THE FUTURE
OF TRANSPORT

PUBLISHED PROJECT REPORT PPR1030

Skid resistance benchmark surveys 2021

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Report details

Report prepared for:	National Highways, SES
Project/customer reference:	SPaTS 2: T0098
Copyright:	© TRL Limited
Report date:	14/03/2022
Report status/version:	1.0
Quality approval:	

Anton Watts (Project Manager)	**Anton Watts**	Martin Greene (Technical Reviewer)	**Martin Greene**

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Contents amendment record

This report has been amended and issued as follows:

Version	Date	Description	Editor	Technical Reviewer
1.0	27/05/2022	Published version	S Brittain	M Greene

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 2021, 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.

Two sites (site 8 and site 35) were 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 2021 analysis. Currently 11 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 392 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 2021 was an "slightly low skid resistance" year in comparison to the average of the previous three years but a "slightly high skid resistance" year when considering all of the years in the analysis. In addition the minimum value of the skid resistance values appears to have occurred around the middle/late survey period boundary in 2021.

For the 2021 survey, the between run variation of the data from the concrete sites (6.00 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).

The current analysis procedure uses data collected over the last 10 years for the analysis. This should be repeated in future years, however methods for combining these separate analyses should be investigated in future years so that the trend since 2010 (or 2002 if the results of the long-term analysis can also be incorporated).

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1 Introduction

1.1 Background

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.

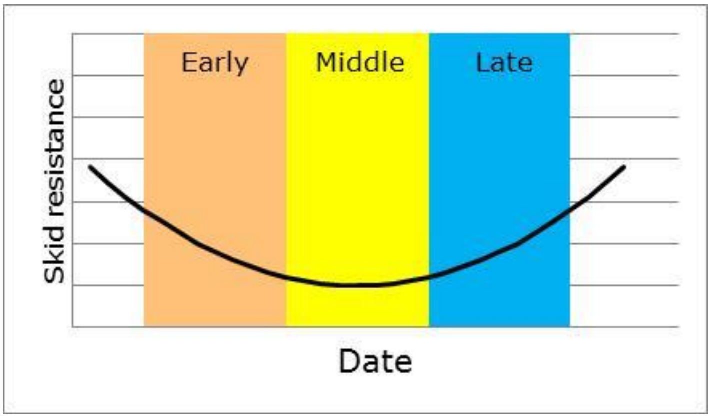

Figure 1.1: Expected seasonal variation of skid resistance over the summer

Table 1.1: Dates for the skid resistance survey periods

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

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 2021 surveys, data from 2012 to 2021 would be used. The results from this analysis, incorporating the data from the 2021 surveys, are given in section 4.

Over time this approach will result in overlapping sets of 10 year analyses. Therefore, in future years consideration should be given to identify a suitable approach for combining this data to allow the examination of trends over the whole period.

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. In addition to the work on overlapping 10 year analyses discussed above, future analyses may consider if the long term analysis should be dropped due the reduction in data available to make a robust assessment.

3 Survey issues

3.1 Alignment of data

In previous years 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 are, 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).

However, when the alignment of data was being checked for the 2021 survey data it was identified that these markers were not present, and as such all of the data was manually aligned (using the graph shapes and OSGR data).

It is planned to amend this process to use the Machine Survey Pre-processor (MSP) software provided by National Highways to survey contractors to fit data to the network. This fitting could be done by either the survey contractor or the company reviewing the data. This process should provide accurately aligned data with only minor changes required from the visual analysis of the data. However, before this can be achieved, route files will need to be created for the sites. These should be based on the node positions for HAPMS sections to make it easier to compare the data to HAPMS records. Due to differences in the alignment of data for the benchmark sites analysis this may require positional offsets applied to the fitted data (i.e. the node does not correspond to zero chainage) or realignment of the processed survey data to the new positions. Once implemented, it will be necessary to review the route files for each subsequent analysis to confirm that the HAPMS section referencing has not changed for these lengths (and update the files and analysis accordingly).

3.2 Issues and observations from surveys

For the 2021 survey data, five sites (6, 8, 11, 23 and 35) had potential issues identified from the data, the National Highways pavement management system (HAPMS) construction records, the video and/or from the operator’s notes (recorded in the directory of benchmark sites).

3.2.1 Site 6

The first 890m of site 6 was resurfaced between the Early and Middle surveys as seen in Figure 3.1. A resurfacing was also noted in the operator’s notes and HAPMS construction records. The affected length has been marked as invalid for the 2021 analysis.

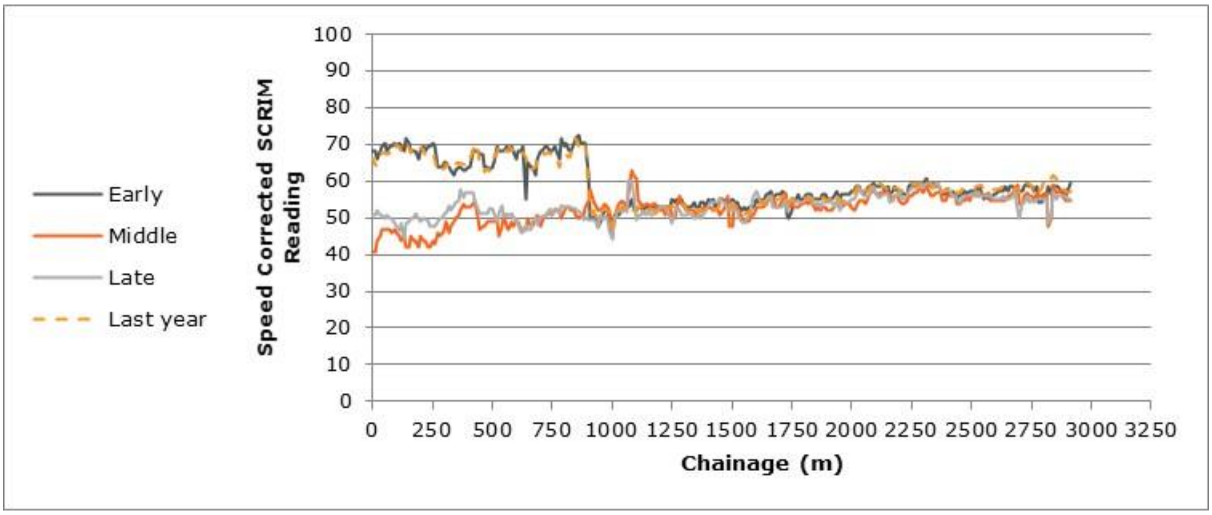

Figure 3.1: Skid resistance values from the 2021 survey for site 6

3.2.2 Site 8

A resurfacing between the Early and Middle surveys for the end of the site (1280m onwards) was recorded in the operator’s notes. The HAPMS construction information identifies a resurfacing from 1260m onwards, however it also includes a resurfacing from 275 to 1260m a few days before (while still after the Early survey). These resurfacings are not clearly visible in the survey data (Figure 3.2), however the data from 280m onwards in the 2021 survey has been marked as invalid for use in analysis of trends due to the resurfacings.

