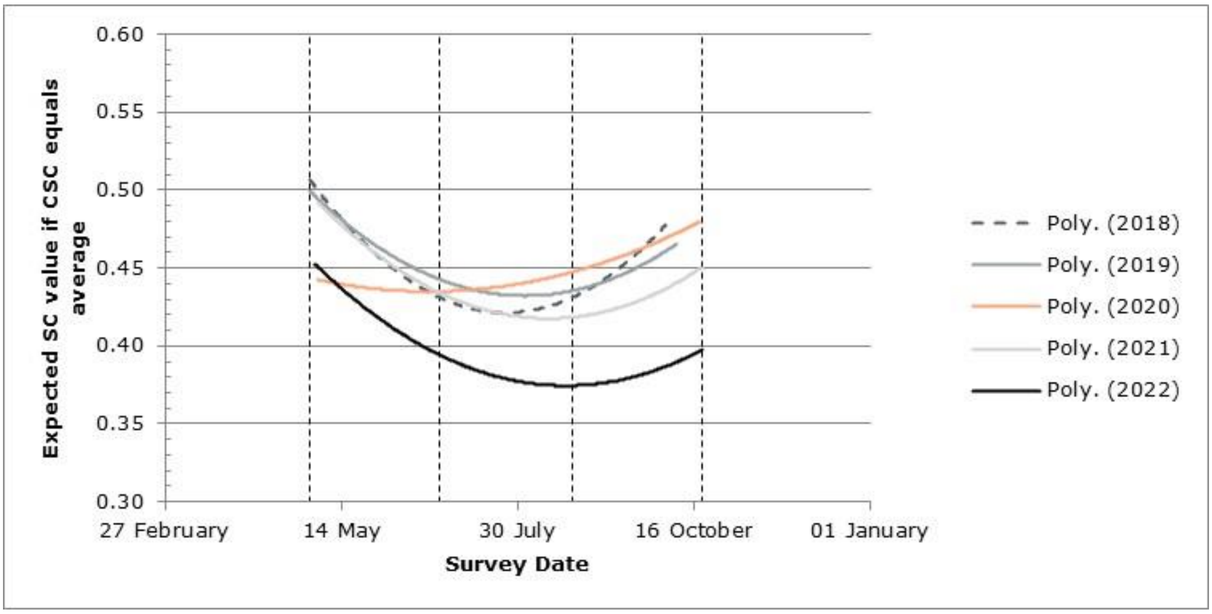

Figure 4.3: Expected SC values (sites 1-39)

It can be seen from Figure 4.3 that the within year seasonal variation, varies slightly from year to year. It can also be seen that the shape for the 2022 data suggests the minimum skid resistance value occurred close to the boundary between the middle and late surveys in that dataset. A similar shape was seen in 2021, however for the 2021 surveys some of the late surveys (approximately 1/3 of the data) were undertaken by a different survey vehicle which could have explained the variation in that year. At this stage there is not enough evidence that the survey dates should be amended (particularly as the 2020 data suggests a shift in the opposite direction) but it should continue to be monitored in future analyses.

The analysis of the 2022 LECFs (Brittain, 2023) also suggested that the minimum value for skid resistance occurred around the middle/late boundary. However, a slightly shallower trend for seasonal variation within the year was seen. The LECF analysis provides an estimate of ongoing trends of the overall seasonal variation of the network, however it is complicated by the fact that it uses data from different areas for each period to perform the analysis. Therefore, the trend seen from the benchmark sites is generally the more reliable of the two when considering the overall trend in skid resistance over time. However, in terms of estimating future CSC values for the network, the results from the LECF analysis should be used (as it is using the same data that would be used in future LECF calculations).

The analysis of the 2022 LECFs also found that the measured skid resistance over the year was lower than the average of the previous three years. On examination of Table 4.2 it can be seen that the average for the benchmark sites for 2022 was 52.2 and the average of the three previous years (2019, 2020 and 2021) was 58.5. It can also be seen that the measured SR is noticeably lower in 2022 than any of the other years in the analysis. This low value is likely due to the very warm and dry summer experienced in 2022, and suggests that climate change may cause larger variations in the skid resistance level recorded on the network. It should also be noted that this particularly low value in 2022 will cause the seasonally corrected network data in 2023 (CSC) to be lower than in recent years which is likely to resulting in a notable increase in lengths identified as requiring an investigation under CS228 in 2023.

4.3 Expected distribution of SC for concrete sites

The approach used to visualise the distribution of SC values for asphalt sites (see section 4.2) was also applied to the concrete sites and the results are shown in Figure 4.4.

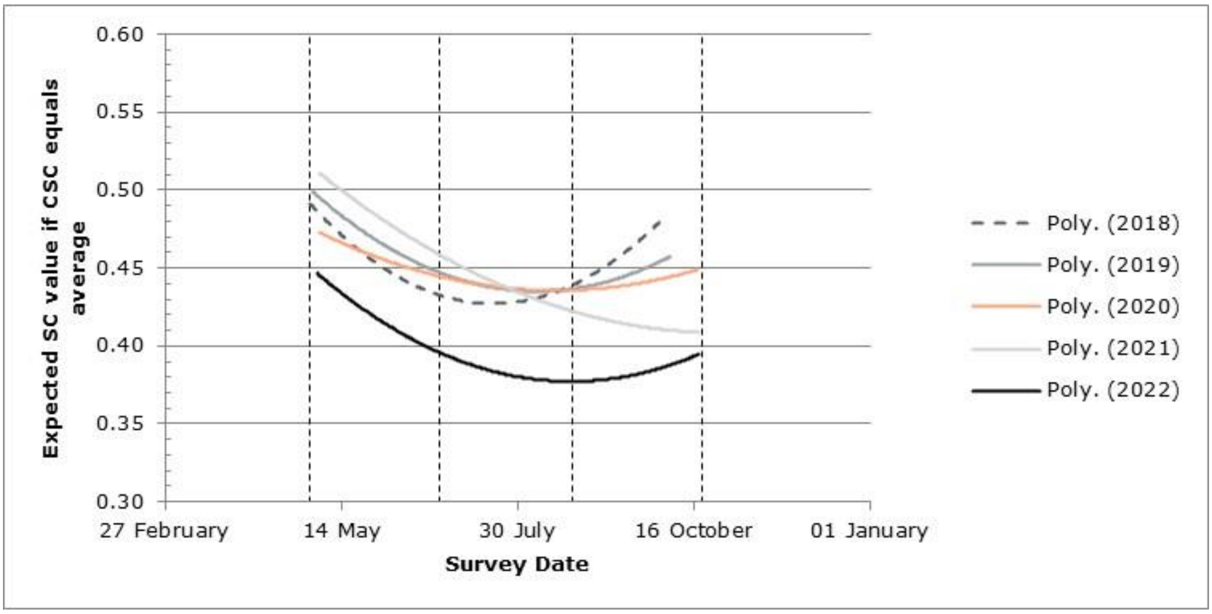

Figure 4.4: Expected SC values (sites 40-43)

The data for concrete sites over the last 5 years suggests that these sites are experiencing seasonal variation. However, with the exception of 2022, which is reasonably close, these shapes are different to that for the asphalt sites. In the analysis of the 2022 LECFs it was noted that applying the LECFs to the concrete sites would improve the data, but not remove all of the between year variability. Therefore, the practice of applying an LECF of 1 to the concrete lengths on the Strategic Road Network (SRN) should continue (as there is not sufficient length to calculate robust stand-alone LECFs for concrete surfaces).

4.4 Monitoring lengths available for the analysis

Prior to the 2020 analysis, the procedure used data collected since 2010 and excluded any lengths that had been maintained or had incomplete surveys over the period. This meant that the lengths available to the analysis reduced slightly each year. In the analysis of the 2019 data it was proposed that the procedure would be changed to a rolling 10 year cut-off so that lengths previously excluded could be brought back into the analysis. This rolling cut-off was first applied to the analysis of the 2020 surveys meaning data collected since 2011 was used. The analysis of the 2022 surveys used data collected since 2013. The lengths used in the analysis for each survey year is given in Figure 4.5 for asphalt lengths and in Figure 4.6 for concrete lengths.

