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Skid resistance benchmark surveys 2019

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Executive summary

As part of its process for managing skid resistance on the Strategic Road network (SRN), Highways England 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, Highways England 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 2019, 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.

No sites 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 2019 analysis. Currently 14 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 to increase the amount of data used, resulted in 393 individual 100m lengths being suitable for use in the investigation of skid resistance trends since 2010.

Comparison of the mean summer skid coefficient (MSSC) values from the benchmark sites suggests that 2019 was an “average to slightly high skid resistance” year in comparison to the average of the previous three years but an “average to high skid resistance” year when considering all of the years in the analysis. In addition, the within year variation for 2019 was close to the average of the values since 2010. However the analysis of the 2019 LECFs (Brittain, 2020) suggested that 2019 was a “slightly low year” for skid resistance in comparison to the average of the previous three years. Due to differences in the data used for the two analyses, the results from the benchmark sites should be used when considering the overall trend in skid resistance over time for the Highways England network and the results from the LECF analysis should be used when estimating future CSC values for the network.

For the 2019 survey, the between run variation of the data from the concrete sites (3.40 SR) was slightly higher than the expected variation of repeat skid resistance measurements on a given day under the same weather conditions (3 SR). However this variation is seen to be different to the variation of 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 since 2010 and excludes any lengths that have been maintained or had incomplete surveys over this period. As such the lengths available to the analysis have reduced slightly each year. It is recommended that a 10 year rolling cut-off (or similar) is considered in future analyses in order to maintain a robust dataset.

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1 Introduction

1.1 Background

In order to investigate long term trends in skid resistance values, Highways England 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. Highways England 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, Highways England 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.

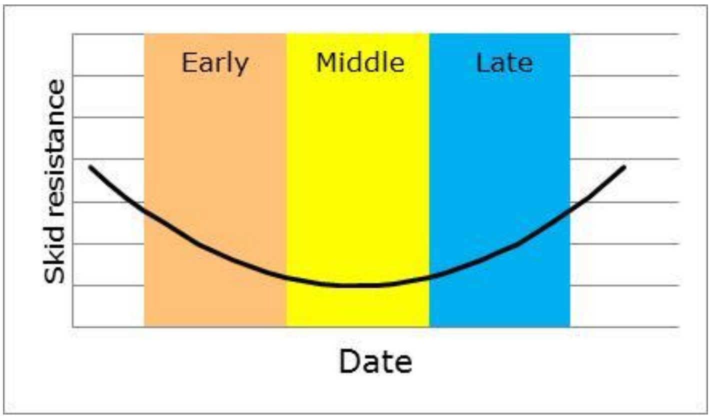

Figure 1.1 Expected seasonal variation of skid resistance over the summer

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	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.

1.3 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 program 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. The results from this analysis, incorporating the data from the 2019 surveys, are given in section 3.

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.

2 Survey issues

2.1 Alignment of data

Markers are entered into the survey data using push button entry. When using these markers to align the data, 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).

2.2 Issues and observations from surveys

For the 2019 survey data, eight sites (3, 22, 23, 26, 28, 29, 34 and 38) had potential issues identified from the data, the video and/or from the operator's notes (recorded in the directory of benchmark sites). Where the data, video or operator's notes suggest a resurfacing the HAPMS construction records were also reviewed.

2.2.1 Site 3

It was seen from the video for site 3 (and recorded in the operator's notes) that the early survey was undertaken in the hard shoulder instead of lane 1 due to road works. Although lane 1 was still open to traffic it could be seen that temporary reduced width markings were in place making it unsuitable for the survey to be carried out in that lane. An image from the survey video is shown in Figure 2.1 below.

Figure 2.1 Still from video of early survey of site 3

The survey data for this site from the three surveys this year (2019) and the average values for the site from last year (2018) are shown in Figure 2.2.

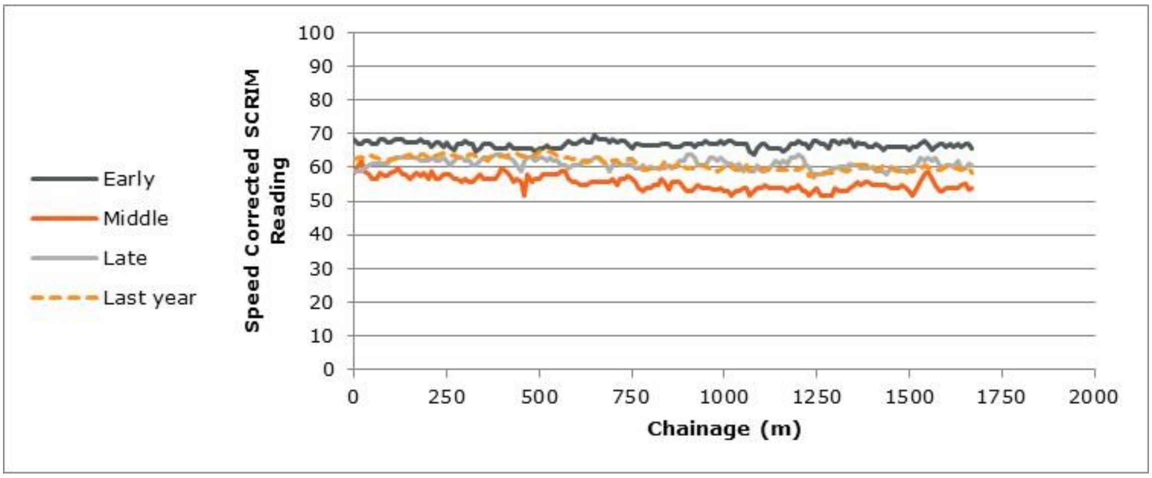

Figure 2.2 Skid resistance values from the 2019 survey for site 3

From this data it can be seen that the early survey data is not too dissimilar from the other surveys. As such the 2019 data should be considered as valid in order to help maintain the size of the dataset for the analysis. However as the whole of this site was resurfaced in 2016 it is currently excluded from the analysis. Although not currently used in either analysis (the long term trend or the since 2010 analysis), this site should be continued to be surveyed so that it can be brought back in when the survey date cut-off is reviewed. The survey date cut-off is further discussed in section 3.4.

2.2.2 Site 22

During the early survey for Site 22 there was a road closure on lane 1, causing the survey to be carried out on lane 2. During the middle survey there was a closure on lane 2, and in the late survey there were no road works. The survey data from these surveys is shown in Figure 2.3.