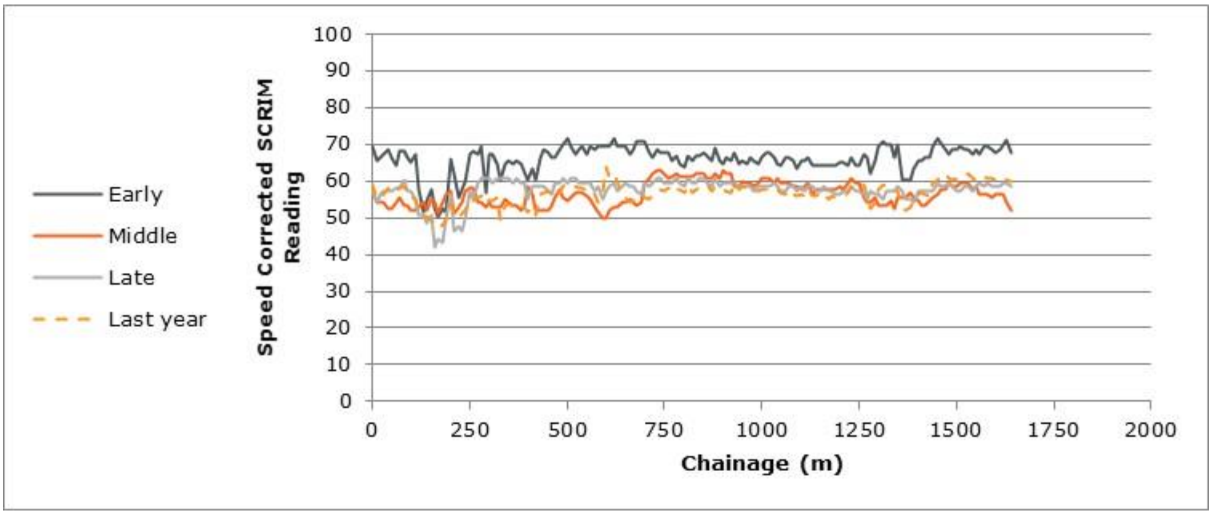

Figure 3.2: Skid resistance values from the 2021 survey for site 8

3.2.3 Site 11

The Middle survey included two lengths marked as a deviation (i.e. change from test line). This was due to road works amending the traffic lane (which were also present in the Early and Late surveys). This was recorded (for all three surveys) in the operator's notes. The effected length of the 2021 data has been marked as invalid for use in analysis of trends.

3.2.4 Site 23

Due to roadworks, this site was surveyed in lane 2 for all three surveys. As such the 2021 data for this site has been marked as invalid for use in the analysis of trends.

3.2.5 Site 35

The end of the site (from 1330m onwards) was resurfaced between the Middle and Late surveys as seen in Figure 3.3. A resurfacing was also noted in the operator's notes and HAPMS construction records. The affected length has been marked as invalid for the 2021 analysis.

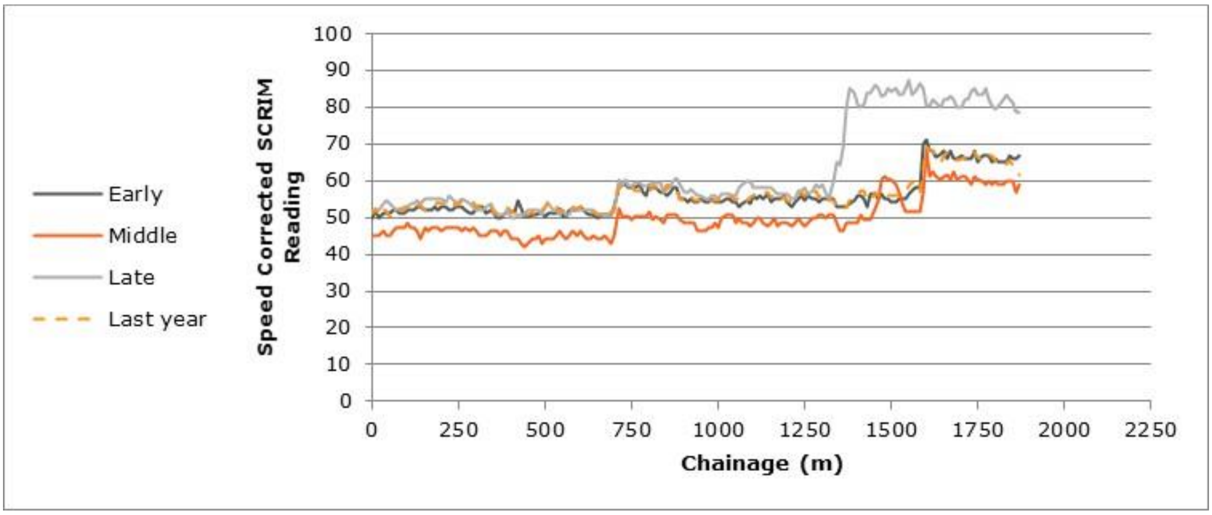

Figure 3.3: Skid resistance values from the 2021 survey for site 35

3.2.6 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
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

Two sites (8 and 35) were removed from the long term reference benchmark sites this year. There are currently 11 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
32	M58
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 2012 onwards.

For the 2021 surveys, following the removal of unsuitable lengths, 288 (of 627) individual 100m lengths were available for the investigation of skid resistance trends over 10 years for the asphalt sites and 104 (of 109) 100m lengths for the concrete sites. This is the same number of lengths used in last year's analysis for both the asphalt and concrete sites.

3.2.7 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 assuming that the site is surveyed in the new lane 1 in 2022.

4 Results from the 2021 surveys

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 2021 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 2021 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 2021 data the between run standard deviation (BRSD) is above the 3 SR threshold for both the asphalt and the concrete sites. The values for BRSD are similar for both the asphalt sites and the concrete sites which is contrary to previous experience where the asphalt sites tend to produce higher BRSD.