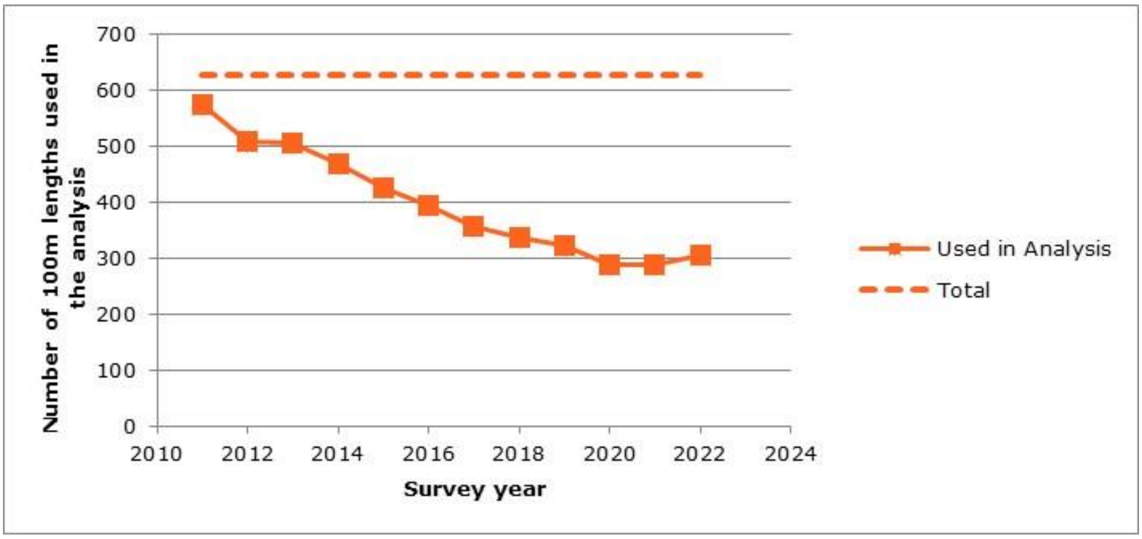

Figure 4.5: Number of 100m asphalt lengths used in the anlaysis

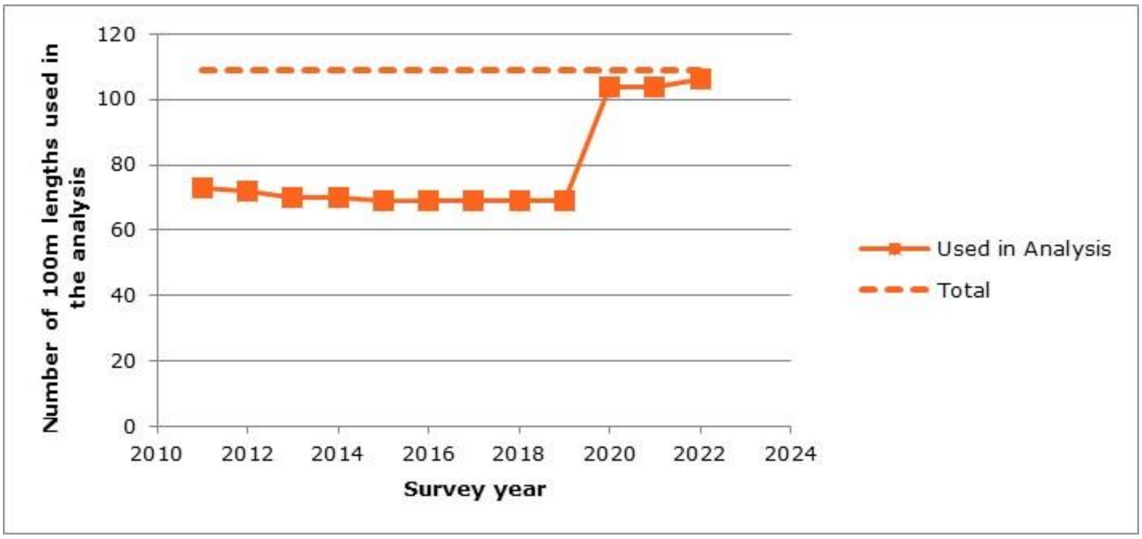

Figure 4.6: Number of 100m concrete lengths used in the anlaysis

It can be seen from these two graphs that the number of lengths (both Asphalt and Concrete) used in the current analysis have increased slightly this year. Overall, 49% of the asphalt lengths were used in the current analysis, and 97% of the concrete lengths.

5 Results since 2010

As noted in section 2.2, a method for combining the current 10 year rolling analysis with previous analyses has been developed in order to provide trends in SR values since 2010. The result of this analysis is presented in Figure 5.1 and Table 5.1.

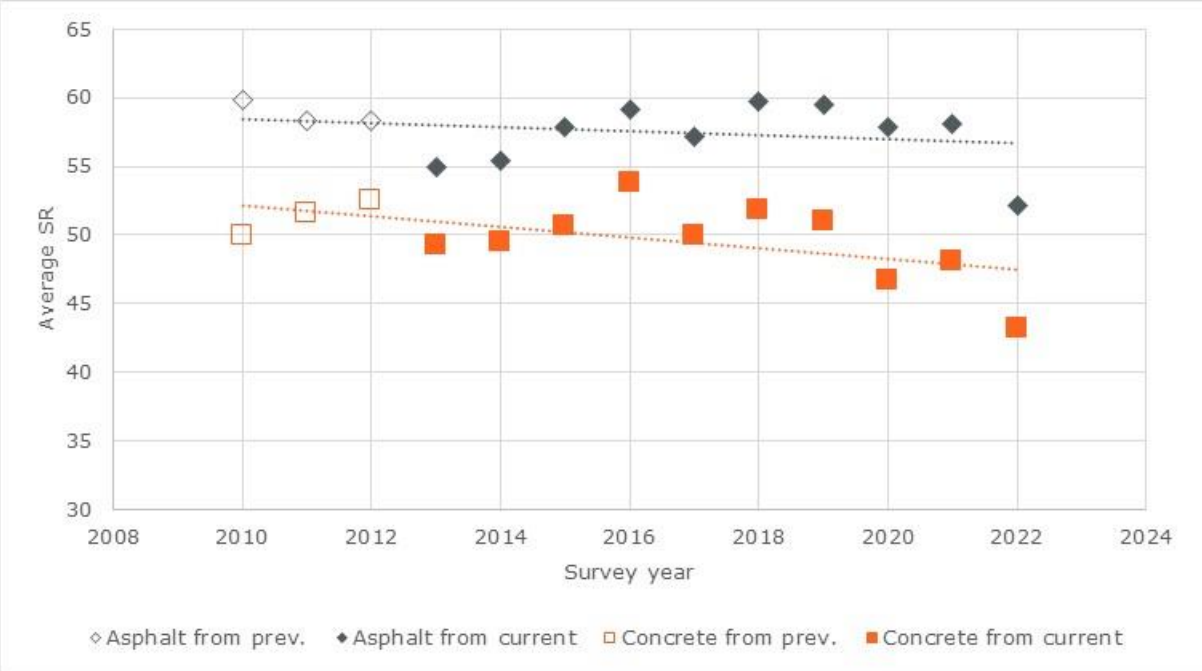

Figure 5.1: Average SR of Benchmark sites since 2010

Table 5.1: Average SR of Benchmark sites since 2010

Year	Asphalt sites	Concrete sites
2010 (estimate)	59.82	49.92
2011 (estimate)	58.28	51.53
2012 (estimate)	58.38	52.47
2013	54.92	49.23
2014	55.46	49.48
2015	57.92	50.60
2016	59.12	53.80
2017	57.18	49.93
2018	59.75	51.80
2019	59.46	51.00
2020	57.85	46.69
2021	58.08	48.03
2022	52.17	43.16

With the exception of the 2022 data, the data shown in Figure 5.1 and Table 5.1 suggests a relatively flat trend over time for the Asphalt lengths. As previously noted the skid resistance values on the asphalt lengths were particularly low in 2022. This observation is further reinforced as it can be seen from Figure 5.1 that the 2022 value is noticeably lower than all of the other values since 2010.

The concrete lengths appear to have a flat trend between 2010 and 2019, however the 2020 to 2022 data suggests a potential downward trend for the concrete lengths. This should be continued to be monitored to determine if this trend continues or if it stabilises. It is also recommended that the concrete lengths on the network as a whole should be investigated to identify if this trend appears to be present on all concrete lengths or just the subset used in this analysis. It is noted that a network analysis would have added variability in it due to each length only being surveyed in one of the survey periods in each year and as such the results might be inconclusive.

6 Investigation into geographic effects on trends in skid resistance

The benchmark sites are distributed relatively evenly around the National Highways SRN. As such the analysis given in sections 4 and 5 provides good information on the overall trend for the SRN. However, it is possible that parts of the SRN may experience different trends in skid resistance over time due to more localised changes in climate or other effects.

To investigate possible locational effects, the benchmark sites were split into groups based on their location on the SRN. In order to maintain reasonably sized datasets for the analysis, it was decided that two grouping analyses would be undertaken. The first would compare the eastern and western sites, and the second would compare northern, middle and southern sites. As there are relatively few concrete sites (and they show different patterns to the asphalt sites) these sites have been excluded from this analysis. The list of sites and the groupings assigned are listed in Appendix A. A pictorial representation of the east/west grouping is shown in Figure 6.1 and for the north/middle/south grouping in Figure 6.2 (although not included in the analysis the concrete sites are also shown to indicate their locations). The number of 100m lengths available for each grouping in the 2022 analysis is shown in Table 6.1.

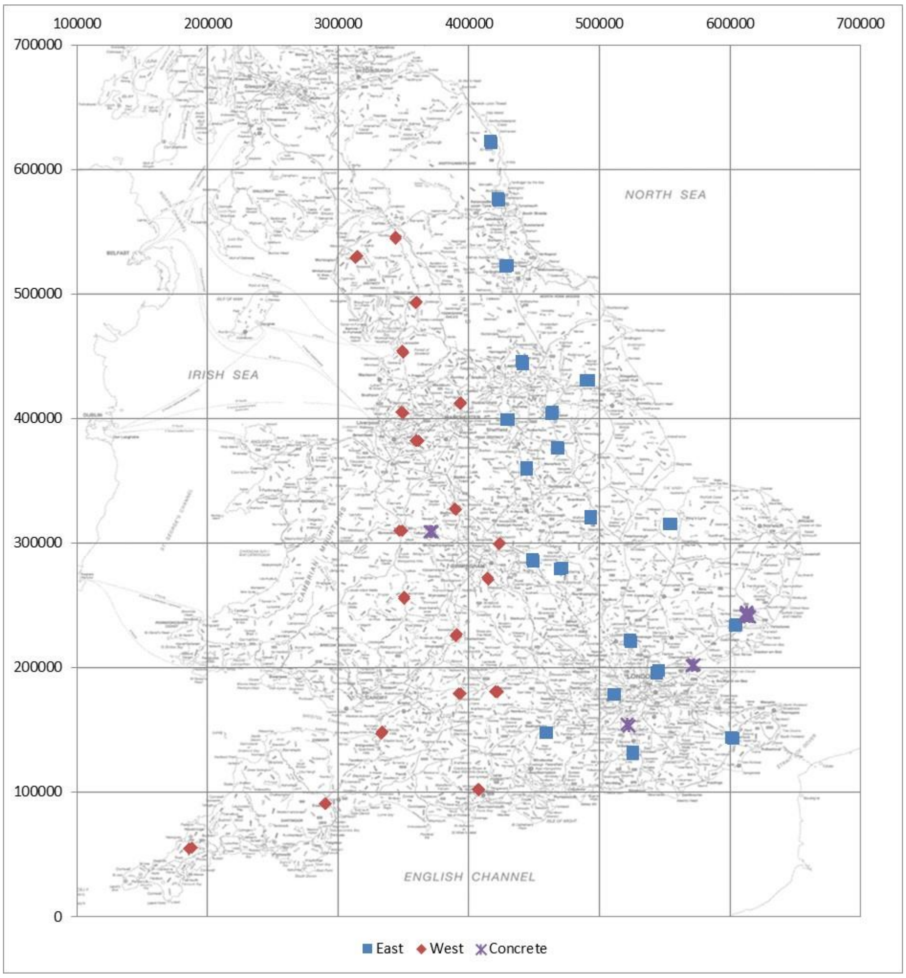

Figure 6.1: Map of east/west grouping of Benchmark sites (contains Ordinance Survey data © Crown copyright and database right 2023)