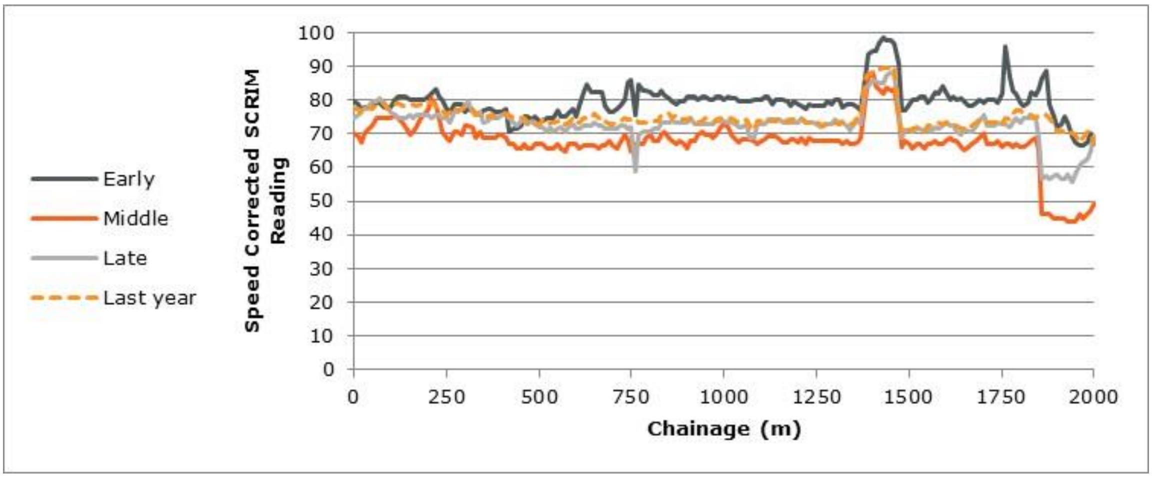

Figure 2.3 Skid resistance values from the 2019 survey for site 22

It can be seen that this year's data differs from last year at the end of the site (approximately 1800m onwards), and a new surfacing is recorded in the operator's notes for this length. Therefore, this part of the site should be excluded from the analysis. However, to maintain data coverage (and due to the similarities in the performance between lane 1 and 2 on this site) the rest of the site should be kept in the "since 2010" analysis. However, it should be noted that the site will continue to be excluded from the long term trend (from 2002) due to it having been resurfaced in 2008.

2.2.3 Site 23

Site 23 was surveyed on the hard shoulder for all three surveys due to road works. However, in this instance lane one was open to traffic with a full width lane (although slightly offset). An image from the survey video is shown in Figure 2.4 Therefore consideration should have been given to surveying the site in the correct lane using the lane 2 survey method. The survey data from this site was inconsistent and different from the previous survey data and, as such, should be excluded from both analyses.

Figure 2.4 Still from video of early survey of site 23

2.2.4 Site 26

Site 26 was surveyed in lane 2 for part of the mid survey due to a lane closure following a traffic incident. In addition, the operator's notes identify a new surfacing for the length of the site. Examination of the survey data shows that the results collected this year are consistent with the previous year; the survey data is shown in Figure 2.5. As such this suggests that the site has only had the lane markings repainted rather than a new surfacing. Examination of the HAPMS construction records identified no recorded maintenance in 2018 or 2019. Therefore, this site should not be excluded based on the 2019 data. However, it is noted that the site was not surveyed in 2014 and is therefore currently excluded from both analyses. In addition, examination of the HAPMS construction records identified that the site was resurfaced in 2016 which would also exclude it from the analyses.

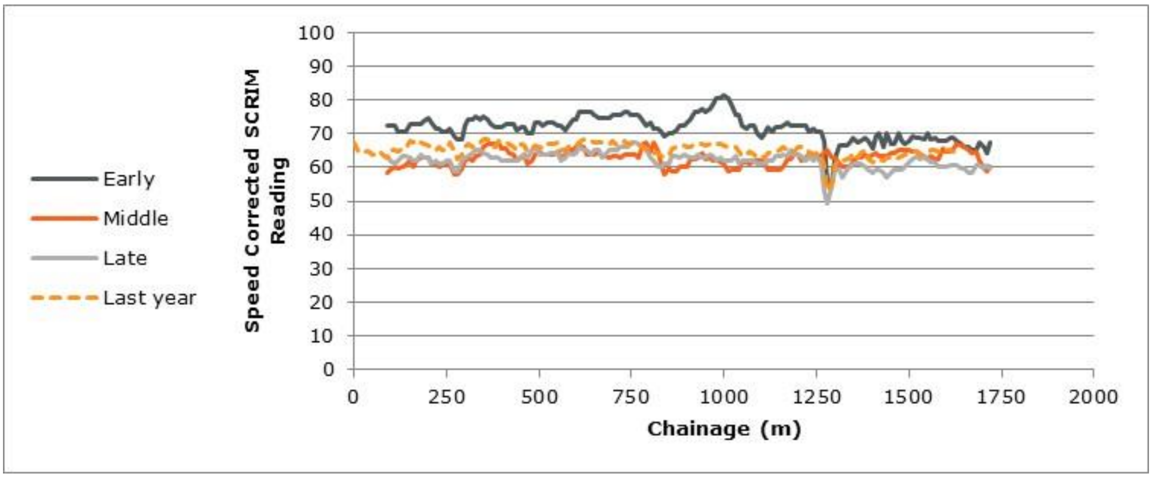

Figure 2.5 Skid resistance values from the 2019 survey for site 26

2.2.5 Site 28

The operator's notes for site 28 identified a new surfacing for the first 400m at the start of the site. However when comparing the videos from the 2019 surveys to the 2018 surveys it does not appear to be a new surfacing. Examination of the HAPMS construction records indicated that no maintenance had been carried out during 2018 or 2019.

2.2.6 Site 29

Examination of the survey data for site 29 suggests that from approximately 1500m or possibly 1200m to the end of the site has been resurfaced between the early and middle surveys. This was not identified in the operator's notes; however a review of the video suggests that the length has been resurfaced from approximately 1200m. The HAPMS records identify the length as being resurfaced on the 21st October (i.e. after the late survey). The survey data is shown in Figure 2.6. Due to the variation in the data (and the HAPMS construction record) the end of this site has been removed from the "since 2010" analysis (the site was excluded from the long term analysis due to treatment on the first half of the site in 2015).

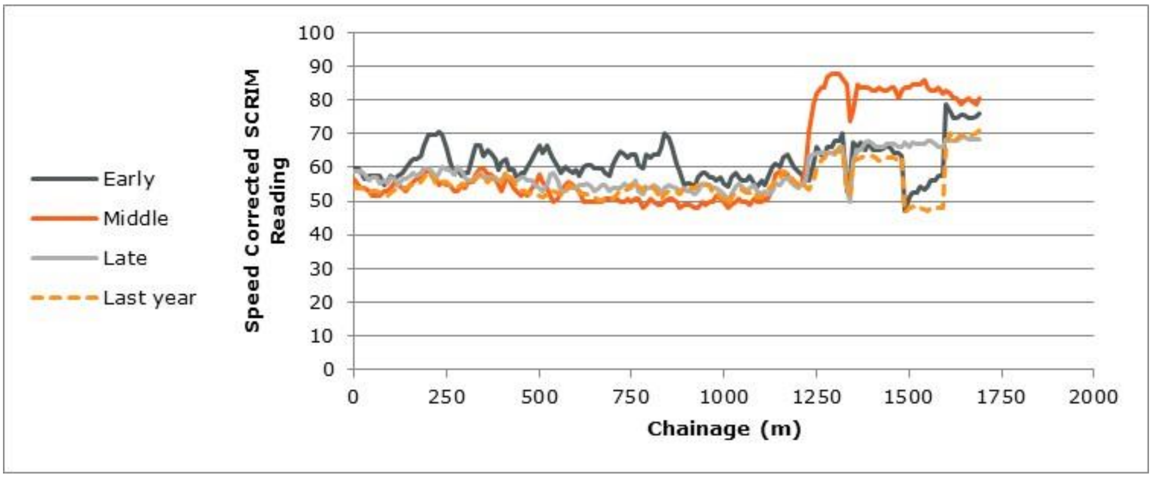

Figure 2.6 Skid resistance values from the 2019 survey for site 29

2.2.7 Site 34

The operator's notes for site 34 identify that the whole site has been resurfaced (partly before the early survey and partly before the middle survey). The survey data for the site appears to be consistent with the 2017 survey (the site was only surveyed in the early period in 2018), which suggests that the site has not been resurfaced. The HAPMS records for these sections were also checked and no maintenance was recorded for 2019. The survey data can be seen in Figure 2.7. However, as the site was not fully surveyed in 2018, it is currently excluded from the analyses.