Table 4.1: 2021 survey data

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	11	68.7	62.2	67.1	3.69	66.0
2	5	63.4	58.4	62.0	2.79	61.2
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	1	68.0	56.6	59.3	5.94	61.3
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	13	50.6	46.5	42.2	5.05	46.4
10	15	66.0	57.6	53.7	6.46	59.1
11	0	-	-	-	-	-
12	8	68.2	54.0	53.4	8.72	58.5
13	11	57.3	43.4	43.6	8.02	48.1
14	16	71.6	57.0	53.7	9.69	60.8
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	18	66.2	52.4	63.0	7.59	60.6
22	17	77.9	72.2	82.6	5.28	77.5
23	0	-	-	-	-	-
24	10	60.1	51.7	53.9	4.50	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	22	52.8	50.6	60.3	5.99	54.6
31	18	66.8	54.0	62.5	6.62	61.1
32	13	53.1	45.5	45.7	4.90	48.1
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	12	53.6	47.3	55.0	4.19	52.0
36	10	64.8	47.7	54.5	8.83	55.7
37	13	60.1	53.8	64.2	5.69	59.4
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	54	51.5	44.2	39.0	6.74	44.9
42	18	55.0	44.1	42.4	6.88	47.2
43	19	54.0	49.5	47.4	3.58	50.3
Asphalt 0-39	288	62.6	54.1	57.8	6.31	58.2
Concrete 40-43	104	54.1	46.7	43.6	6.00	48.1

A summary of between run standard deviations (BRSD) and the average SR values since 2012 are presented in Table 4.2 for the asphalt lengths and in

Table 4.3 for the concrete lengths. The averages are also shown in Figure 4.1 along with the trend lines for the data.

Table 4.2: Summary of asphalt site data

Year	BRSD	Average SR
2012	2.28	58.4
2013	3.53	55.0
2014	5.12	55.4
2015	4.98	57.8
2016	4.10	59.2
2017	6.15	57.0
2018	5.65	59.5
2019	4.93	59.4
2020	4.87	57.8
2021	6.31	58.2
Average	4.93	57.8

Table 4.3: Summary of concrete site data

Year	BRSD	Average SR
2012	2.20	53.4
2013	1.80	49.3
2014	3.53	49.6
2015	5.29	50.7
2016	2.16	53.9
2017	3.93	50.1
2018	4.52	52.0
2019	4.07	51.2
2020	3.20	46.8
2021	6.00	48.1
Average	3.90	50.5

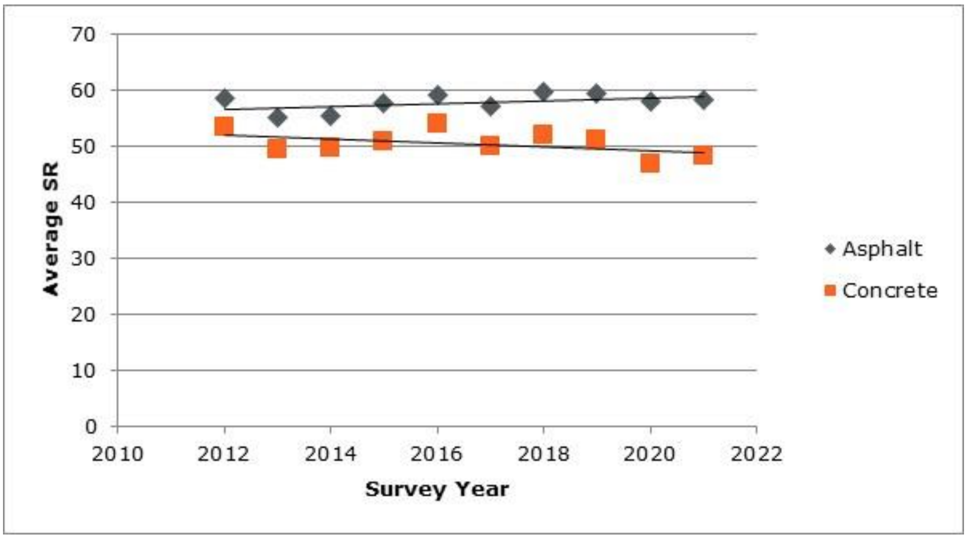

Figure 4.1: Average SR of Benchmark sites over time

These tables and figure show that the between run or between period standard deviation for the asphalt surfaces is highest for the 2014, 2015, 2017, 2018, 2019, 2020 and 2021 survey years, and lowest in 2012. In addition, it can be seen that for three of the ten years, the between period standard deviation for the concrete lengths (and for the asphalt sections in 2012) 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 (and on the asphalt sites in 2012) is likely to be mainly or solely caused by normal machine variation.

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 2021 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 4.2.

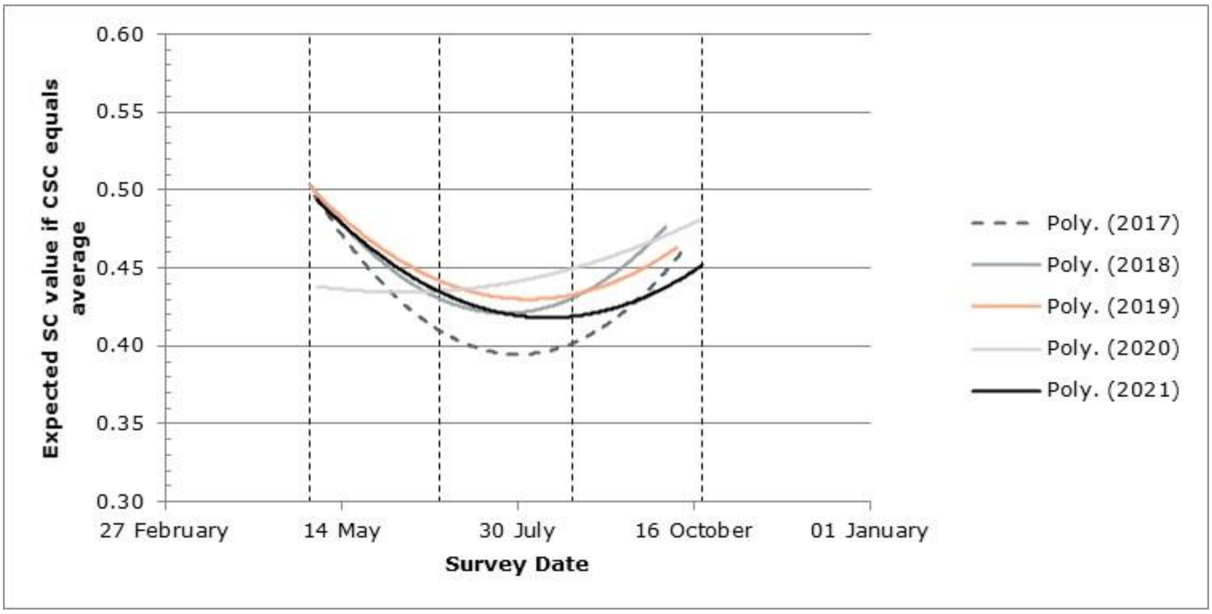

Figure 4.2: Expected SC values (sites 1-39)

It can be seen from Figure 4.2 that the within year seasonal variation, varies slightly from year to year. It can also be seen that the shape for the 2021 suggests the minimum skid resistance value occurred close to the boundary between the middle and late surveys in that dataset. It is also noted that for the late surveys some of the Asphalt sites were surveyed by a different survey vehicle to the rest of the surveys (amounting to approximately 1/3 of the data used in the analysis). On examination of the data it appears that the inclusion of this data slightly increased the values seen for the late period.