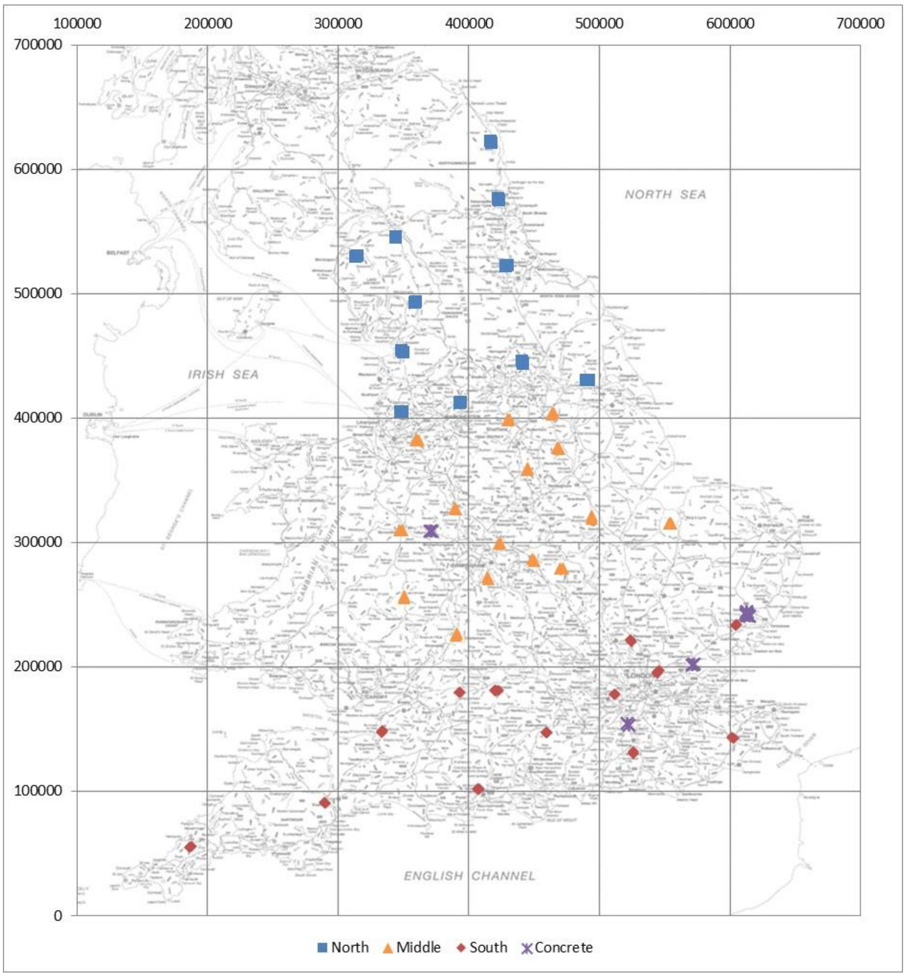

Figure 6.2: Map of north/middle/south grouping of Benchmark sites (contains Ordinance Survey data © Crown copyright and database right 2023)

Table 6.1: Number of 100m lengths in each geographic grouping for the analysis

Group	Number of 100m lengths
East	181
West	121
North	100
Middle	110
South	95

After splitting the sites into different groups the average SR values for each grouping and each year were calculated. For this analysis we are interested in how the average SR varies over time for each grouping. Therefore, the difference in the SR value each year relative to the earliest year in the analysis (2013) was calculated for each grouping. This data can be seen in Figure 6.3 and Figure 6.4.

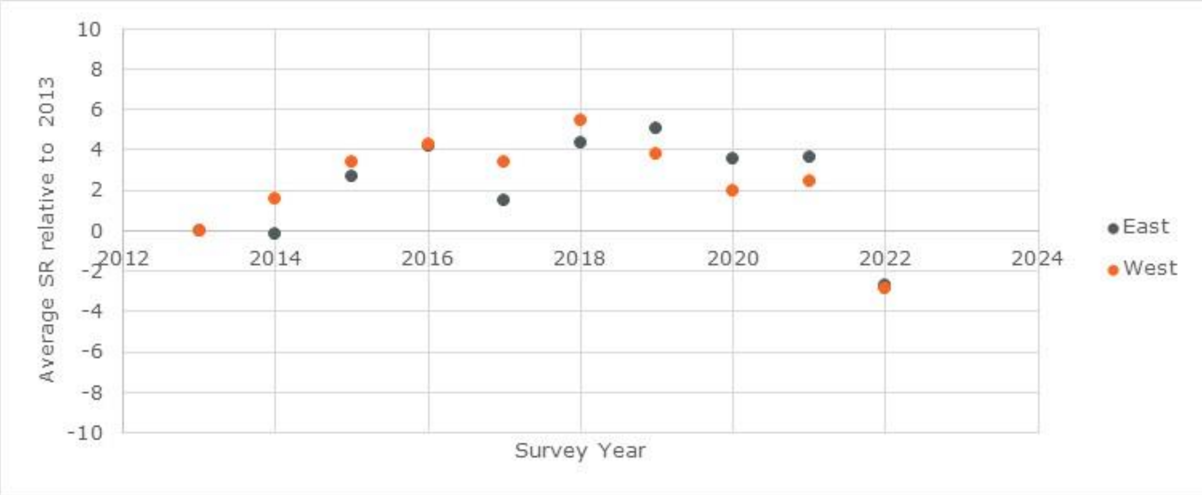

Figure 6.3: Average SR relative to 2013 of (Asphalt) Benchmark sites geographically spit East/West

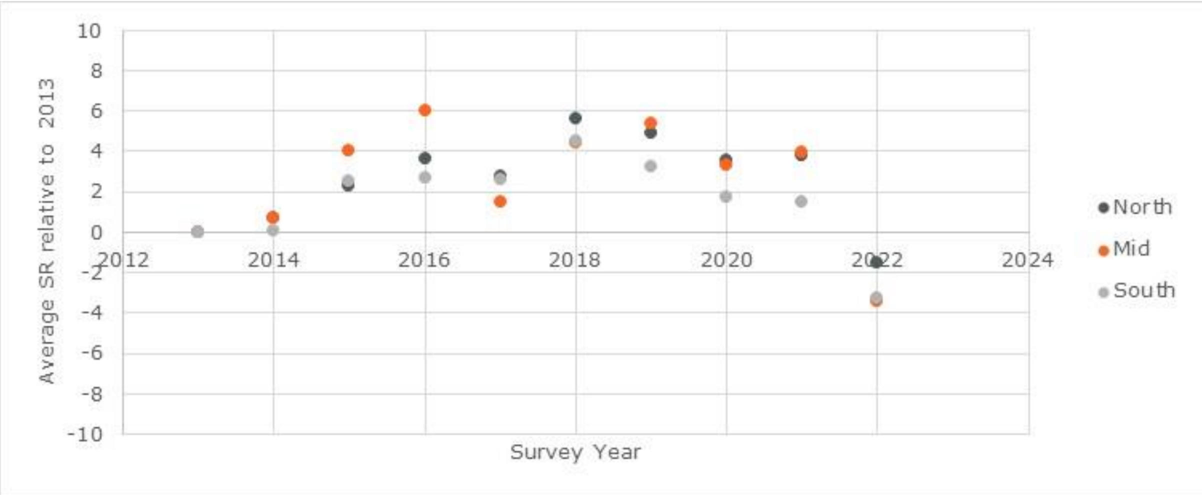

Figure 6.4: Average SR relative to 2013 of (Asphalt) Benchmark sites geographically spit North/Middle/South

From Figure 6.3 and Figure 6.4 it can be seen that all five groups follow the same basic shape over time. The differences in the east and west groupings look to be mostly due to noise as which is the higher of the two swaps round frequently during the analysis (and they produce almost the same value in 2022). In the latitude split, the variation for the middle also appears to be noise as it swings from the highest to the lowest between years.

However, the south grouping is consistently lower relative to its 2013 baseline than the north to its 2013 baseline since 2018. This could suggest that the seasonal variation is different between the north and the south of the SRN. This should be further investigated by repeating this assessment in next year’s analysis of the benchmark sites. In addition, consideration should be given to extending the number of years (similar to the analysis carried out in section 5). If there is a north/south effect on seasonal variation then it would be natural to assume that the middle sites should lie somewhere in between. However, this is not the case in the data seen. It is possible that the range of this possible north/south effect is changing from year to year leading to the variability in the results seen for the middle grouping. This will be difficult to investigate, but should be taken into consideration in future analyses.

In addition to potentially varying in average skid resistance each year, it is possible that the within year variation may differ between the locations. To investigate this the average between run standard deviation (BRSD) values were also calculated for each grouping and year. These numbers provide an indication of how shallow or deep the within year seasonal variation curves are (the higher the number the deeper the curve). As before the BRSD values are calculated by using the root mean square approach. This data can be seen in Figure 6.5 and Figure 6.6.

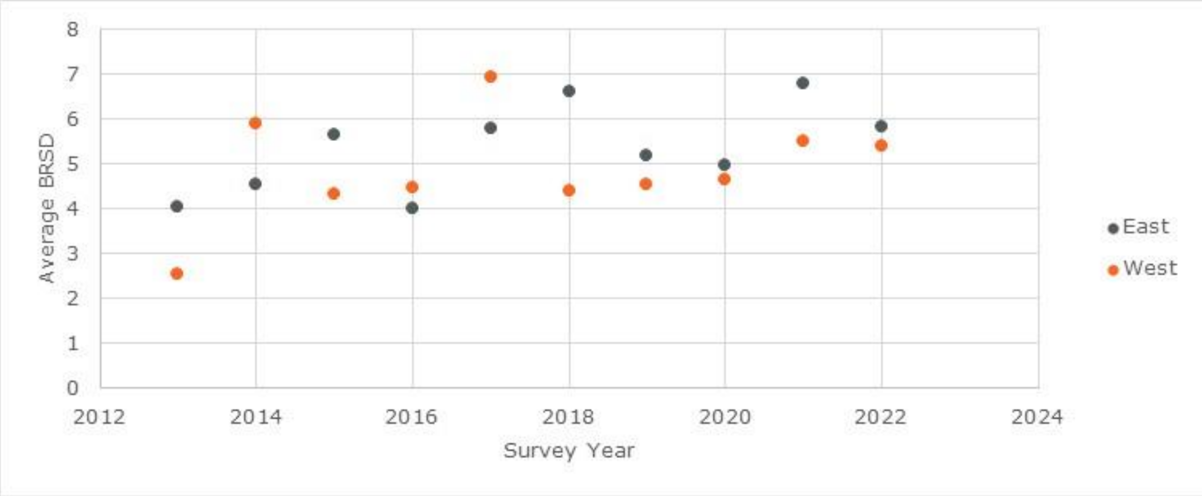

Figure 6.5: Average BRSD of (Asphalt) Benchmark sites geographically spit east/west