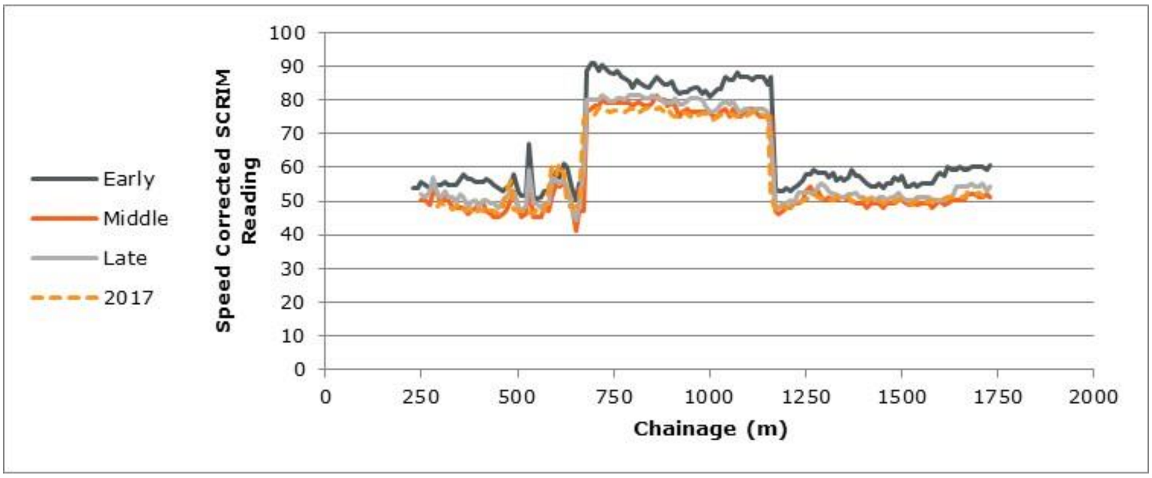

Figure 2.7 Skid resistance values from the 2019 survey for site 34

2.2.8 Site 38

Analysis of the survey data for site 38 identified a possible resurfacing between the early and middle surveys from approximately 1600m to the end of the site. This was not identified in the operator's notes. Examination of the survey video suggests that there might be a new surfacing, however the middle and late surveys were undertaken in wet and damp conditions making it difficult to determine. Based on the survey data, the end of the site has been excluded from the "since 2010" analysis. However as it is a very short amount of the site, this site has not been removed from the long term (from 2002) analysis. The survey data for this site can be seen in Figure 2.8.

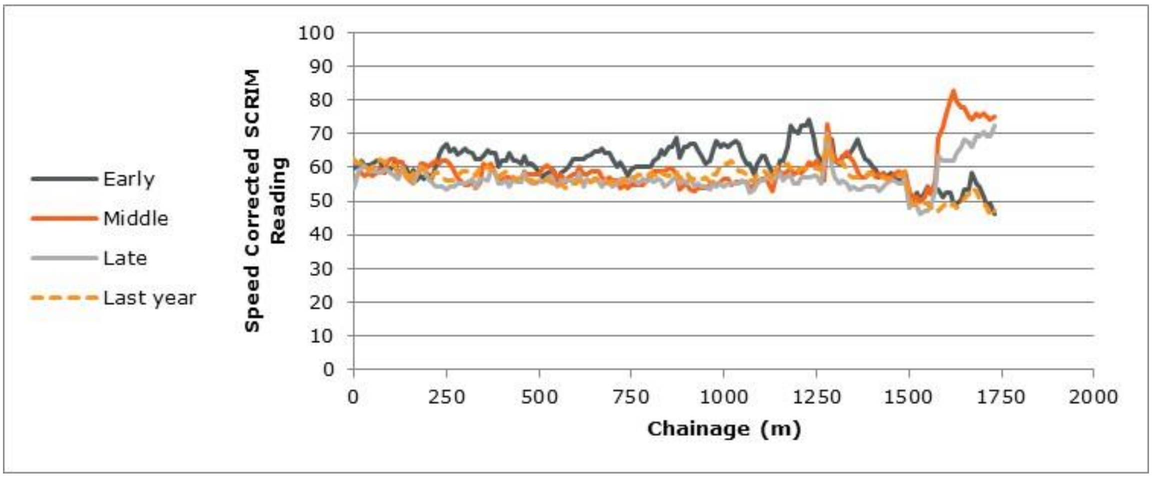

Figure 2.8 Skid resistance values from the 2019 survey for site 38

2.2.9 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 2.1. Site 38 is shown in grey italics as it has not been removed, but should be removed if any additional issues are found.

Table 2.1 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)*

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.

No sites were removed from the long term reference benchmark sites this year. There are currently 14 long term reference benchmark sites and these are listed in Table 2.2.

Table 2.2 Reference benchmark sites

Site	Road
1	A30
8	M20
9	A23
12	A12
13	A47
14	A1
19	A49
25	M40
27	A616
31	M6
32	M58
35	A66
36	M6
38	A1

An approach proposed in the analysis of the 2011 data to increase the amount of collected data used, enabled skid resistance trends of individual 100m lengths to be analysed from 2010 onwards.

For the 2019 surveys, following the removal of unsuitable lengths, 324 (of 627) individual 100m lengths were available for the investigation of skid resistance trends since 2010 for the asphalt sites and 69 (of 109) 100m lengths for the concrete sites. This is a reduction from last year’s analysis of 14 individual 100m lengths for the asphalt sites; no individual 100m lengths were removed from the concrete sites.

3 Results from the 2019 surveys

3.1 Average SR and between survey variation

The analysis procedure adopted in 2011 may, over time, result in some of the sites reducing to very short lengths and these 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 2019 surveys are given in Table 3.1.

If any maintenance occurs on the benchmark sites, the lengths that are used in this analysis will reduce between years. Therefore, the data provided in previous years' reports will not always be directly comparable to that in the current year's report. To provide a comparison to the results of this year's analysis, the data from the surveys between 2010 and 2018 was reprocessed using the same lengths as used for the 2019 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, 2016) 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 2019 data the between run standard deviation (BRSD) is above 3 SR for both the asphalt and the concrete sites. The BRSD is larger for the asphalt sites in comparison to the concrete sites. This is consistent with expectations and results in previous years (with the exception of 2015 where the deviation for the concrete sites was higher than for the asphalt sites).