The analysis of the 2021 LECFs (Brittain, 2022)also suggested that the minimum value for skid resistance occurred around the middle/late boundary. However, a fairly shallow 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 2021 LECFs also found that the measured skid resistance over the year was slightly lower but very close to 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 2021 was 57.8 and the average of the three previous years (2018, 2019 and 2020) was 58.9.

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 4.3.

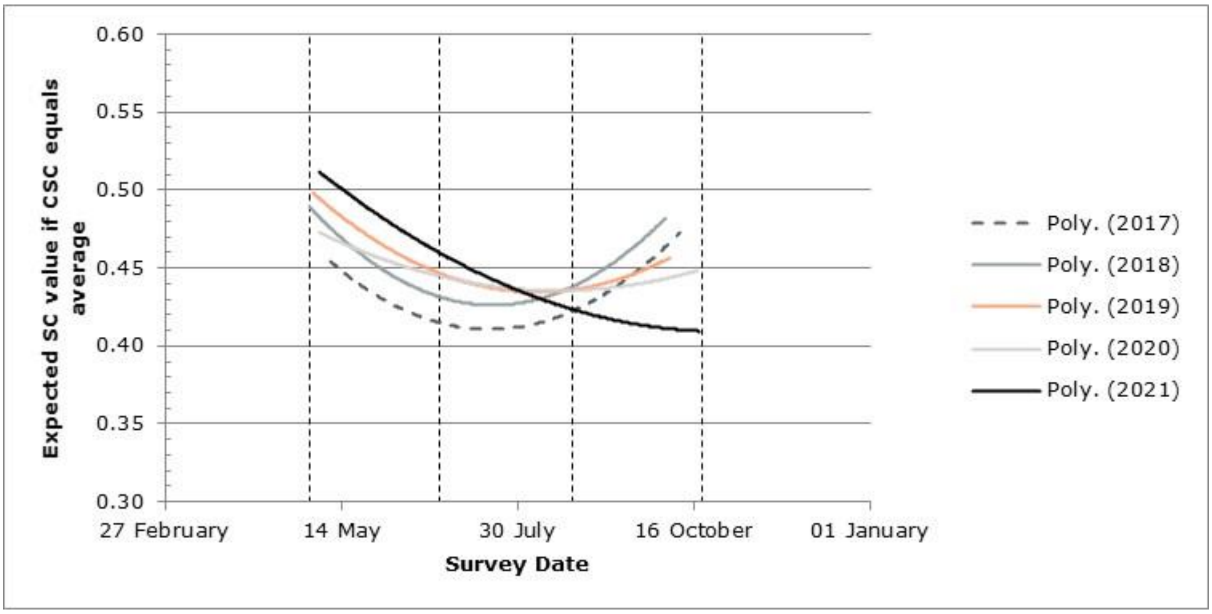

Figure 4.3: Expected SC values (sites 40-43)

The data for concrete sites in 2017 and 2018, and to a lesser extent in 2019 and 2020, suggest that these sites are experiencing within year seasonal variation. However, it is noted that the variation seen is different to that for the asphalt sites. The 2021 data is showing variation over the course of the year, but noticeably the values do not rise back up in the late period. 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 2021 surveys used data collected since 2012. The lengths used in the analysis for each survey year is given in Figure 4.4 for asphalt lengths and in Figure 4.5 for concrete lengths.