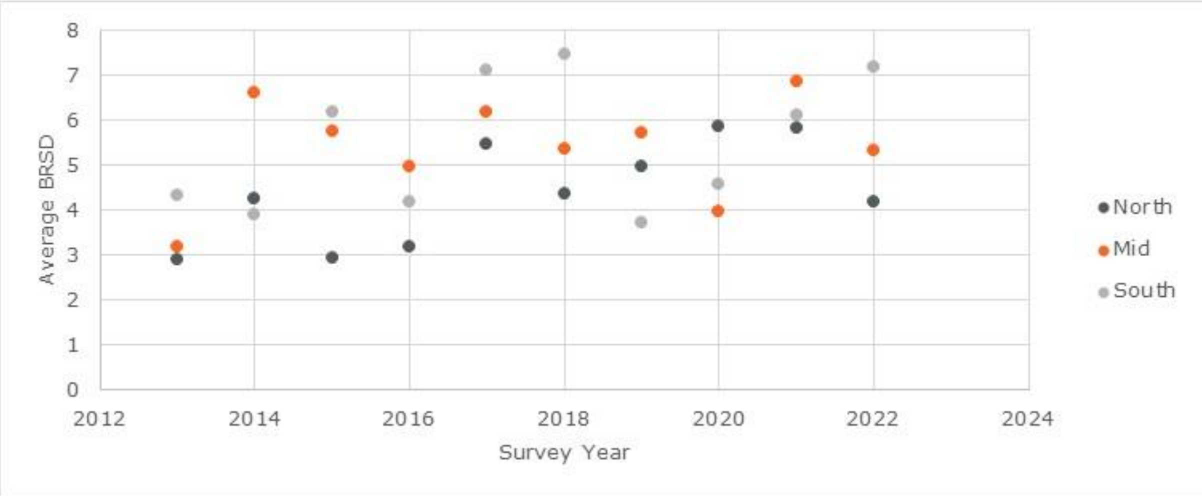

Figure 6.6: Average BRSD of (Asphalt) Benchmark sites geographically spit north/middle/south

From Figure 6.5 and Figure 6.6 it can be seen that the five groupings show similar ranges of BRSD and there is no particular trend with time that can be seen.

7 Conclusions and recommendations

7.1 Data coverage

One site (site 32) was removed from the long-term reference benchmark site list (sites which have a full survey history and have had no treatment since 2002) in the analysis of the 2022 data. Currently 10 of the original 39 sites are suitable for use in the investigation of trends since 2002 (given in Appendix B) and 411 individual 100m lengths (305 asphalt lengths and 106 concrete lengths) are suitable for use in the investigation of trends over the last ten years.

7.2 Alignment of data

During the 2021 analysis it was recommended that the survey data should be fitted based on OSGR coordinates using MSP before undertaking the visual assessment (and fine correction) of the alignment. This was undertaken for the 2022 analysis discussed in this report. It was found that this made the reviewing and fine correction of the alignment easier and more efficient. It is therefore recommended that this procedure is repeated in future analyses. However, it is noted that the suitability of the route files used for the fitting should be reviewed each year (examining for network changes) and updated accordingly.

7.3 Development of the analysis procedure

The current analysis procedure for each year of benchmark site data uses a rolling 10 year cut-off for the analysis. This means that over time (as more years are added) this approach will result in several overlapping sets of 10 year analyses.

Therefore, prior to the 2022 analysis a procedure was developed which allows earlier data to be used to provide values outside of the current 10 year analysis, back to the start of this approach (2010) normalised to the values of the current analysis. It is recommended that this procedure is continued in future benchmark site analyses, to provide monitoring of the longer-term trends in skid resistance.

The original analysis procedure which allows for the examination of trends going back to 2002 will become less robust with each passing year (due to the reduction in available sites for this approach). Therefore, consideration should be given in future years to drop this analysis.

7.4 Results (rolling 10 year analysis)

Investigation into the average SR values for Asphalt sites suggests that 2022 was noticeably lower than the average SR value for both the last 10 and 3 years. This was also seen on the concrete sites. These low values are likely due to the very warm and dry summer experienced in 2022, and suggests that climate change may cause larger variations in the skid resistance level recorded on the network. It should also be noted that this particularly low value in 2022 will cause the seasonally corrected network data in 2023 (CSC) to be lower likely resulting in a notable increase in lengths identified as requiring an investigation under CS228 in 2023.

The analysis also found that the minimum SR value appeared to occur on the middle/late period boundary. Both of these findings are consistent with the analysis of the 2022 LECFs (Brittain, 2023). The LECF analysis provides an estimate of ongoing trends of the overall seasonal variation of the network, however it is complicated by the fact it uses data from different areas for each period to perform the analysis. Therefore, the trend seen from the benchmark sites is generally the more reliable of the two when considering the overall trend in skid resistance over time (if the conclusions differ).

For the 2022 data, the between period standard deviation for the concrete sites was above the 3 SR threshold (at 4.21 SR) suggesting some form of seasonal variation. However, the work on the analysis of the 2022 LECFs found that applying the LECFs would improve the 2022 data but would not remove all of the between year variability. Therefore, the practice of applying an LECF of 1 to the concrete lengths should continue (as there is not sufficient length to calculate robust stand-alone LECFs for concrete surfaces).

7.5 Results since 2010

A method was developed for combining successive rolling 10 year analyses which allows for the investigation of trends since 2010. This analysis found that, with the exception of the 2022 data, the SR values for the asphalt lengths appear to be relatively stable. The data for the concrete lengths suggests a flat trend between 2010 and 2019, followed by a downward trend between 2019 and 2022. This analysis also identified that average SR values in 2022 (both asphalt and concrete) were lower than all of the values since 2010.

It is possible that the low value in 2022 is a one off due to the particularly hot and dry weather seen in the summer of 2022, however it may also be an indication of longer term changes due to climate change.

As the concrete data shows low values for the last three years, it its recommended that the concrete lengths on the network as a whole should be investigated to see if this trend is seen on the network or is an anomaly for the subset used for this analysis. However, it is noted that a network analysis would have added variability in it due to each length only being surveyed in one of the survey periods in each year and, as such, the results might be inconclusive.

7.6 Geographic effects on trends in skid resistance

An investigation was carried out to see if different geographic groupings of the benchmark sites experience different seasonal variation. This found that there did not appear to be any difference between the east and west, however there might be an effect when moving south to north through England. However, it was not possible to come to a clear conclusion on this and therefore geographical effects should be further investigated and built upon in future benchmark sites analyses.

References

Note: this list of references contains both unpublished reports (UPR) and client project reports (CPR) produced for National Highways. Please make a personal application to National Highways if you wish to obtain a copy.

Brittain, S. (2012). *SCRIM Benchmark surveys 2011 (CPR 1298).* Wokingham: TRL.

Brittain, S. (2020). *Skid resistance benchmark surveys 2019 (PPR 950).* Wokingham: TRL.

Brittain, S. (2023). *Calculation of Local Equilbrium Correction Factors for the 2022 Skid Resistance surveys (PPR2024).* Wokingham: TRL.

DMRB CS 228. (n.d.). *Design Manual for Roads and Bridges Volume 7 Section 1, CS 228 Skidding resistance*. London: The Stationery Office.

Donbavand, J., & Brittain, S. (2007). *Task 3: Review of Correction Factors (UPR/IE/213/06).* Wokingham: TRL.

TRL. (2020). *Accreditation and Quality Assurance of Sideways Force Skid Resistance Survey Devices v4.1 [online]. [Accessed 4th March 2021].* Available from World Wide Web: https://ukrlg.ciht.org.uk/ukrlg-home/guidance/road-condition-information/data-collection/skid-resistance/.

Appendix A Benchmark site locations

Table A.1: Location details of the benchmark sites

Site No.	Area	Road	Direction	Section(s)	Length (m)	Description	Nodes	East or West group	North, Middle or South group
1	1	A30	E/B	0800A30/400	2260	Studs under A3076 bridge at Mitchell to studs at 2260m	21435-21460	West	South
2	1	A30	W/B	1100A30/115	1180	End of slip On from A377 to studs at 1180m	492-431	West	South
3	2	M5	S/B	3300M5/210, 3300M5/220	1694	End of slip On at Jct 22 to studs at 1694m	15179-15184-15185	West	South
4	2	M4	E/B	3900M4/162	1226	End of slip On at Jct 17 to studs at 1226m	448-446	West	South
5	3	M3	S/B	1700M3/383, 1700M3/391	1003	Start of slip Off at Jct 7 (A30) to studs at 1003m	75990-75940-75897	East	South
6	3	M4	E/B	0300M4/393, 0300M4/391	2875	End of slip On at Jct 15 to studs at 2875m	35593-35941-35489	West	South
7	3	A31	E/B	1200A31/461, 1200A31/467	1358	Exit from Ameysford Rbt to studs under B3072 bridge	12071-12076-12999	West	South
8	4	M20	E/B	2200M20/290	1634	End of slip On at Jct 9 (A20/A28) for 1634m	5230-1859	East	South
9	4	A23	N/B	3800A23/340	1402	Studs just after bridge over approx. 1050m after B2110 (bridge over at Handcross) to studs under footbridge at 1402m	13078-13216	East	South
10	M25 DBFO	M11	N/B	1500M11/114, 1500M11/116	2473	Start of slip Off at Jct 5 (A1168) to start of concrete	70050-70060-70070	East	South
11	M25 DBFO	M4	W/B	5540M4/244	976	Start of slip Off to Heston Services to end of Slip On	32828-32830	East	South
12	6	A12	N/B	1500A12/294	1053	Studs at Suffolk boundary to start of slip road off to B1029	40560-42270	East	South
13	6	A47	E/B	2600A47/145, 2600A47/147	1348	Studs under bridge at centre of Terrington St John interchange to bridge at 1348m	5027-5733-50343	East	Middle
14	7	A1	N/B	2500A1/110	2150	End of slip On from South Witham to Jct Left (to North Witham)	7005-7015	East	Middle
15	7	A1	N/B	3000A1/345, 3000A1/347, 3000A1/360	1426	Jct L to Elkesley Village (744m N of B6387) 1426m to Jct Rt	20125-20129	East	Middle
16	8	A1(M)	S/B	1900A1M/58	1946	End of slip On at Jct 7 to studs under bridge at 1981m	1530-11489	East	South
17	7	A14	E/B	2800A14/120	1728	Studs under bridge 3742m W of A508 (bridge over) to studs under bridge at 1728m	1820-2022	East	Middle
18	2	M5	N/B	1600M5/138	1264	Studs under A4019 bridge at Jct 10 to studs under next bridge	4231-30034	West	Middle
19	9	A49	N/B	1800A49/320	1760	Jct R (to Stoke Prior) to River Bridge	43133-43134	West	Middle
20	9	A5	W/B	3200A5/293	1641	Exit from A49/A5112 Rbt to studs under bridge at 1641m	50293-50289	West	Middle
21	10	M56	W/B	0600M56/419, 0600M56/422	1898	End of slip On at Jct 10 (A49) to studs at 1898m	63410-63501-63601	West	Middle
22	7	A5	S/B	2400A5/50	2007	Studs near start of 2 lanes 2.5k S of Jct B577 for 2007m to studs near end of 2 lanes (studs are at start and end of grassed central reserve).	20067-20049	East	Middle
23	9	M6	S/B	3400M6/430	995	Studs 2255m before start of slip Off at	23101-	West	Middle