Table 3.1 2019 survey data

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	8	68.2	63.6	71.3	4.08	67.7
2	6	64.2	59.0	64.7	3.54	62.7
3	0	-	-	-	-	-
4	5	62.2	58.1	63.5	2.84	61.3
5	2	62.4	60.4	63.1	1.41	62.0
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	9	62.4	59.7	65.6	3.15	62.6
9	13	47.1	49.3	50.5	3.30	48.9
10	17	61.5	59.0	62.7	2.45	61.1
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	18	57.5	53.4	52.9	2.86	54.6
17	15	49.5	39.0	40.7	5.73	43.1
18	9	60.7	56.2	51.5	5.00	56.1
19	16	58.2	51.2	52.0	3.90	53.8
20	0	-	-	-	-	-
21	16	66.4	56.2	60.8	5.55	61.1
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	11	69.9	62.6	64.5	3.89	65.7
26	0	-	-	-	-	-
27	16	72.5	60.1	64.4	6.45	65.7
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	12	61.2	50.9	59.6	5.92	57.3
31	17	67.2	57.2	62.2	5.18	62.2
32	14	52.6	47.2	49.8	3.24	49.8
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	17	58.3	50.4	54.2	4.17	54.3
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	19	44.8	39.6	40.3	3.03	41.6
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	324	62.8	55.3	58.3	4.72	58.8
Concrete 40-43	69	52.0	47.3	49.7	3.40	49.7

A summary of between run standard deviations (BRSD) and the average SR values since 2010 are presented in Table 3.2 for the asphalt lengths and in Table 3.3 for the concrete lengths. The averages are also shown in Figure 3.1 along with the trend lines for the data.

Table 3.2 Summary of asphalt site data

Year	BRSD	Average SR
2010	5.10	59.6
2011	2.93	58.0
2012	2.30	58.1
2013	3.36	54.7
2014	4.80	55.1
2015	4.94	57.5
2016	3.79	58.6
2017	6.28	56.9
2018	5.41	59.2
2019	4.72	58.8
Average	4.52	57.6

Table 3.3 Summary of concrete site data

Year	BRSD	Average SR
2010	2.47	47.6
2011	1.56	49.3
2012	2.34	50.2
2013	1.98	47.3
2014	3.37	47.7
2015	5.06	49.3
2016	2.18	52.5
2017	3.87	48.6
2018	3.76	50.8
2019	3.40	49.7
Average	3.17	49.3

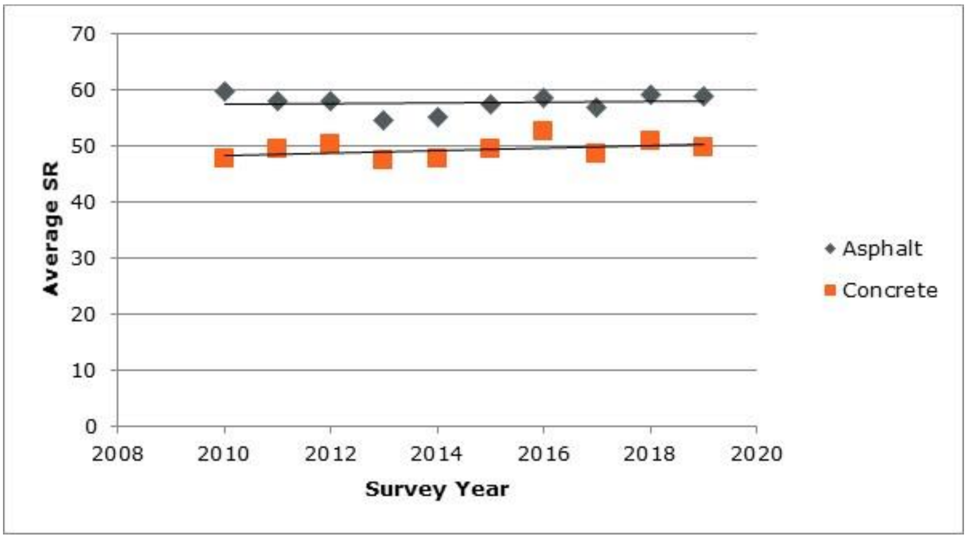

Figure 3.1 Average SR of Benchmark sites over time

These tables and figure show that the between run or between period standard deviation for the asphalt surfaces is highest for the 2010, 2014, 2015, 2017, 2018 and 2019 survey years, and lowest in 2012. In addition it can be seen that for half of the 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 (and on the asphalt sites in 2012) is likely to be mainly or solely caused by normal machine variation.

3.2 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 they are not, as they would only correct within year variation and are being applied to 100m lengths). The average MSSC value for the complete 2019 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 3.2.

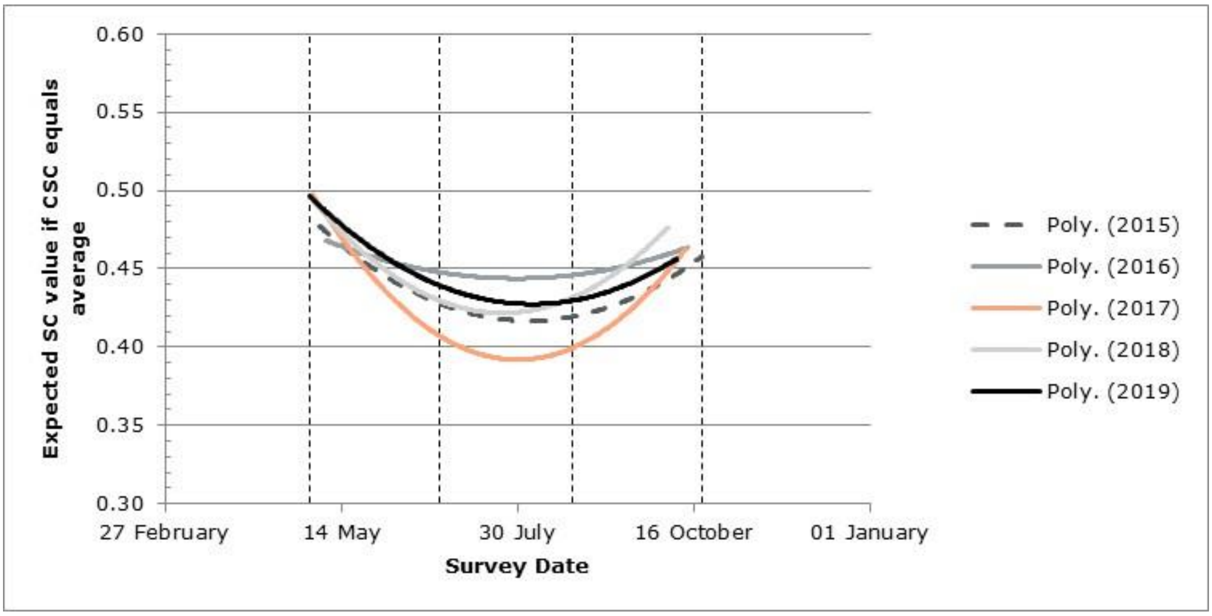

Figure 3.2 Expected SC values (sites 1-39)

It can be seen from Figure 3.2 that the within year seasonal variation, varies slightly from year to year with the largest changes seen in 2017, followed by 2015, 2018 and 2019 (as noted in section 3.1). The minimum for the 2019 data occurs towards the end of the middle period and the skid resistance levels for the late surveys are lower than the early surveys.