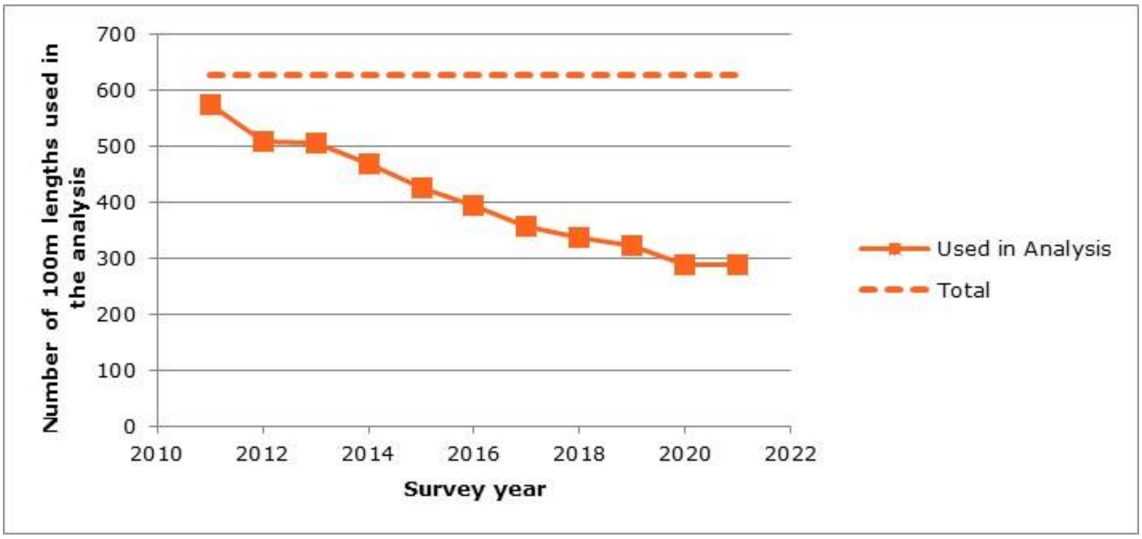

Figure 4.4: Number of 100m asphalt lengths used in the anlaysis

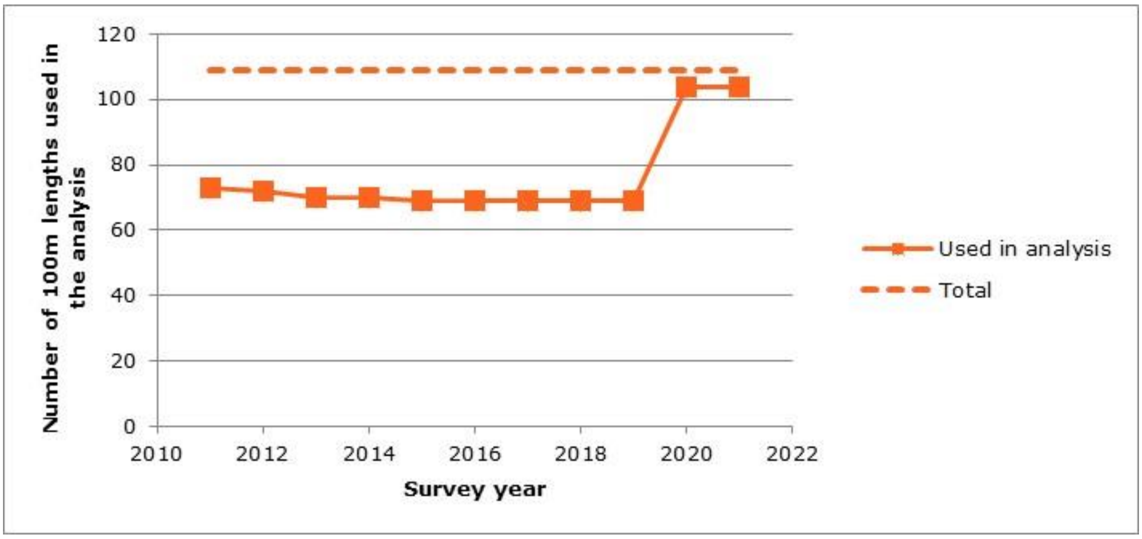

Figure 4.5: Number of 100m concrete lengths used in the anlaysis

It can be seen from these two graphs that the number of lengths (both Asphalt and Concrete) used in the current analysis have remained constant over the last two years. Overall, 46% of the asphalt lengths were used in the current analysis, and 95% of the concrete lengths.

5 Conclusions and recommendations

5.1 Data coverage

Two sites (site 8 and site 35) were 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 2021 data. Currently 11 of the original 39 sites are suitable for use in the investigation of trends since 2002 (given in Appendix B) and 392 individual 100m lengths (288 asphalt lengths and 104 concrete lengths) are suitable for use in the investigation of trends over the last ten years.

5.2 Alignment of data

It is recommended that, for future analyses, the survey data is fitted based on the OSGR coordinates using MSP. This could either be done by the survey contractor or the company reviewing the data. The plots of the resulting alignment should, however, still be checked for anomalies.

Before this can be achieved route files will need to be created for the sites. This should be based on HAPMS sections but may require offsetting the fitted values or realignment of the processed survey data to the new positions. Once implemented, it will be necessary to review the route files for each subsequent analysis to confirm that the HAPMS section referencing has not changed for these lengths (and update the files and analysis accordingly).

5.3 Results

Investigation into the average SR values for Asphalt sites suggests that 2021 was slightly higher than the average SR value of the last 10 years and slightly below the average when compared to the last three years. The analysis also found that the minimum SR value (on asphalt sites) appeared to occur on the middle/late period boundary. Both of these findings are consistent with the analysis of the 2021 LECFs (Brittain, 2022). The analysis of the benchmark sites suggested a normal to large change in skid resistance over the course of the year due to seasonal variation. The LECF analysis suggested very little change over the year. 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.

For the 2021 data the between period standard deviation for the concrete sites was well above the 3 SR threshold (at 6.00 SR) suggesting some form of seasonal variation. However, it is noted that the asphalt sites showed the skid resistance values rising in the Late survey period whereas the concrete sites did not. 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).

5.4 Further 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, in future years consideration should be given to identifying a suitable approach for combining this data to allow examination of trends over the whole period.

So that it is possible to examine trends going back to 2002, an analysis based on the original approach was also undertaken. Due to the reduction in available sites, this analysis will become less robust with each passing year. Therefore, consideration should be given in future years to drop this analysis or to merge the conclusions from it into the combined 10 year analyses dataset.

References

Note: this list of references contains both unpublished reports (UPR) and client project reports (CPR) produced for Highways England. Please make a personal application to Highways England 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. (2022). *Calculation of Local Equilbrium Correction Factors for the 2021 Skid Ressitance surveys (PPR1031).* Wokingham: TRL.

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	Route	Direction	Section(s)	Length (m)	Description	Nodes
1	1	A30	E/B	0800A30/400	2260	Studs under A3076 bridge at Mitchell to studs at 2260m	21435-21460
2	1	A30	W/B	1100A30/115	1180	End of slip On from A377 to studs at 1180m	492-431
3	2	M5	S/B	3300M5/210, 3300M5/220	1694	End of slip On at Jct 22 to studs at 1694m	15179-15184-15185
4	2	M4	E/B	3900M4/162	1226	End of slip On at Jct 17 to studs at 1226m	448-446
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
6	3	M4	E/B	0300M4/393, 0300M4/391	2875	End of slip On at Jct 15 to studs at 2875m	35593-35941-35489
7	3	A31	E/B	1200A31/461, 1200A31/467	1358	Exit from Ameysford Rbt to studs under B3072 bridge	12071-12076-12999
8	4	M20	E/B	2200M20/290	1634	End of slip On at Jct 9 (A20/A28) for 1634m	5230-1859
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
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
11	M25 DBFO	M4	W/B	5540M4/244	976	Start of slip Off to Heston Services to end of Slip On	32828-32830
12	6	A12	N/B	1500A12/294	1053	Studs at Suffolk boundary to start of slip road off to B1029	40560-42270
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
14	7	A1	N/B	2500A1/110	2150	End of slip On from South Witham to Jct Left (to North Witham)	7005-7015
15	7	A1	N/B	3000A1/345	1426	Jct L to Elkesley Village (744m N of B6387) 1426m to Jct Rt	20125-20129
16	8	A1(M)	S/B	1900A1M/58	1946	End of slip On at Jct 7 to studs under bridge at 1981m	1530-11489
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
18	2	M5	N/B	1600M5/138	1264	Studs under A4019 bridge at Jct 10 to studs under next bridge	4231-30034
19	9	A49	N/B	1800A49/320	1760	Jct R (to Stoke Prior) to River Bridge	43133-43134
20	9	A5	W/B	3200A5/293	1641	Exit from A49/A5112 Rbt to studs under bridge at 1641m	50293-50289
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
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