Site No.	Area	Road	Direction	Section(s)	Length (m)	Description	Nodes	East or West group	North, Middle or South group
						Jct 14 to studs at 995m	23001		
24	9	M42	N/B	3700M42/334	1090	Studs 1090m before start of Slip Off to Jct 10 (A5) to start of Slip Off	28687-28685	West	Middle
25	9	M40	S/B	3700M40/183	1403	End of slip On at Jct 17 (M42 Jct 3a) to start of slip Off at Jct 16	29504-29503	West	Middle
26	7	M1	S/B	1000M1/216	1600	End of slip on at Tibshelf services to studs at “Jct 28 1 mile” sign	10054 (now 9997)-10052	East	Middle
27	12	A616	W/B	4405A616/30	1717	Studs L Jct A629 to studs on river bridge at 1717m	61630-61644	East	Middle
28	10	M62	E/B	4200M62/450, 4200M62/460	1308	End of slip On at Jct 21 to studs at 1308m	22105-22107	West	North
29	12	M18	S/B	4400M18/108	1681	End of slip On at Jct 4 (A630) to studs at 1681m	4308-321	East	Middle
30	12	A63	W/B	2000A63/409	2378	End of slip On at A1034 to studs at bridge over 2378m	2002-30482	East	North
31	13	M6	S/B	2300M6/291	1973	End of slip On at Jct 33 to start of slip Off to Lancaster services	18323-18239	West	North
32	10	M58	W/B	2300 M58/431	1570	End of slip On at Jct 5 to start of slip Off at Jct 4	8618-20005	West	North
33	A1DD DBFO	A1	N/B	2700A1/242, 2700A1/252	1864	End of slip On at Bramham to start of slip Off to A659 (may now be DBFO)	21488-21422-21184	East	North
34	14	A1(M)	N/B	1300A1M/212, 1300A1M/216	1426	End of slip on at Jct 59 (A167) to studs at 1426m	17-18-19	East	North
35	13	A66	E/B	0900A66/142	1860	Studs on bridge over B5292 (1950m E of A5086 Rbt) to studs at 1860m	31347-31507	West	North
36	13	M6	S/B	0900M6/373, 0900M6/379	1121	Start of slip Off at Jct 37 (A684) to end of slip On at Jct 37	14192-14187-14181	West	North
37	13	M6	S/B	0900M6/351	1385	Start of slip Off to Southwaite services to end of slip On from services	14779-14766	West	North
38	14	A1	S/B	2900A1/106	1727	Studs (road under) 2.22km before A19 bridge over to studs at 1727m (25m after Newcastle sign and 45m before start of slip off to A19)	14063-14002	East	North
39	14	A1	N/B	2900A1/380	2200	Jct Rt B6347 (to Christon Bank) to studs at start of dual c/way central reserve	11030-11101	East	North
40	9	M54	E/B	3200M54/784	1434	Asphalt/PQC surface change @ marker post 27/7 to start slip off to J4	54006-40100	Concrete	Concrete
41	6	A14	E/B	3500A14/632 to 3500A14/716	5601	End slip on J54, Sproughton to start slip off J56, Wherstead	90366-90301	Concrete	Concrete
42	6	A12	S/B	1500A12/158	1960	Baddow Park Overbridge to Slip off	40950-40960	Concrete	Concrete
43	M25 DBFO	M25	C/W	3600M25/464	2004	MP55/0 to MP57/0	21543-21541	Concrete	Concrete

Appendix B Benchmark site data processed using the old analysis procedure (asphalt sites only)

B.1 2022 survey results

The average speed corrected skid readings (speed corrected SR) and the range between the highest and lowest average speed corrected SR for the 2022 surveys are shown in Table B.1. These values may differ from those in Table 4.1 in the main analysis as the data in that table will have any lengths with maintenance over the last 10 years removed (whereas Table B.1 includes the whole length of the site). In this table, four sites are shown in grey text due to anomalies in the surveys. These anomalies are discussed in section 3.2.

Table B.1: Results of the 2022 surveys

Site	Early speed corrected SR	Middle speed corrected SR	Late speed corrected SR	Average	Range
1	62.80	55.05	46.15	54.67	16.64
2	63.12	54.90	55.67	57.90	8.23
3	61.36	54.30	52.70	56.12	8.66
4	52.94	47.77	46.68	49.13	6.26
5	62.47	51.03			
6	56.31	54.07	50.37	53.58	5.94
7	60.15	50.39	57.69	56.08	9.76
8	*58.32*	*53.82*	*55.70*	*55.95*	*4.50*
9	44.13	38.46	41.58	41.39	5.67
10	61.18	49.14	52.15	54.16	12.04
11	67.79	58.22	62.60	62.87	9.56
12	63.04	46.92	52.14	54.03	16.12
13	47.48	40.39	40.68	42.85	7.09
14	60.58	48.75	51.70	53.68	11.83
15	49.52	43.24	44.63	45.80	6.28
16	60.24	44.93	49.01	51.39	15.31
17	42.44	35.99	40.76	39.73	6.46
18	62.86	56.13	55.70	58.23	7.17
19	65.56	59.59	59.81	61.65	5.97
20	58.35	53.55	51.97	54.63	6.38
21	*56.61*	*47.75*	*48.86*	*51.07*	*8.86*
22	71.46	63.44	64.71	66.54	8.02
23	68.90	60.99	60.75	63.55	8.15
24	59.22	46.59	49.06	51.62	12.63
25	64.52	56.28	53.64	58.15	10.88
26	58.81	53.26	54.14	55.40	5.55
27	62.42	54.72	55.26	57.47	7.71
28	49.14	41.78	42.75	44.56	7.35
29	52.75	42.83	47.37	47.65	9.93
30	53.46	42.51	48.93	48.30	10.95
31	*60.91*	*54.26*	*58.94*	*58.04*	*6.64*
32	*47.41*	*38.57*	*37.51*	*41.17*	*9.90*
33	66.00	54.42	58.72	59.72	11.58
34	64.00	54.13	57.89	58.67	9.86
35	56.72	49.95	53.78	53.48	6.77
36	52.72	45.30	49.75	49.26	7.41
37	59.19	53.04	56.42	56.22	6.15
38	55.01	47.10	49.41	50.51	7.90
39	55.87	51.97	48.67	52.17	7.20

B.2 Mean Summer Skid Coefficient

The average of the reference benchmark sites over the course of the benchmark programme (since 2002) is produced in Figure B.1. The reference benchmark sites are the sites with a full survey history and which have not undergone treatment during the course of the programme. These sites are further discussed in section 3.2.

The very late surveys (conducted in 2006, 2007, 2008 and 2009) are excluded from this calculation and the surveys undertaken under the old survey period dates are shown as empty diamonds. Due to COVID-19, traffic levels on the road network were noticeably lower in 2020. To mark this data as a potential outlier it is highlighted as an orange diamond.

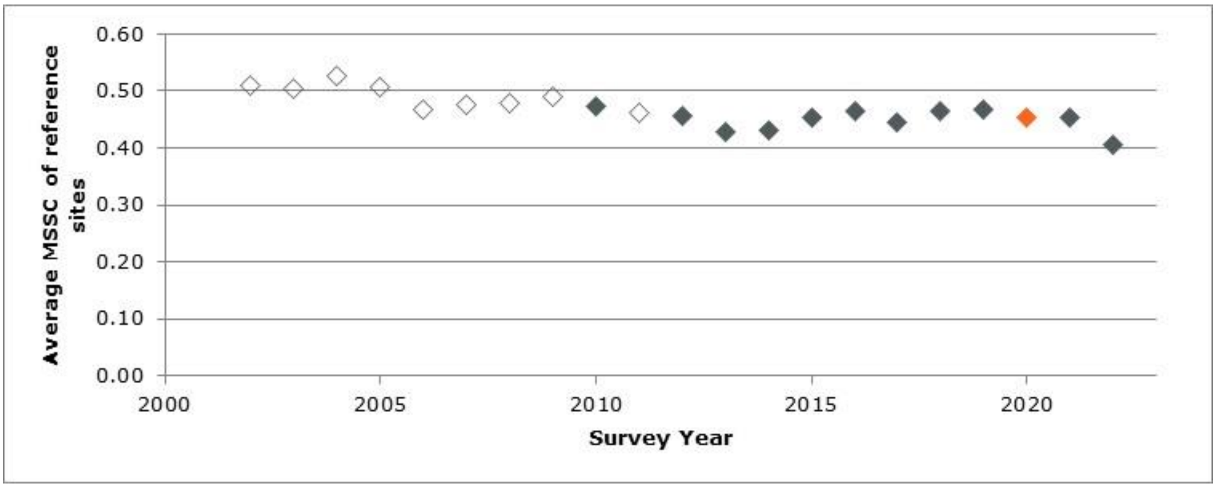

Figure B.1: Average MSSC of reference sites since 2002

The majority of points in Figure B.1 suggest an equilibrium state of the benchmark sites that has changed between two levels. The first level running from 2002 to 2005 around an average of 0.5 and the second running from 2006 onwards around an average of 0.45. However, it is noted that the value recorded for the 2022 surveys is noticeably lower than the recent trend. At this stage it is not possible to state whether this is an anomalous point, the start of a new equilibrium level, or some other trend.

The changes between the two equilibrium levels could be due to the changes between the survey dates for these surveys. However, if the extended survey dates were the cause, then we would expect the values to be higher for the more recent surveys (as they include late survey where the skid resistance value has been restored). Other options include longer term seasonal changes, e.g. climate change or a reduction in the skid resistance performance of the sites (possibly as a result of a change in traffic levels for the sites compared to those assumed in the design of the surfacings).

MSSC values (excluding the very late surveys) produced for each of the asphalt benchmark sites over the course of the benchmark site programme are provided in Table B.2. The non-reference benchmark sites are also shown but are highlighted in grey and italics in the table. In addition, surveys conducted on the reference benchmark sites using the old survey periods (as discussed in section 1.1) are highlighted in red. The change in survey periods should result in a slightly higher MSSC value (due to the expected higher value for the late survey) for any years which are using the new survey boundaries relative to the old boundaries.