In addition, Figure 3.2 appears to show that 2019 was an "average to slightly high year" for skid resistance relative to the last five years (this is also reflected in the average values for all of the years seen in Table 3.2). The analysis of the 2019 LECFs (Brittain, 2020) suggested that 2019 was a "slightly low year" for skid resistance values in comparison to the average of the previous three years. On examination of Table 3.2 it can be seen that the average SR value for 2019 was 58.8 and the average of the three previous years (2016, 2017 and 2018) was 58.2. This shows that the SR value for the benchmark sites in 2019 was very close (but slightly higher) than the average of the previous three years. 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 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).

3.3 Expected distribution of SC for concrete sites

The approach used to visualise the distribution of SC values for asphalt sites (see section 3.2) was also applied to the concrete sites and the results are shown in Figure 3.3.

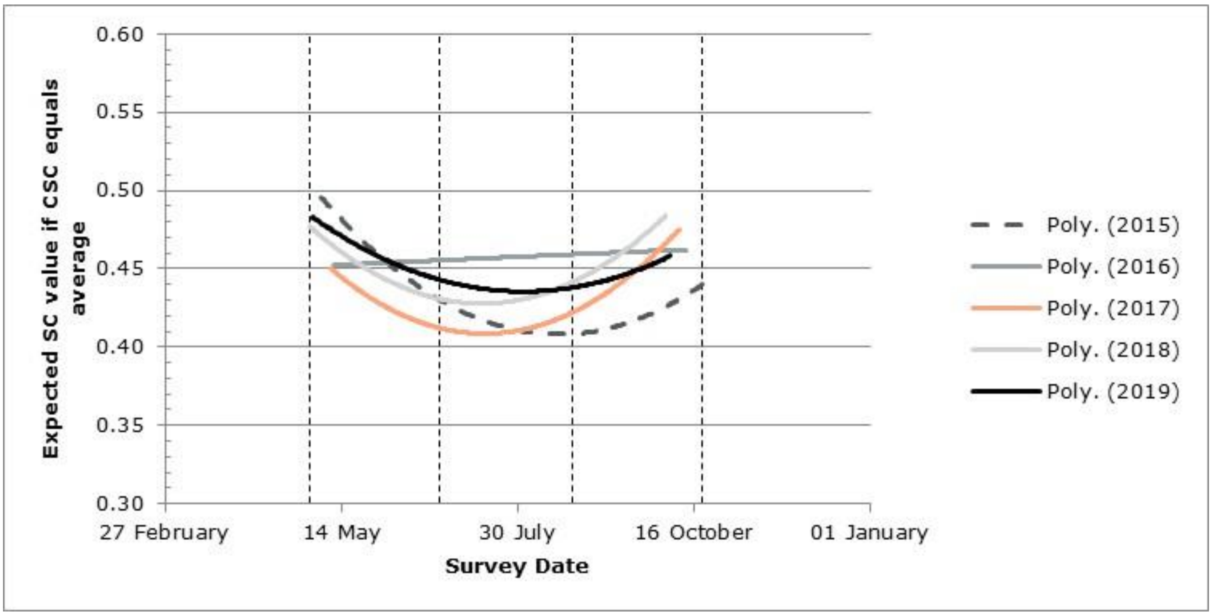

Figure 3.3 Expected SC values (sites 40-43)

The data for concrete sites in 2015, 2017, and 2018 (and to a lesser extent 2019) suggest that these sites are experiencing within season variation. However it is noted that the variation seen is different to that for the asphalt sites and the pattern is absent or reduced in 2016 and earlier years (not shown). 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).

3.4 Future development of the analysis procedure

The current analysis procedure uses data collected since 2010 and excludes any lengths that have been maintained or had incomplete surveys over this period. As such the lengths available to the analysis have reduced slightly each year. The lengths used in the analysis for each survey year is given in Figure 3.4 for asphalt lengths and in Figure 3.5 for concrete lengths.