Site No.	Area	Route	Direction	Section(s)	Length (m)	Description	Nodes
23	9	M6	S/B	3400M6/430	995	Studs 2255m before start of slip Off at Jct 14 to studs at 995m	23101-23001
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
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
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
27	12	A616	W/B	4405A616/30	1717	Studs L Jct A629 to studs on river bridge at 1717m	61630-61644
28	10	M62	E/B	4200M62/450	1308	End of slip On at Jct 21 to studs at 1308m	22105-22107
29	12	M18	S/B	4400M18/108	1681	End of slip On at Jct 4 (A630) to studs at 1681m	4308-321
30	12	A63	W/B	2000A63/409	2378	End of slip On at A1034 to studs at bridge over 2378m	2002-30482
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
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
33	A1DDD BFO	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
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
35	13	A66	E/B	0900A66/142	1860	Studs on bridge over B5292 (1950m E of A5086 Rbt) to studs at 1860m	31347-31507
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
37	13	M6	S/B	0900M6/351	1385	Start of slip Off to Southwaite services to end of slip On from services	14779-14766
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
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
40	9	M54	E/B	3200M54/784	1434	Asphalt/PQC surface change @ marker post 27/7 to start slip off to J4	54006-40100
41	6	A14	E/B	3500A14/632 to 3500A14/716	5601	End slip on J54, Sproughton to start slip off J56, Wherstead	90366-90301
42	6	A12	S/B	1500A12/158	1960	Baddow Park Overbridge to Slip off	40950-40960
43	M25 DBFO	M25	C/W	3600M25/464	2004	MP55/0 to MP57/0	21543-21541

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

B.1 2021 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 2021 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, five 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 2021 surveys

Site	Speed corrected SR			Average	Range
	Early	Middle	Late		
1	64.08	57.63	62.98	61.56	6.45
2	64.43	58.05	62.99	61.83	6.37
3	64.16	55.95	60.60	60.24	8.21
4	52.01	48.18	50.88	50.36	3.83
5	68.48	57.06	58.14	61.23	11.42
6	59.15	52.28	53.10	54.84	6.87
7	59.88	52.35	59.90	57.38	7.55
8	65.91	56.51	57.54	59.99	9.39
9	50.46	46.52	42.00	46.33	8.47
10	64.58	56.03	53.29	57.97	11.29
11	76.71	64.15	65.62	68.83	12.56
12	68.68	53.38	53.51	58.52	15.30
13	57.45	43.62	43.82	48.30	13.83
14	70.73	55.83	53.01	59.86	17.72
15	63.14	48.11	47.76	53.00	15.38
16	62.88	53.53	48.48	54.96	14.40
17	44.02	41.32	45.88	43.74	4.56
18	62.60	55.13	57.96	58.56	7.47
19	62.90	56.42	60.88	60.07	6.48
20	66.49	52.20	55.63	58.10	14.29
21	65.72	51.91	62.39	60.01	13.81
22	76.31	70.86	80.70	75.95	9.84
23	-	-	-	-	-
24	60.10	51.81	53.74	55.22	8.29
25	66.23	63.10	60.91	63.42	5.32
26	72.70	57.81	57.01	62.51	15.69
27	77.39	61.17	68.38	68.98	16.21
28	58.16	43.93	49.91	50.67	14.24
29	58.39	53.79	57.30	56.50	4.60
30	52.90	50.60	60.97	54.83	10.37
31	66.84	53.87	62.62	61.11	12.97
32	53.08	45.41	45.33	47.94	7.75
33	66.23	61.50	66.18	64.64	4.73
34	65.12	60.44	67.77	64.44	7.33
35	55.74	49.97	62.62	56.11	12.65
36	64.60	47.68	54.42	55.56	16.91
37	60.08	53.76	63.84	59.23	10.07
38	58.51	57.81	61.54	59.29	3.73
39	59.68	55.21	59.52	58.14	4.47

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 program. 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.

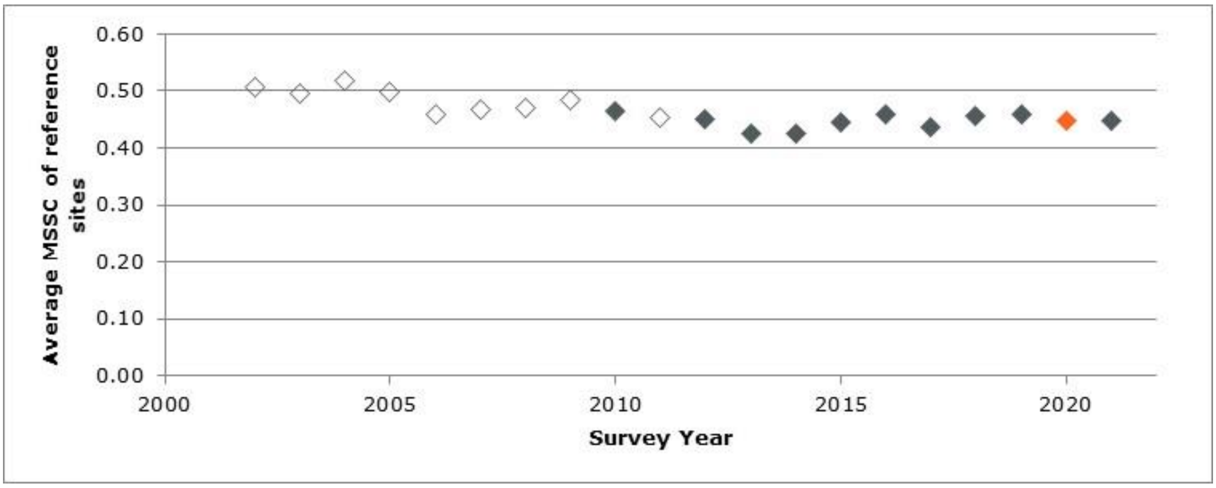

Figure B.1: Average MSSC of reference sites since 2002

Examination of Figure B.1 suggests 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.

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	MSSC 2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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	-		
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
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
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
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
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
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
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
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
32	y	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
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
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
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
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
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
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
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
Ref sites		0.51	0.50	0.52	0.50	0.46	0.47	0.47	0.48	0.46	0.45	0.45	0.42	0.43	0.45	0.46	0.44	0.46	0.46	0.45	0.45