Table B.2: MSSC values for the asphalt sites (1-39)

Site	Ref	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1	y	0.60	0.57	0.59	0.58	0.55	0.55	0.54	0.57	0.54	0.55	0.52	0.46	0.47	0.51	0.49	0.50	0.52	0.50	0.48	0.48	0.43
2	*n*	*0.56*	*0.54*	*0.55*	*0.54*	*0.54*	*0.54*	*0.52*	-	*0.50*	*0.51*	*0.51*	*0.46*	*0.47*	*0.51*	*0.47*	*0.49*	*0.50*	*0.48*		*0.48*	*0.45*
3	*n*	*0.55*	*0.52*	*0.53*	*0.52*	*0.50*	*0.47*	*0.47*	*0.53*	*0.48*	*0.49*	*0.47*	*0.44*	*0.44*	*0.47*	*0.46*	*0.48*	*0.48*	-	*0.47*	*0.47*	*0.44*
4	*n*	*0.61*	*0.60*	*0.60*	*0.59*	*0.58*	-	*0.56*	-	*0.53*	*0.47*	*0.48*	*0.44*	*0.44*	*0.47*	*0.45*	*0.46*	*0.47*	*0.47*	*0.42*	*0.39*	*0.38*
5	*n*	*0.55*	*0.55*	*0.58*	-	*0.53*	*0.53*	*0.53*	*0.49*	-	*0.51*	*0.53*	*0.47*	*0.50*	*0.50*	*0.50*	*0.51*	*0.50*	*0.48*	*0.45*	*0.48*	-
6	*n*	*0.54*	*0.52*	*0.52*	*0.53*	*0.51*	*0.51*	*0.51*	*0.53*	*0.52*	*0.48*	*0.50*	*0.47*	*0.46*	*0.52*	*0.51*	*0.50*	*0.47*	*0.49*	*0.46*	*0.43*	*0.42*
7	*n*	*0.54*	*0.52*	*0.51*	*0.52*	*0.49*	-	*0.50*	*0.52*	*0.51*	*0.51*	*0.51*	*0.47*	*0.51*	*0.49*	*0.49*	*0.46*	*0.49*	*0.47*	*0.44*	*0.45*	*0.44*
8	*n*	*0.55*	*0.53*	*0.53*	*0.51*	*0.50*	*0.50*	*0.49*	*0.51*	*0.51*	*0.47*	*0.49*	*0.45*	*0.45*	*0.45*	*0.46*	*0.45*	*0.50*	*0.48*	*0.44*	*0.47*	*0.44*
9	y	0.46	0.44	0.44	0.44	0.39	0.39	0.39	0.41	0.40	0.38	0.40	0.39	0.35	0.37	0.37	0.37	0.38	0.38	0.37	0.36	0.32
10	*n*	*0.55*	*0.54*	*0.57*	*0.55*	*0.54*	*0.55*	-	*0.55*	*0.51*	*0.50*	*0.51*	*0.45*	*0.44*	*0.46*	*0.47*	*0.47*	*0.48*	*0.47*	*0.45*	*0.45*	*0.42*
11	*n*	*0.55*	*0.54*	*0.57*	*0.56*	*0.51*	*0.51*	*0.51*	*0.55*	*0.56*	*0.53*	-	*0.49*	*0.49*	*0.50*	*0.52*	*0.52*	*0.51*	*0.53*	*0.54*	*0.54*	*0.49*
12	y	0.42	0.42	0.59	0.50	0.45	0.44	0.49	0.46	0.45	0.43	0.44	0.41	0.43	0.43	0.46	0.43	0.45	0.46	0.47	0.46	0.42
13	y	0.45	0.45	0.47	0.45	0.40	0.41	0.43	0.42	0.41	0.40	0.37	0.35	0.36	0.41	0.40	0.36	0.40	0.42	0.41	0.38	0.33
14	Y	0.57	0.55	0.57	0.55	0.53	0.52	0.51	0.53	0.49	0.48	0.48	0.47	0.44	0.50	0.50	0.46	0.48	0.50	0.48	0.47	0.42
15	*n*	*0.49*	*0.48*	*0.48*	*0.47*	*0.45*	-	*0.43*	*0.44*	*0.42*	*0.42*	*0.42*	*0.38*	*0.39*	*0.47*	*0.41*	*0.41*	*0.43*	*0.45*	*0.42*	*0.41*	*0.36*
16	*n*	*0.54*	*0.56*	*0.56*	*0.51*	*0.51*	*0.52*	-	*0.49*	*0.49*	*0.47*	*0.46*	*0.41*	*0.42*	*0.43*	*0.43*	*0.43*	*0.44*	*0.43*	*0.43*	*0.43*	*0.40*
17	*n*	*0.39*	*0.38*	*0.39*	*0.37*	*0.35*	*0.36*	*0.36*	*0.37*	*0.34*	*0.32*	*0.32*	*0.32*	*0.32*	*0.36*	*0.33*	*0.31*	*0.33*	*0.34*	*0.36*	*0.34*	*0.31*
18	*n*	*0.54*	*0.49*	*0.48*	*0.45*	*0.44*	*0.44*	*0.43*	*0.48*	*0.45*	*0.44*	*0.41*	*0.41*	*0.40*	*0.43*	*0.43*	*0.45*	*0.45*	*0.45*	*0.50*	*0.46*	*0.45*
19	*n*	*0.50*	*0.47*	*0.47*	*0.46*	*0.43*	*0.44*	*0.42*	*0.46*	*0.45*	*0.42*	*0.43*	*0.39*	*0.40*	*0.43*	*0.43*	*0.44*	*0.43*	*0.42*		*0.47*	*0.48*
20	*n*	*0.38*	*0.35*	*0.34*	*0.34*	*0.31*	*0.34*	-	*0.42*	*0.40*	*0.39*	*0.39*	*0.35*	*0.39*	*0.46*	*0.50*	*0.46*	*0.48*	*0.47*	*0.45*	*0.45*	*0.43*
21	*n*	*0.44*	*0.42*	*0.43*	*0.42*	*0.39*	*0.39*	*0.39*	-	*0.44*	*0.47*	*0.46*	*0.44*	*0.44*	*0.45*	*0.48*	*0.45*	*0.45*	*0.47*	*0.44*	*0.47*	*0.40*
22	*n*	*0.49*	*0.50*	*0.48*	*0.46*	*0.48*	*0.46*	-	*0.52*	*0.51*	*0.51*	*0.54*	*0.52*	*0.55*	*0.56*	*0.57*	*0.54*	*0.58*	*0.57*	*0.56*	*0.59*	*0.52*
23	*n*	*0.45*	*0.44*	*0.47*	*0.45*	*0.41*	-	-	*0.49*	*0.45*	*0.46*	*0.45*	*0.44*	*0.44*	*0.46*	*0.47*	*0.45*	*0.47*	-			*0.50*
24	*n*	*0.49*	*0.49*	*0.51*	*0.49*	*0.49*	*0.49*	*0.45*	-	*0.46*	*0.44*	*0.44*	*0.44*	*0.44*	*0.46*	*0.47*	*0.44*	*0.46*	*0.46*	*0.44*	*0.43*	*0.40*
25	y	0.55	0.53	0.54	0.53	0.51	0.53	0.49	0.54	0.51	0.51	0.51	0.48	0.55	0.53	0.55	0.51	0.52	0.51	0.50	0.49	0.45
26	*n*	*0.48*	*0.45*	*0.47*	*0.45*	*0.43*	*0.43*	*0.41*	*0.44*	*0.50*	*0.47*	*0.48*	*0.42*	-	*0.43*	*0.54*	*0.50*	*0.51*	*0.51*	*0.49*	*0.49*	*0.43*
27	y	0.46	0.56	0.52	0.52	0.48	0.50	0.49	0.50	0.48	0.47	0.47	0.45	0.44	0.46	0.53	0.49	0.50	0.51	0.50	0.54	0.45
28	*n*	*0.43*	*0.42*	*0.39*	*0.41*	*0.37*	*0.35*	*0.38*	*0.41*	-	*0.36*	*0.37*	*0.36*	-	*0.37*	*0.38*	*0.37*	*0.39*	*0.40*	*0.38*	*0.40*	*0.35*
29	*n*	*0.49*	*0.46*	*0.47*	*0.47*	*0.42*	*0.43*	*0.43*	*0.43*	*0.42*	*0.41*	*0.42*	*0.40*	*0.39*	*0.51*	*0.44*	*0.43*	*0.43*	*0.47*	*0.42*	*0.44*	*0.37*
30	*n*	*0.50*	*0.46*	*0.48*	*0.46*	*0.45*	*0.44*	-	-	*0.45*	*0.44*	*0.43*	*0.39*	*0.39*	*0.41*	*0.42*	*0.40*	*0.43*	*0.45*	*0.43*	*0.43*	*0.38*
31	y	0.58	0.55	0.54	0.54	0.48	0.50	0.52	0.51	0.50	0.50	0.49	0.46	0.45	0.48	0.48	0.48	0.50	0.48	0.47	0.48	0.45
32	*n*	*0.47*	*0.44*	*0.43*	*0.42*	*0.38*	*0.38*	*0.38*	*0.42*	*0.39*	*0.38*	*0.38*	*0.38*	*0.36*	*0.38*	*0.40*	*0.38*	*0.38*	*0.39*	*0.37*	*0.37*	*0.32*
33	*n*	*0.56*	*0.52*	*0.54*	*0.51*	*0.50*	-	*0.48*	*0.50*	*0.50*	*0.50*	*0.50*	*0.48*	*0.49*	*0.50*	*0.48*	*0.56*	*0.50*	*0.51*	*0.50*	*0.50*	*0.47*
34	*n*	*0.44*	*0.39*	*0.44*	*0.41*	*0.40*	*0.38*	*0.38*	*0.42*	-	*0.42*	*0.43*	*0.41*	*0.43*	*0.43*	*0.46*	*0.46*	-	*0.48*	*0.47*	*0.50*	*0.46*
35	*n*	*0.51*	*0.49*	*0.49*	*0.47*	*0.43*	*0.47*	*0.44*	*0.45*	*0.46*	*0.44*	*0.43*	*0.40*	*0.40*	*0.42*	*0.42*	*0.44*	*0.45*	*0.42*	*0.44*	*0.44*	*0.42*
36	y	0.49	0.47	0.49	0.47	0.43	0.45	0.47	0.47	0.45	0.43	0.44	0.40	0.41	0.42	0.43	0.42	0.45	0.44	0.42	0.43	0.38
37	*n*	*0.53*	*0.50*	*0.52*	*0.50*	*0.48*	*0.47*	*0.45*	-	*0.49*	*0.48*	*0.47*	*0.43*	*0.46*	*0.45*	*0.46*	*0.47*	*0.49*	*0.47*	*0.46*	*0.46*	*0.44*
38	y	0.52	0.49	0.51	0.48	0.45	0.46	0.46	0.48	0.49	0.47	0.43	0.41	0.42	0.42	0.44	0.41	0.44	0.46	0.46	0.46	0.39
39	*n*	*0.44*	*0.40*	*0.42*	*0.40*	*0.36*	*0.38*	*0.36*	*0.39*	*0.38*	*0.36*	*0.44*	*0.40*	*0.44*	*0.46*	*0.47*	*0.46*	*0.46*	*0.46*	*0.45*	*0.45*	*0.41*
Ref sites	-	0.51	0.50	0.53	0.51	0.47	0.48	0.48	0.49	0.47	0.46	0.46	0.43	0.43	0.45	0.46	0.44	0.47	0.47	0.45	0.45	0.41