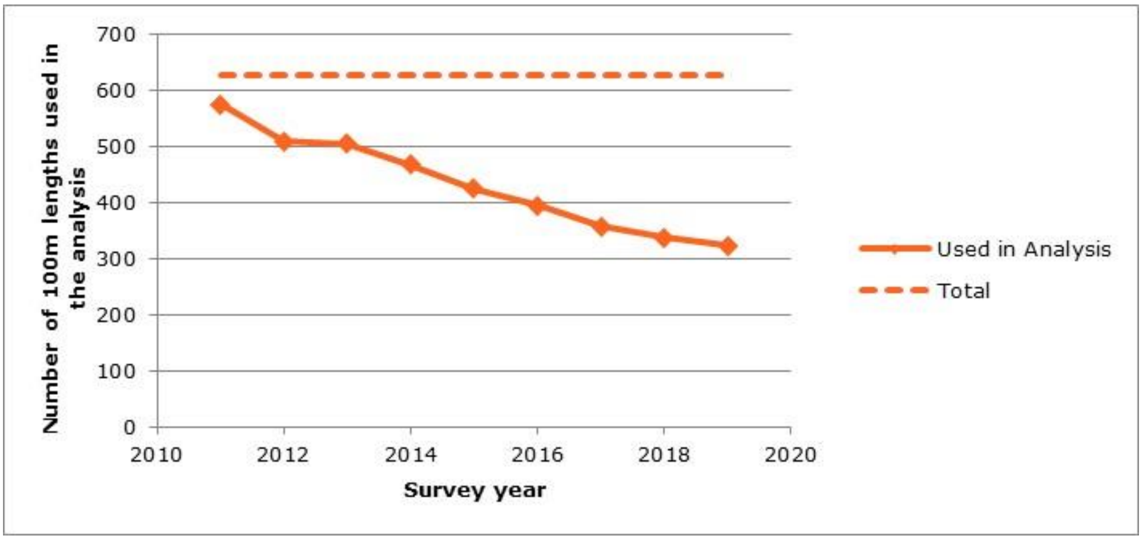

Figure 3.4 Number of 100m asphalt lengths used in the anlaysis

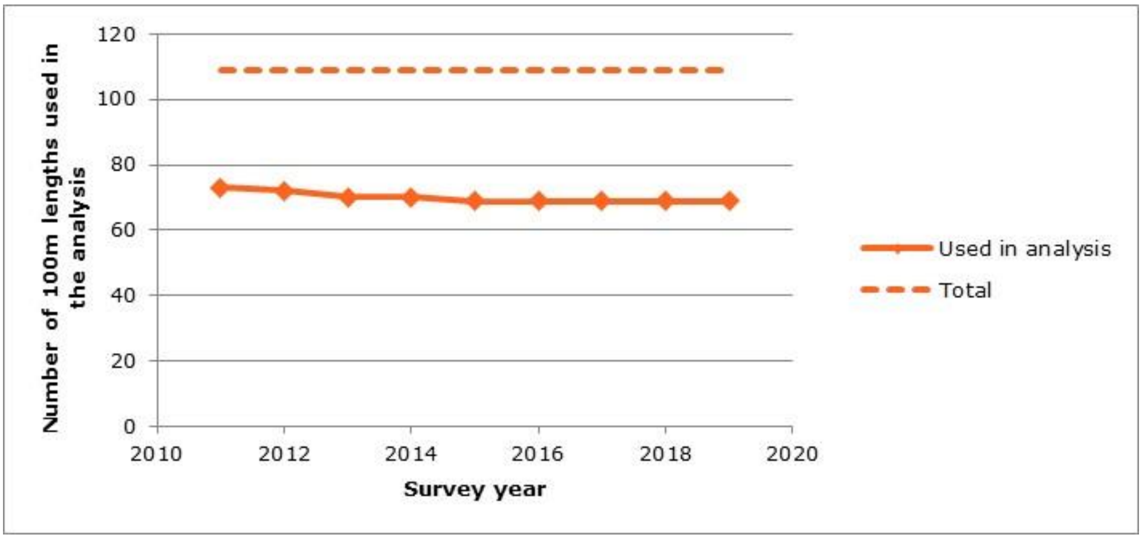

Figure 3.5 Number of 100m concrete lengths used in the anlaysis

It can be seen from these two graphs that just over 50% of the asphalt lengths are used in the current analysis and just over 60% of the concrete lengths. In order to avoid this dropping to a point where it reduces the robustness of the analysis, consideration should be given to implementing a rolling cut-off of 10 years of past data to the analysis. This would mean for the analysis of the 2020 surveys the data since 2011 would be used (and for the 2021 surveys the data since 2012, etc). Applying this approach will bring back lengths into the analysis that have previously been excluded (but have continued to be surveyed).

Applying a 10 year rolling cut-off allows for the trend over the past 10 years to be generated as part of the analysis. However, it should also be possible to combine the summary results from the analyses in different years in order to produce an overall trend in the skid resistance levels since 2010.

It may also be possible to combine these results with the results of the old analysis procedure (discussed in Appendix B) to produce the overall trend since 2002. However, the data before 2010 was collected using the old survey periods (discussed in section 1.1). It might therefore be more suitable to drop this earlier data from the summarised results.

It is recommended that these options (along with other methods of maintaining a robust dataset) are investigated, in addition to applying the current approach, in the analysis of the 2020 benchmark surveys to determine a suitable way forward.

4 Conclusions and recommendations

4.1 Data coverage

No sites 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 2019 data. Currently 14 of the original 39 sites are suitable for use in the investigation of trends since 2002 (given in Appendix B) and 393 individual 100m lengths (324 asphalt lengths and 69 concrete lengths) are suitable for use in the investigation of trends since 2010.

4.2 Results

Investigation into the average SR values suggests that 2018 was an “average to high skid resistance year” for the asphalt lengths when compared to the average of the previous years and close to but slightly higher than the average of the previous three years. The within year variation for 2019 was close to the average of the values since 2010. However, the analysis of the 2019 LECFs (Brittain, 2020) suggested that 2019 was a “slightly low year” for skid resistance in comparison to the average of the previous three years. Due to differences in the data used for the two analyses, the results from the benchmark sites are more robust when considering the overall trend in skid resistance over time for the Highways England network, while the results from the LECF analysis should be used when estimating future CSC values for the network.

For the 2019 data the between period standard deviation for the concrete sites was above 3 SR suggesting that this variation is likely to be in part caused by seasonal variation. However this variation was still quite low (3.40) and is seen to be different to the variation on the asphalt sites. 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).

4.3 Further development of the analysis procedure

The current analysis procedure uses data collected since 2010 and excludes any lengths that have been maintained or had incomplete surveys over this period. As such the lengths available for inclusion in the analysis has reduced slightly each year. It is recommended that a 10 year rolling cut-off, or similar, is considered for future analyses (e.g. for the 2020 survey the data collected since 2011 would be used).

This amended approach would produce the overall trends in skid resistance over the preceeding 10 years (if a rolling cut-off of 10 years is applied). It should be possible to combine the summary results from the analyses in different years in order to produce an overall trend in the skid resistance levels since 2010 (the first year of data in the current analysis approach).

It may also be possible to combine these results with the results of the old analysis procedure (discussed in Appendix B) to produce the overall trend since 2002. However, the data before 2010 was collected using the old survey periods (discussed in section 1.1). Therefore, it might be more suitable to drop this earlier data from the summarised results.

It is recommended that these options are investigated, in addition to applying the current approach, in the analysis of the 2020 benchmark surveys to determine a suitable way forward.

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). *Calculation of Local Equilibrium Correction Factors for the 2019 Skid resistance surveys (PPR 951).* Wokingham: TRL.

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

TRL. (2016). *Accreditation and Quality Assurance of Sideways Force Skid Resistance Survey Devices [online]. [Accessed 1st January 2019].* Available from World Wide Web: http://www.ukroadsliaisongroup.org/en/asset-condition/road-condition-information/data-collection/skid-resistance/index.cfm.

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 2019 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 2019 surveys are shown in Table B.1. These values may differ from those in Table 3.1 in the main analysis as the data in that table will have any lengths with maintenance since 2010 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 2.2.

Table B.1 Results of the 2019 surveys

Site	Speed corrected SR			Average	Range
	Early	Middle	Late		
1	64.26	59.96	67.75	63.99	7.79
2	63.66	58.29	64.55	62.17	6.25
3	66.73	55.42	61.04	61.07	11.31
4	61.30	57.14	62.58	60.34	5.44
5	62.76	60.28	63.46	62.17	3.18
6	64.12	58.26	64.21	62.20	5.95
7	59.26	54.22	67.39	60.29	13.17
8	61.20	57.68	64.48	61.12	6.80
9	47.08	49.43	50.45	48.99	3.37
10	60.84	58.22	62.18	60.41	3.96
11	65.46	71.45	67.80	68.23	5.99
12	66.12	54.29	56.84	59.08	11.84
13	58.29	48.52	53.39	53.40	9.77
14	71.77	58.60	63.64	64.67	13.17
15	64.90	52.83	54.95	57.56	12.07
16	57.42	53.42	52.78	54.54	4.65
17	49.57	39.17	41.00	43.25	10.40
18	61.43	57.62	52.71	57.25	8.72
19	58.23	51.17	52.08	53.83	7.06
20	65.01	55.10	59.47	59.86	9.91
21	65.38	55.19	59.50	60.02	10.18
22	79.51	67.46	72.80	73.26	12.05
23	-	-	-	-	-
24	63.51	55.91	56.30	58.57	7.60
25	69.56	62.32	64.16	65.35	7.25
26	71.49	62.81	62.18	65.49	9.31
27	72.74	60.51	64.56	65.94	12.23
28	53.45	46.18	52.36	50.66	7.27
29	61.58	61.06	58.32	60.32	3.25
30	61.34	50.99	60.72	57.68	10.35
31	66.91	56.60	61.95	61.82	10.31
32	52.66	47.52	49.57	49.92	5.14
33	73.50	60.87	61.14	65.17	12.63
34	65.70	58.64	60.62	61.65	7.06
35	58.38	50.49	54.46	54.44	7.89
36	61.18	51.26	55.38	55.94	9.92
37	63.35	56.48	59.04	59.62	6.88
38	61.04	59.34	56.80	59.06	4.24
39	62.18	58.17	57.73	59.36	4.45

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 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. 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 2.2.