Appendix C Historic data processed using the current defined site lengths

Table C.1: 2012 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	11	68.1	68.2	68.7	2.18	68.3
2	5	65.3	66.3	64.4	1.07	65.3
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	1	72.4	67.7	69.8	2.33	70.0
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	13	53.8	49.3	50.8	2.82	51.3
10	15	64.8	62.1	63.6	1.45	63.5
11	0	-	-	-	-	-
12	8	56.8	53.9	55.6	1.55	55.4
13	11	49.0	47.2	46.3	1.47	47.5
14	16	62.9	58.3	64.6	3.94	61.9
15	1	52.0	49.5	51.0	1.23	50.8
16	19	63.5	57.0	57.5	3.70	59.3
17	10	40.7	42.6	39.5	1.57	40.9
18	0	-	-	-	-	-
19	0	-	-	-	-	-
20	0	-	-	-	-	-
21	18	60.7	61.1	57.3	2.38	59.7
22	17	69.3	68.8	71.1	1.33	69.7
23	0	-	-	-	-	-
24	10	56.9	56.2	57.4	0.80	56.8
25	12	65.6	65.4	66.7	1.02	65.9
26	0	-	-	-	-	-
27	16	62.5	59.2	60.2	1.75	60.6
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	22	55.6	54.2	52.9	1.63	54.2
31	18	62.9	64.9	62.6	1.48	63.5
32	13	49.8	48.5	48.9	1.18	49.1
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	12	55.1	54.8	50.3	2.77	53.4
36	10	57.8	57.3	55.9	1.50	57.0
37	13	62.4	63.2	56.3	3.78	60.6
38	14	58.4	56.2	53.5	2.52	56.0
39	3	58.4	55.7	53.4	2.55	55.8
40	13	63.3	60.9	60.2	1.78	61.5
41	54	51.8	52.3	55.5	2.22	53.2
42	18	57.2	54.4	57.0	1.81	56.2
43	19	46.8	42.9	48.0	2.71	45.9
Asphalt 0-39	288	59.6	58.1	57.6	2.28	58.4
Concrete 40-43	104	53.2	52.0	55.0	2.20	53.4

Table C.2: 2013 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	11	65.8	62.9	62.5	1.96	63.7
2	5	61.5	58.4	57.0	2.31	59.0
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	1	66.5	61.1	61.4	3.04	63.0
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	13	45.5	61.4	43.2	10.07	50.1
10	15	58.0	57.5	56.2	1.05	57.2
11	0	-	-	-	-	-
12	8	55.9	52.1	48.7	3.61	52.2
13	11	47.1	44.9	44.2	1.63	45.4
14	16	62.8	65.3	52.9	7.26	60.3
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	18	57.8	57.7	55.9	1.57	57.1
22	17	68.0	65.7	66.4	1.43	66.7
23	0	-	-	-	-	-
24	10	56.1	58.4	54.5	2.09	56.3
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	22	49.2	49.9	51.0	1.29	50.0
31	18	58.1	54.6	63.2	4.38	58.6
32	13	51.2	48.3	48.6	1.86	49.3
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	12	50.6	47.0	51.6	2.48	49.7
36	10	52.9	48.6	54.0	2.97	51.8
37	13	55.9	51.9	57.7	3.04	55.2
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	54	47.4	47.8	47.1	1.16	47.5
42	18	49.3	51.1	48.2	1.52	49.5
43	19	51.9	47.8	46.0	3.31	48.6
Asphalt 0-39	288	55.9	54.8	54.4	3.53	55.0
Concrete 40-43	104	49.8	49.8	48.4	1.80	49.3

Table C.3: 2014 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	11	67.5	60.6	66.2	4.06	64.7
2	5	64.6	54.7	61.5	5.13	60.3
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	1	70.4	60.8	67.2	4.88	66.1
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	13	47.1	45.2	44.6	2.79	45.6
10	15	59.5	51.2	57.7	4.68	56.1
11	0	-	-	-	-	-
12	8	59.4	50.2	56.4	4.86	55.3
13	11	46.9	42.6	47.2	2.89	45.6
14	16	59.8	52.0	58.7	4.45	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	18	59.2	53.9	55.8	3.04	56.3
22	17	76.1	65.5	69.6	5.41	70.4
23	0	-	-	-	-	-
24	10	63.2	53.2	52.5	6.04	56.3
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	22	56.2	44.7	47.0	6.20	49.3
31	18	60.7	55.3	59.5	2.93	58.5
32	13	47.1	47.2	45.4	1.72	46.6
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	12	52.6	47.7	50.6	2.58	50.3
36	10	53.7	50.1	52.5	2.24	52.1
37	13	65.6	56.6	56.3	5.40	59.5
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	54	50.9	44.8	49.0	3.52	48.2
42	18	51.8	44.9	53.1	4.49	49.9
43	19	48.5	43.0	47.1	2.95	46.2
Asphalt 0-39	288	59.5	51.9	54.9	5.12	55.4
Concrete 40-43	104	52.0	46.0	50.9	3.53	49.6

Table C.4: 2015 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	11	73.3	64.9	72.3	5.02	70.2
2	5	69.2	58.2	66.4	5.86	64.6
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	1	67.5	64.0	71.0	3.47	67.5
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	13	53.2	41.8	47.9	6.69	47.6
10	15	66.3	53.1	56.7	6.87	58.7
11	0	-	-	-	-	-
12	8	62.4	48.3	53.7	7.18	54.8
13	11	53.1	45.0	58.7	6.95	52.3
14	16	67.3	55.9	70.9	7.91	64.7
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	18	61.6	56.2	55.1	3.95	57.6
22	17	73.7	67.8	73.9	3.54	71.8
23	0	-	-	-	-	-
24	10	63.8	55.3	59.6	4.37	59.6
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	22	53.0	50.9	55.3	2.44	53.0
31	18	61.3	60.9	61.4	1.58	61.2
32	13	51.2	46.2	48.2	3.17	48.5
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	12	56.1	49.6	50.4	3.69	52.1
36	10	53.2	51.9	55.6	2.45	53.6
37	13	61.7	55.1	57.1	3.70	57.9
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	54	53.4	44.3	47.8	5.02	48.5
42	18	57.1	48.8	49.1	4.81	51.7
43	19	51.4	42.1	44.5	5.01	46.0
Asphalt 0-39	288	61.0	53.9	58.5	4.98	57.8
Concrete 40-43	104	55.9	46.4	50.0	5.29	50.7

Table C.5: 2016 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	11	64.0	63.2	75.1	6.87	67.4
2	5	60.6	60.5	65.6	3.09	62.2
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	1	71.0	64.3	64.5	3.83	66.6
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	13	48.0	45.8	48.0	3.05	47.3
10	15	62.1	59.4	59.3	1.89	60.3
11	0	-	-	-	-	-
12	8	60.8	57.7	57.8	2.51	58.7
13	11	51.8	49.1	53.6	2.73	51.5
14	16	70.6	61.8	60.0	5.81	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	18	65.9	61.0	58.4	4.14	61.8
22	17	76.9	70.9	73.9	3.33	73.9
23	0	-	-	-	-	-
24	10	64.1	56.0	61.2	4.29	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	22	56.0	51.5	54.2	3.36	53.9
31	18	64.3	58.7	63.6	3.19	62.2
32	13	50.4	50.3	52.0	2.88	50.9
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	12	54.3	50.1	53.5	2.58	52.6
36	10	59.0	52.6	54.0	4.15	55.2
37	13	60.8	56.4	61.4	2.81	59.6
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	54	51.9	51.5	52.6	1.96	52.0
42	18	52.1	57.4	55.1	2.86	54.8
43	19	53.1	49.7	53.0	2.08	52.0
Asphalt 0-39	288	60.6	57.4	59.5	4.10	59.2
Concrete 40-43	104	53.7	53.6	54.5	2.16	53.9