Appendix C Historic data processed using the current defined site lengths

Table C.1: 2013 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Early avg. SR	Middle avg. SR	Late avg. SR	Between run standard deviation	Average
1	22	60.5	58.0	57.8	1.74	58.8
2	5	61.5	58.4	57.0	2.31	59.0
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	0	-	-	-	-	-
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	14	45.2	61.1	43.1	9.97	49.8
10	23	58.0	57.5	56.1	1.10	57.2
11	3	63.5	61.7	61.1	1.45	62.1
12	9	56.0	52.4	49.2	3.47	52.6
13	13	47.2	44.9	44.3	1.63	45.5
14	17	62.2	65.4	52.7	7.36	60.1
15	1	45.3	48.7	43.1	2.86	45.7
16	19	56.0	52.0	50.9	2.75	53.0
17	10	41.4	40.6	39.9	0.78	40.6
18	0	-	-	-	-	-
19	0	-	-	-	-	-
20	0	-	-	-	-	-
21	14	58.3	57.7	55.6	1.69	57.2
22	16	67.4	65.1	65.7	1.47	66.0
23	0	-	-	-	-	-
24	11	56.0	58.1	54.5	2.00	56.2
25	12	62.5	60.6	60.8	1.12	61.3
26	0	-	-	-	-	-
27	16	57.6	56.9	59.1	1.21	57.9
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	23	49.1	50.0	51.2	1.40	50.1
31	16	58.2	54.9	63.4	4.32	58.8
32	7	50.8	48.6	49.0	1.42	49.5
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	13	50.5	46.9	51.5	2.47	49.6
36	10	52.9	48.6	54.0	2.97	51.8
37	14	55.7	51.7	57.4	3.03	54.9
38	14	56.0	50.1	54.4	3.10	53.5
39	3	56.0	49.2	55.8	3.96	53.7
40	13	56.8	58.8	57.8	1.07	57.8
41	55	47.4	47.7	46.9	1.19	47.3
42	18	49.3	51.1	48.2	1.52	49.5
43	20	52.0	47.9	46.0	3.37	48.6
Asphalt 0-39	305	55.8	54.8	54.2	3.50	54.9
Concrete 40-43	106	49.7	49.7	48.3	1.84	49.2

Table C.2: 2014 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Early avg. SR	Middle avg. SR	Late avg. SR	Between run standard deviation	Average
1	22	62.7	55.9	61.8	3.94	60.1
2	5	64.6	54.7	61.5	5.13	60.3
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	0	-	-	-	-	-
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	14	46.8	44.9	44.5	2.72	45.4
10	23	59.8	51.3	58.1	4.76	56.4
11	3	63.1	57.2	65.9	4.47	62.1
12	9	59.5	50.2	56.5	4.89	55.4
13	13	47.0	42.7	47.2	2.82	45.7
14	17	59.8	51.9	58.9	4.57	56.9
15	1	49.8	38.4	43.8	5.73	44.0
16	19	55.5	52.4	55.3	1.97	54.4
17	10	45.6	37.0	40.6	4.38	41.1
18	0	-	-	-	-	-
19	0	-	-	-	-	-
20	0	-	-	-	-	-
21	14	59.4	54.1	56.1	3.02	56.5
22	16	75.6	64.9	69.0	5.45	69.8
23	0	-	-	-	-	-
24	11	63.1	53.2	52.4	6.03	56.2
25	12	87.5	60.4	63.7	14.77	70.5
26	0	-	-	-	-	-
27	16	61.2	50.6	56.1	5.41	55.9
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	23	56.3	44.9	47.2	6.14	49.5
31	16	61.1	55.6	60.0	3.01	58.9
32	7	47.8	47.5	46.0	1.72	47.1
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	13	52.4	47.6	50.5	2.52	50.2
36	10	53.7	50.1	52.5	2.24	52.1
37	14	65.2	56.2	56.2	5.37	59.2
38	14	58.5	53.0	53.5	3.53	55.0
39	3	61.3	60.4	53.7	4.36	58.5
40	13	61.8	56.9	61.2	2.73	60.0
41	55	50.7	44.7	48.9	3.50	48.1
42	18	51.8	44.9	53.1	4.49	49.9
43	20	48.4	43.1	47.0	2.90	46.2
Asphalt 0-39	305	59.5	51.7	55.2	5.13	55.5
Concrete 40-43	106	51.8	45.9	50.7	3.50	49.5

Table C.3: 2015 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Early avg. SR	Middle avg. SR	Late avg. SR	Between run standard deviation	Average
1	22	68.8	60.3	67.8	5.01	65.6
2	5	69.2	58.2	66.4	5.86	64.6
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	0	-	-	-	-	-
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	14	53.1	41.7	48.0	6.60	47.6
10	23	66.4	53.2	56.5	6.92	58.7
11	3	72.7	56.6	59.7	8.92	63.0
12	9	62.5	48.3	53.8	7.19	54.9
13	13	52.9	44.9	58.7	6.95	52.2
14	17	67.3	56.1	70.9	7.84	64.8
15	1	48.4	42.1	54.5	6.23	48.3
16	19	60.3	51.0	52.8	5.07	54.7
17	10	45.2	40.4	51.6	5.85	45.7
18	0	-	-	-	-	-
19	0	-	-	-	-	-
20	0	-	-	-	-	-
21	14	61.6	56.4	54.4	3.88	57.5
22	16	73.1	67.2	73.3	3.55	71.2
23	0	-	-	-	-	-
24	11	63.5	55.2	59.6	4.30	59.4
25	12	73.2	59.2	71.5	7.70	68.0
26	0	-	-	-	-	-
27	16	63.6	56.9	57.4	3.83	59.3
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	23	53.0	50.8	55.4	2.52	53.1
31	16	62.2	61.9	61.8	1.24	62.0
32	7	49.9	46.6	48.1	2.34	48.2
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	13	56.0	49.6	50.4	3.64	52.0
36	10	53.2	51.9	55.6	2.45	53.6
37	14	61.4	54.7	56.7	3.69	57.6
38	14	59.2	52.9	52.2	4.02	54.8
39	3	61.3	58.4	58.5	1.86	59.4
40	13	71.1	57.8	68.3	7.07	65.7
41	55	53.3	44.1	47.8	5.10	48.4
42	18	57.1	48.8	49.1	4.81	51.7
43	20	51.3	41.9	44.5	5.03	45.9
Asphalt 0-39	305	61.3	53.8	58.6	5.16	57.9
Concrete 40-43	106	55.7	46.1	49.9	5.32	50.6

Table C.4: 2016 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Early avg. SR	Middle avg. SR	Late avg. SR	Between run standard deviation	Average
1	22	59.8	58.8	71.0	7.00	63.2
2	5	60.6	60.5	65.6	3.09	62.2
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	0	-	-	-	-	-
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	14	48.0	46.0	48.5	3.09	47.5
10	23	62.2	59.1	59.8	2.07	60.4
11	3	67.7	61.3	66.6	3.67	65.2
12	9	60.7	57.3	58.1	2.63	58.7
13	13	51.8	48.9	53.6	2.72	51.5
14	17	70.6	61.8	60.0	5.82	64.1
15	1	43.5	46.3	48.3	2.38	46.0
16	19	57.0	51.4	56.0	3.22	54.8
17	10	45.1	41.0	41.6	2.38	42.6
18	0	-	-	-	-	-
19	0	-	-	-	-	-
20	0	-	-	-	-	-
21	14	65.8	61.3	57.6	4.28	61.6
22	16	76.5	70.4	73.1	3.33	73.3
23	0	-	-	-	-	-
24	11	64.0	56.0	61.1	4.22	60.4
25	12	75.6	65.4	68.8	5.38	69.9
26	0	-	-	-	-	-
27	16	62.0	77.0	66.2	7.99	68.4
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	23	55.8	51.6	54.4	3.41	54.0
31	16	64.6	59.0	63.8	3.15	62.4
32	7	50.9	50.3	50.7	2.24	50.6
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	13	54.3	50.1	53.4	2.54	52.6
36	10	59.0	52.6	54.0	4.15	55.2
37	14	60.6	56.4	61.3	2.75	59.4
38	14	53.9	56.3	60.5	3.51	56.9
39	3	60.2	64.3	64.4	2.39	63.0
40	13	64.5	62.7	63.8	1.92	63.7
41	55	51.8	51.2	52.4	2.04	51.8
42	18	52.1	57.4	55.1	2.86	54.8
43	20	53.1	49.7	52.9	2.07	51.9
Asphalt 0-39	305	60.4	57.3	59.7	4.21	59.1
Concrete 40-43	106	53.6	53.4	54.4	2.19	53.8

Table C.5: 2017 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Early avg. SR	Middle avg. SR	Late avg. SR	Between run standard deviation	Average
1	22	71.5	55.5	67.5	8.43	64.8
2	5	75.1	53.9	59.9	11.02	63.0
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	0	-	-	-	-	-
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	14	50.8	42.8	48.4	4.52	47.3
10	23	66.5	52.7	60.8	7.51	60.0
11	3	77.4	59.3	64.3	9.53	67.0
12	9	55.9	49.6	58.5	4.77	54.7
13	13	49.2	41.5	49.4	4.58	46.7
14	17	65.1	50.3	61.2	7.80	58.9
15	1	49.8	42.5	48.4	3.90	46.9
16	19	59.6	48.9	55.1	5.52	54.5
17	10	44.8	34.8	40.9	5.11	40.2
18	0	-	-	-	-	-
19	0	-	-	-	-	-
20	0	-	-	-	-	-
21	14	60.5	52.6	61.0	4.96	58.0
22	16	75.8	61.0	69.3	7.48	68.7
23	0					
24	11	62.6	49.3	55.6	6.73	55.8
25	12	72.4	57.8	65.0	7.30	65.1
26	0	-	-	-	-	-
27	16	64.4	58.4	65.1	3.86	62.6
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	23	53.6	48.2	51.9	3.18	51.2
31	16	66.8	56.5	63.1	5.25	62.1
32	7	54.4	44.2	48.5	5.20	49.0
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	13	60.1	47.1	56.1	6.67	54.4
36	10	61.0	47.8	54.8	6.69	54.6
37	14	66.3	53.3	61.8	6.78	60.5
38	14	57.2	48.4	57.2	5.15	54.3
39	3	64.9	57.0	64.9	4.61	62.3
40	13	60.1	55.7	62.4	3.66	59.4
41	55	49.4	44.8	50.5	3.69	48.2
42	18	49.7	46.0	54.0	4.24	49.9
43	20	50.1	43.8	51.6	4.29	48.5
Asphalt 0-39	305	62.1	50.9	58.5	6.27	57.2
Concrete 40-43	106	50.9	46.1	52.7	3.90	49.9