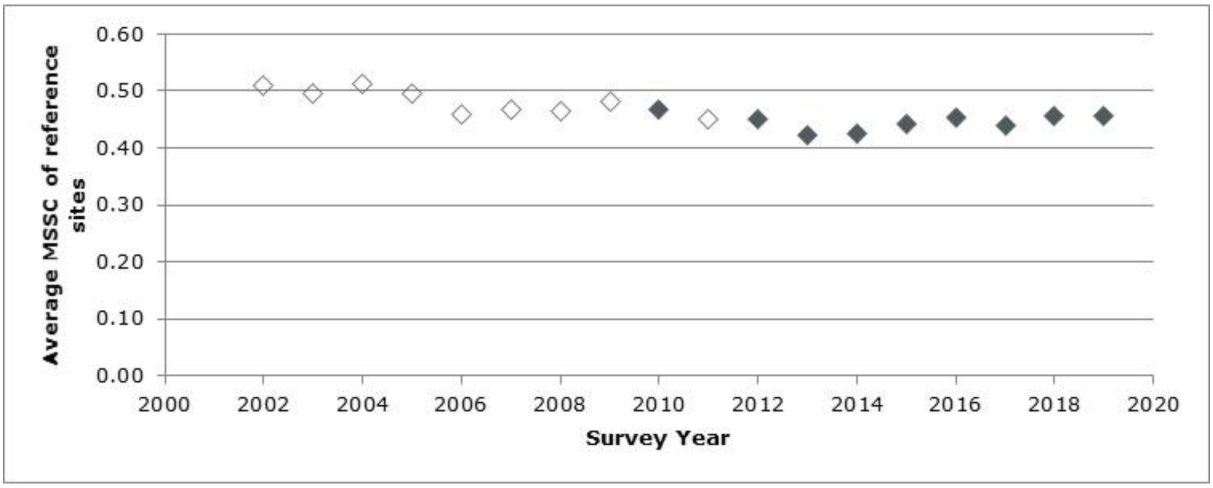

Figure B.1 Average MSSC of reference sites since 2002

Initial examination of Figure B.1 suggests a slight downward trend over time. However it is also possible that the equilibrium state of the benchmark sites 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. It will not be possible to determine which of these scenarios is applicable (or if there is a different pattern) until further years of data is collected.

The changes seen in the skid resistance of the sites over time (either a downward trend or change in equilibrium levels) could be due to 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
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
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
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	-
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
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
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
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
8	y	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
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
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
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
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
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
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
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
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
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
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
19	y	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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
35	y	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
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
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
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
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
Ref sites		0.50	0.49	0.50	0.48	0.45	0.46	0.46	0.47	0.46	0.44	0.44	0.41	0.42	0.44	0.44	0.43	0.46	0.46

Appendix C Historic data processed using the current defined site lengths

Table C.1 2010 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	8	78.8	61.8	65.7	9.00	68.8
2	6	69.5	58.7	64.4	5.46	64.2
3	0	-	-	-	-	-
4	5	68.5	60.2	62.8	4.23	63.9
5	2	69.1	68.1	71.8	1.91	69.6
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	9	73.7	58.2	61.7	8.16	64.5
9	13	55.2	49.0	50.3	3.50	51.5
10	17	70.5	58.4	57.7	7.31	62.2
11	0	-	-	-	-	-
12	8	59.8	54.5	57.2	2.79	57.2
13	11	57.0	49.0	50.2	4.36	52.1
14	16	70.5	58.3	59.8	7.18	62.9
15	1	52.5	49.0	50.8	1.75	50.8
16	18	69.0	59.3	59.5	5.57	62.6
17	15	49.2	41.1	40.0	5.21	43.4
18	9	63.0	52.6	56.0	5.34	57.2
19	16	61.2	56.4	56.2	2.91	57.9
20	0	-	-	-	-	-
21	16	63.5	55.6	58.1	4.13	59.1
22	17	67.3	64.5	64.5	1.68	65.4
23	0	-	-	-	-	-
24	10	63.7	55.9	57.3	4.18	59.0
25	11	68.4	62.2	65.4	3.10	65.3
26	0	-	-	-	-	-
27	16	65.4	59.0	60.5	3.43	61.6
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	12	60.7	50.3	57.5	5.49	56.2
31	17	68.9	61.9	63.2	3.81	64.7
32	14	52.9	46.8	48.5	3.43	49.4
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	17	64.0	57.6	55.4	4.54	59.0
36	10	66.2	55.2	53.9	7.02	58.4
37	13	69.2	60.8	60.7	4.94	63.6
38	14	69.1	58.5	62.5	5.44	63.4
39	3	69.0	51.6	57.4	8.87	59.3
40	13	62.1	59.3	60.7	1.67	60.7
41	19	41.5	39.7	39.6	1.28	40.3
42	18	52.5	50.7	47.0	2.87	50.1
43	19	47.1	40.8	43.5	3.27	43.8
Asphalt 0-39	324	64.8	56.3	57.7	5.10	59.6
Concrete 40-43	69	49.8	46.5	46.6	2.47	47.6

Table C.2 2011 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	8	68.5	70.2	74.7	3.28	71.1
2	6	63.2	66.4	67.1	2.09	65.6
3	0	-	-	-	-	-
4	5	62.7	59.6	56.7	3.03	59.7
5	2	70.7	66.6	71.6	2.64	69.6
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	9	57.5	60.3	61.0	2.02	59.6
9	13	48.0	51.0	48.4	2.30	49.1
10	17	59.6	62.3	62.8	1.87	61.5
11	0	-	-	-	-	-
12	8	52.9	55.7	53.7	1.57	54.1
13	11	52.6	46.8	53.4	3.62	51.0
14	16	62.7	58.3	60.5	2.29	60.5
15	1	53.0	49.5	51.5	1.76	51.4
16	18	59.7	60.4	59.4	0.76	59.8
17	15	42.8	40.3	39.0	2.03	40.7
18	9	63.7	51.7	52.1	6.90	55.8
19	16	58.1	51.5	52.5	3.60	54.0
20	0	-	-	-	-	-
21	16	63.7	57.6	60.1	3.76	60.5
22	17	66.4	65.1	65.1	1.03	65.5
23	0	-	-	-	-	-
24	10	58.7	57.9	52.9	3.19	56.5
25	11	66.8	65.6	64.1	1.34	65.5
26	0	-	-	-	-	-
27	16	64.1	58.4	57.5	3.66	60.0
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	12	58.1	51.5	54.3	3.67	54.7
31	17	67.4	61.9	63.1	2.93	64.1
32	14	50.0	46.5	49.5	2.25	48.7
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	17	59.7	54.8	56.0	2.63	56.9
36	10	57.1	52.1	54.2	2.60	54.5
37	13	64.3	61.2	61.0	1.91	62.2
38	14	66.2	59.0	59.2	4.21	61.5
39	3	62.1	56.4	55.5	3.64	58.0
40	13	60.9	63.0	59.1	2.08	61.0
41	19	40.3	41.3	42.8	1.51	41.5
42	18	52.7	52.9	55.6	1.74	53.7
43	19	44.3	45.2	45.2	0.82	44.9
Asphalt 0-39	324	59.8	56.8	57.4	2.93	58.0
Concrete 40-43	69	48.5	49.5	49.9	1.56	49.3