Table C.6: 2017 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	11	76.3	59.2	71.7	8.94	69.1
2	5	75.1	53.9	59.9	11.02	63.0
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	1	66.6	62.1	62.5	2.51	63.7
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	13	50.8	43.0	48.5	4.46	47.4
10	15	68.0	52.8	61.0	8.27	60.6
11	0	-	-	-	-	-
12	8	55.8	49.6	58.1	4.57	54.5
13	11	49.1	41.5	49.5	4.62	46.7
14	16	65.3	50.3	61.2	7.85	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	18	60.6	52.2	60.6	5.09	57.8
22	17	76.3	61.7	69.9	7.42	69.3
23	0	-	-	-	-	-
24	10	62.7	49.4	55.6	6.71	55.9
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	22	53.5	48.0	51.7	3.22	51.1
31	18	66.2	56.4	62.6	5.05	61.7
32	13	54.0	43.6	47.8	5.37	48.4
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	12	60.2	47.2	56.2	6.67	54.5
36	10	61.0	47.8	54.8	6.69	54.6
37	13	66.5	53.3	62.1	6.87	60.7
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	54	49.6	44.9	50.6	3.71	48.4
42	18	49.7	46.0	54.0	4.24	49.9
43	19	50.2	43.8	51.8	4.37	48.6
Asphalt 0-39	288	61.9	50.9	58.2	6.15	57.0
Concrete 40-43	104	51.1	46.2	52.9	3.93	50.1

Table C.7: 2018 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	11	77.8	65.9	71.4	6.07	71.7
2	5	71.3	60.9	61.9	5.76	64.7
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	1	67.4	61.2	62.0	3.39	63.6
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	13	53.9	42.7	49.9	6.38	48.8
10	15	68.1	54.7	63.7	6.91	62.2
11	0	-	-	-	-	-
12	8	66.9	47.8	58.5	9.67	57.7
13	11	57.7	46.2	50.4	5.94	51.4
14	16	70.3	53.9	62.2	8.28	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	18	61.6	52.0	61.9	5.97	58.5
22	17	78.7	73.5	73.1	3.21	75.1
23	0	-	-	-	-	-
24	10	61.3	57.1	59.7	2.27	59.4
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	22	61.1	48.6	57.1	6.46	55.6
31	18	64.1	59.9	66.9	3.71	63.7
32	13	51.6	43.5	50.8	4.85	48.6
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	12	55.8	54.5	58.6	2.27	56.3
36	10	59.4	53.7	60.8	4.06	58.0
37	13	65.5	59.5	63.7	3.31	62.9
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	54	53.1	45.1	51.0	5.04	49.7
42	18	55.5	51.0	56.8	3.28	54.4
43	19	53.1	43.9	50.3	4.78	49.1
Asphalt 0-39	288	63.8	54.4	60.5	5.65	59.5
Concrete 40-43	104	54.4	47.9	53.7	4.52	52.0

Table C.8: 2019 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	11	68.7	64.6	72.8	4.29	68.7
2	5	63.6	58.7	64.5	3.50	62.3
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	1	61.5	59.5	62.6	1.60	61.2
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	13	47.1	49.3	50.5	3.30	48.9
10	15	61.3	59.3	62.4	2.06	61.0
11	0	-	-	-	-	-
12	8	65.5	54.5	56.6	5.95	58.9
13	11	58.0	48.7	53.5	4.71	53.4
14	16	72.6	59.0	64.1	7.12	65.2
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	18	65.8	55.6	60.1	5.51	60.5
22	17	80.2	69.3	73.7	5.77	74.4
23	0	-	-	-	-	-
24	10	63.9	55.9	56.0	4.86	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	22	61.0	50.8	60.7	6.47	57.5
31	18	67.0	56.8	61.8	5.23	61.9
32	13	53.0	47.8	49.8	3.28	50.2
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	12	57.2	48.7	53.1	4.43	53.0
36	10	61.3	51.4	55.3	5.34	56.0
37	13	63.4	56.3	59.3	3.77	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	54	54.4	46.9	47.9	4.51	49.7
42	18	57.1	48.9	51.6	4.40	52.5
43	19	47.2	48.2	49.9	1.76	48.4
Asphalt 0-39	288	63.4	55.6	59.1	4.93	59.4
Concrete 40-43	104	54.6	48.5	50.5	4.07	51.2

Table C.9: 2020 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	11	69.5	63.9	62.1	4.23	65.1
2	5	67.5	62.1	58.3	4.70	62.6
3	0	-	-	-	-	-
4	0	-	-	-	-	-
5	1	58.3	54.1	58.7	2.53	57.0
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	0	-	-	-	-	-
9	13	45.7	43.9	51.9	5.50	47.2
10	15	62.3	56.7	56.8	3.43	58.6
11	0	-	-	-	-	-
12	8	64.5	55.7	60.9	4.69	60.4
13	11	48.9	52.6	54.6	3.12	52.0
14	16	58.7	60.6	66.4	4.23	61.9
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	18	52.9	54.5	62.1	5.12	56.5
22	17	68.9	75.8	74.0	3.99	72.9
23	0	-	-	-	-	-
24	10	56.9	55.6	58.8	1.96	57.1
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	22	47.9	53.9	62.7	7.54	54.8
31	18	54.2	60.4	65.6	5.88	60.1
32	13	44.3	49.0	49.9	3.84	47.7
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	12	57.7	49.8	55.4	4.23	54.3
36	10	50.0	52.0	59.1	4.95	53.7
37	13	52.9	59.0	65.8	6.54	59.2
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	54	47.0	41.8	42.8	3.70	43.9
42	18	50.4	47.0	46.3	2.74	47.9
43	19	47.3	45.9	46.1	1.35	46.5
Asphalt 0-39	288	55.9	56.4	61.1	4.87	57.8
Concrete 40-43	104	48.6	45.4	46.3	3.20	46.8

Skid resistance benchmark surveys 2021

National Highways (NH) manages levels of skid resistance on their 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, therefore the data is corrected by use of correction factors called LECFs. To monitor the ongoing trends in skid resistance NH 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 2021.

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ISSN 2514-9652

ISBN 978-1-915227-14-0

PPR1030