Table C.6: 2018 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Early avg. SR	Middle avg. SR	Late avg. SR	Between run standard deviation	Average
1	22	73.5	61.2	67.5	6.29	67.4
2	5	71.3	60.9	61.9	5.76	64.7
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	0	-	-	-	-	-
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	14	53.9	42.7	49.9	6.30	48.8
10	23	67.8	54.4	63.4	6.91	61.9
11	3	72.2	55.7	64.6	8.55	64.2
12	9	67.0	47.6	58.4	9.87	57.7
13	13	57.6	46.4	50.4	5.85	51.5
14	17	70.4	53.8	62.1	8.38	62.1
15	1	52.0	43.4	48.3	4.32	47.9
16	19	65.1	47.4	56.1	8.94	56.2
17	10	47.6	36.3	43.4	5.84	42.4
18	0	-	-	-	-	-
19	0	-	-	-	-	-
20	0	-	-	-	-	-
21	14	61.7	50.8	61.7	6.52	58.1
22	16	78.2	72.9	72.4	3.28	74.5
23	0	-	-	-	-	-
24	11	61.1	57.0	59.6	2.20	59.3
25	12	67.8	66.0	68.3	1.42	67.4
26	0	-	-	-	-	-
27	16	67.8	59.6	65.0	4.29	64.1
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	23	61.0	48.6	57.2	6.44	55.6
31	16	64.4	60.6	67.7	3.64	64.2
32	7	51.9	45.6	51.5	3.88	49.6
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	13	55.8	54.4	58.4	2.21	56.2
36	10	59.4	53.7	60.8	4.06	58.0
37	14	65.2	59.1	63.4	3.35	62.6
38	14	61.6	54.2	58.0	3.90	57.9
39	3	65.3	60.3	64.5	2.83	63.4
40	13	60.4	60.8	65.4	3.12	62.2
41	55	53.0	44.8	50.8	5.12	49.5
42	18	55.5	51.0	56.8	3.28	54.4
43	20	52.8	43.9	50.1	4.67	48.9
Asphalt 0-39	305	64.2	54.4	60.6	5.82	59.7
Concrete 40-43	106	54.3	47.7	53.5	4.55	51.8

Table C.7: 2019 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Early avg. SR	Middle avg. SR	Late avg. SR	Between run standard deviation	Average
1	22	64.4	60.2	67.9	4.16	64.2
2	5	63.6	58.7	64.5	3.50	62.3
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	0	-	-	-	-	-
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	14	47.1	49.4	50.4	3.23	49.0
10	23	60.9	58.4	62.3	2.55	60.5
11	3	62.4	73.2	66.8	5.51	67.4
12	9	65.9	54.4	56.7	6.16	59.0
13	13	58.2	48.5	53.4	4.92	53.4
14	17	72.6	59.1	64.2	7.07	65.3
15	1	54.9	48.3	44.7	5.16	49.3
16	19	57.4	53.4	52.8	2.84	54.5
17	10	49.5	39.1	40.5	5.71	43.1
18	0	-	-	-	-	-
19	0	-	-	-	-	-
20	0	-	-	-	-	-
21	14	66.2	55.4	60.1	5.84	60.6
22	16	79.4	68.6	73.2	5.71	73.7
23	0	-	-	-	-	-
24	11	63.5	55.9	56.3	4.67	58.6
25	12	69.7	62.4	64.3	3.83	65.5
26	0	-	-	-	-	-
27	16	72.5	60.1	64.4	6.45	65.7
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	23	61.4	50.9	60.8	6.63	57.7
31	16	67.3	57.3	62.5	5.16	62.4
32	7	52.3	47.2	50.2	3.08	49.9
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	13	56.9	48.5	53.0	4.40	52.8
36	10	61.3	51.4	55.3	5.34	56.0
37	14	63.4	56.5	59.1	3.76	59.7
38	14	62.6	57.9	56.0	3.91	58.9
39	3	67.5	62.4	62.3	3.11	64.1
40	13	62.5	55.1	60.5	4.06	59.3
41	55	54.3	46.7	47.7	4.56	49.6
42	18	57.1	48.9	51.6	4.40	52.5
43	20	46.9	47.9	49.6	1.78	48.2
Asphalt 0-39	305	63.2	55.7	59.4	4.93	59.5
Concrete 40-43	106	54.4	48.3	50.3	4.09	51.0

Table C.8: 2020 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Early avg. SR	Middle avg. SR	Late avg. SR	Between run standard deviation	Average
1	22	65.3	59.3	58.6	4.09	61.1
2	5	67.5	62.1	58.3	4.70	62.6
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	0	-	-	-	-	-
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	14	45.6	43.6	51.9	5.57	47.0
10	23	61.2	55.9	55.9	3.45	57.7
11	3	65.3	60.1	70.6	5.29	65.3
12	9	64.8	55.5	61.2	4.96	60.5
13	13	49.1	52.6	54.5	3.00	52.1
14	17	58.6	60.7	66.6	4.35	62.0
15	1	41.5	44.9	45.8	2.26	44.1
16	19	56.5	50.1	59.5	5.05	55.4
17	10	42.1	43.3	41.4	2.26	42.3
18	0	-	-	-	-	-
19	0	-	-	-	-	-
20	0	-	-	-	-	-
21	14	52.4	54.4	62.0	5.19	56.3
22	16	68.6	75.3	73.6	3.88	72.5
23	0	-	-	-	-	-
24	11	56.7	55.5	58.7	1.94	57.0
25	12	64.5	61.8	66.8	2.78	64.4
26	0	-	-	-	-	-
27	16	60.2	62.0	70.5	5.57	64.2
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	23	47.9	53.9	62.9	7.68	54.9
31	16	55.0	61.2	66.0	5.68	60.7
32	7	42.8	48.7	50.1	4.45	47.2
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	13	57.3	49.6	55.4	4.20	54.1
36	10	50.0	52.0	59.1	4.95	53.7
37	14	52.8	58.8	65.4	6.39	59.0
38	14	56.2	56.6	63.5	4.69	58.8
39	3	57.3	60.2	67.4	5.24	61.6
40	13	54.4	57.6	61.2	3.51	57.7
41	55	47.0	41.7	42.9	3.72	43.8
42	18	50.4	47.0	46.3	2.74	47.9
43	20	47.1	45.8	45.9	1.32	46.3
Asphalt 0-39	305	56.4	56.3	60.9	4.85	57.8
Concrete 40-43	106	48.5	45.3	46.3	3.21	46.7

Table C.9: 2021 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Early avg. SR	Middle avg. SR	Late avg. SR	Between run standard deviation	Average
1	22	64.3	57.8	63.1	3.76	61.7
2	5	63.4	58.4	62.0	2.79	61.2
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	0	-	-	-	-	-
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	14	50.5	46.5	42.0	5.05	46.4
10	23	64.6	56.1	53.2	6.19	58.0
11	3	72.3	59.7	61.1	6.93	64.4
12	9	68.6	53.6	53.7	8.93	58.6
13	13	57.4	43.6	43.9	7.98	48.3
14	17	71.3	56.5	53.5	9.70	60.4
15	1	52.3	39.7	38.1	7.79	43.4
16	19	63.0	53.6	48.5	7.58	55.0
17	10	39.1	36.8	41.9	2.73	39.3
18	0	-	-	-	-	-
19	0	-	-	-	-	-
20	0	-	-	-	-	-
21	14	66.3	52.3	62.7	7.50	60.4
22	16	77.6	71.7	82.2	5.31	77.2
23	0	-	-	-	-	-
24	11	60.1	51.8	53.7	4.46	55.2
25	12	66.5	63.3	61.2	2.78	63.7
26	0	-	-	-	-	-
27	16	76.8	60.8	67.7	8.09	68.5
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	23	52.9	50.6	61.0	6.58	54.8
31	16	67.3	54.5	62.8	6.59	61.5
32	7	52.7	45.3	46.6	4.73	48.2
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	13	53.4	47.2	54.8	4.14	51.8
36	10	64.8	47.7	54.5	8.83	55.7
37	14	60.1	53.8	63.9	5.54	59.3
38	14	58.6	57.6	61.9	2.68	59.4
39	3	63.9	61.3	65.1	2.04	63.4
40	13	63.7	56.8	59.2	3.86	59.9
41	55	51.4	44.0	38.9	6.76	44.8
42	18	55.0	44.1	42.4	6.88	47.2
43	20	53.8	49.3	47.2	3.58	50.1
Asphalt 0-39	305	62.5	54.1	57.6	6.30	58.1
Concrete 40-43	106	54.0	46.6	43.5	6.00	48.0

Skid resistance benchmark surveys 2022

National Highways manages levels of skid resistance on strategic road network by carrying out single annual skid resistance surveys. These are carried out over the course of the summer and are split over three survey periods. It is known that skid resistance varies during the year and between years. To monitor the ongoing trends in skid resistance National Highways established a series of benchmark sites. These sites are surveyed in all three of the survey periods during the survey season. This report discusses the analysis of the data collected in 2022.cusses the analysis of the data collected in 2022.

Other titles from this subject area

PPR 1030 Skid resistance benchmark surveys 2021. S Brittain. 2022

PPR 989 Skid resistance benchmark surveys 2020. S Brittain. 2021

PPR 950 Skid resistance benchmark surveys 2019. S Brittain. 2020

PPR 905 Skid resistance benchmark surveys 2018. S Brittain. 2019

TRL
Crowthorne House, Nine Mile Ride,
Wokingham, Berkshire, RG40 3GA,
United Kingdom
T: +44 (0) 1344 773131
F: +44 (0) 1344 770356
E: enquiries@trl.co.uk
W: www.trl.co.uk

ISSN 2514-9652

DOI 10.58446/ezee1455

PPR2023