Table C.3 2012 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR Early	Average SR Middle	Average SR Late	Between run standard deviation	Average
1	8	67.5	68.8	69.5	2.14	68.6
2	6	65.4	66.1	64.5	1.02	65.3
3	0	-	-	-	-	-
4	5	62.3	63.5	59.2	2.21	61.7
5	2	72.0	68.2	70.2	1.95	70.1
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	9	63.7	58.8	63.3	3.04	61.9
9	13	53.8	49.3	50.8	2.82	51.3
10	17	64.7	63.0	63.9	1.78	63.9
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	18	63.5	57.0	57.7	3.66	59.4
17	15	40.8	42.8	39.7	1.59	41.1
18	9	54.9	52.4	51.8	1.65	53.1
19	16	56.6	55.1	52.1	2.43	54.6
20	0	-	-	-	-	-
21	16	61.2	61.5	57.9	2.32	60.2
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	11	65.7	65.5	67.1	0.96	66.1
26	0	-	-	-	-	-
27	16	62.5	59.2	60.2	1.75	60.6
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	12	55.9	54.7	53.5	1.57	54.7
31	17	63.2	65.1	62.9	1.47	63.7
32	14	49.7	48.5	48.7	1.05	49.0
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	17	56.5	56.2	51.6	2.77	54.7
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	19	39.1	40.0	44.1	2.71	41.0
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	324	59.2	57.8	57.3	2.30	58.1
Concrete 40-43	69	50.5	48.5	51.6	2.34	50.2

Table C.4 2013 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	8	66.0	63.0	62.3	2.04	63.8
2	6	61.0	58.1	56.8	2.20	58.6
3	0	-	-	-	-	-
4	5	57.5	56.9	57.0	0.32	57.1
5	2	66.8	61.1	61.5	3.22	63.1
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	9	56.8	59.1	58.1	1.45	58.0
9	13	45.5	61.4	43.2	10.07	50.1
10	17	58.0	57.4	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	18	56.0	52.0	50.9	2.73	52.9
17	15	41.5	40.8	40.1	0.82	40.8
18	9	52.5	52.3	51.0	0.85	52.0
19	16	49.5	52.1	50.2	1.38	50.6
20	0	-	-	-	-	-
21	16	58.2	58.3	56.6	1.50	57.7
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	11	62.6	60.6	60.9	1.16	61.4
26	0	-	-	-	-	-
27	16	57.6	56.9	59.1	1.21	57.9
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	12	49.0	50.2	51.3	1.51	50.2
31	17	58.1	54.8	63.4	4.36	58.8
32	14	50.9	48.1	48.4	1.79	49.1
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	17	51.9	48.1	52.7	2.50	50.9
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	19	36.6	37.3	36.8	0.53	36.9
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	324	55.4	54.5	54.1	3.36	54.7
Concrete 40-43	69	48.0	47.8	46.2	1.98	47.3

Table C.5 2014 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	8	67.6	59.8	65.7	4.28	64.4
2	6	64.6	54.8	61.7	5.07	60.4
3	0	-	-	-	-	-
4	5	58.6	53.4	58.3	2.94	56.8
5	2	71.2	62.1	67.9	4.63	67.1
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	9	58.5	56.2	57.2	1.22	57.3
9	13	47.1	45.2	44.6	2.79	45.6
10	17	59.7	51.2	57.9	4.74	56.3
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	18	55.5	52.4	55.2	1.95	54.4
17	15	45.7	37.2	40.8	4.33	41.2
18	9	54.4	45.8	51.2	4.44	50.5
19	16	53.2	47.6	54.2	3.66	51.7
20	0	-	-	-	-	-
21	16	59.6	54.8	56.3	2.86	56.9
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	11	87.5	60.5	63.9	14.73	70.6
26	0	-	-	-	-	-
27	16	61.2	50.6	56.1	5.41	55.9
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	12	56.1	45.3	47.3	5.82	49.6
31	17	61.0	55.6	59.8	2.94	58.8
32	14	46.9	46.8	45.6	1.44	46.4
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	17	54.0	49.0	52.1	2.62	51.7
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	19	40.8	35.5	39.5	2.89	38.6
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	324	58.8	51.6	54.9	4.80	55.1
Concrete 40-43	69	49.7	44.0	49.2	3.37	47.7

Table C.6 2015 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	8	73.2	64.4	71.5	4.98	69.7
2	6	70.3	58.5	66.6	6.25	65.1
3	0	-	-	-	-	-
4	5	60.4	60.6	61.6	0.96	60.9
5	2	67.0	59.8	68.6	5.02	65.1
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	9	62.5	53.5	59.5	4.75	58.5
9	13	53.2	41.8	47.9	6.69	47.6
10	17	66.4	53.2	56.7	6.90	58.8
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	18	60.2	50.9	52.7	5.04	54.6
17	15	45.3	40.8	51.5	5.60	45.9
18	9	57.3	49.3	56.9	4.53	54.5
19	16	56.2	51.5	58.7	3.74	55.5
20	0	-	-	-	-	-
21	16	62.3	56.9	55.8	3.97	58.3
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	11	73.4	59.3	71.6	7.74	68.1
26	0	-	-	-	-	-
27	16	63.6	56.9	57.4	3.83	59.3
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	12	53.2	51.2	55.4	2.44	53.3
31	17	61.8	61.5	61.6	1.29	61.6
32	14	50.8	46.3	48.1	2.84	48.4
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	17	57.9	50.8	51.6	4.05	53.5
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	19	42.7	36.2	38.0	3.41	39.0
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	324	60.7	53.5	58.3	4.94	57.5
Concrete 40-43	69	54.2	45.2	48.4	5.06	49.3

Table C.7 2016 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	8	63.0	62.5	74.8	7.22	66.8
2	6	61.4	61.1	65.4	2.83	62.6
3	0	-	-	-	-	-
4	5	58.7	55.3	61.3	3.10	58.4
5	2	69.0	63.5	65.7	3.22	66.0
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	9	59.1	59.1	62.1	2.09	60.1
9	13	48.0	45.8	48.0	3.05	47.3
10	17	62.2	59.5	59.5	1.90	60.4
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	18	57.0	51.3	55.9	3.28	54.8
17	15	45.4	41.1	42.0	2.48	42.8
18	9	54.4	51.6	57.7	3.14	54.6
19	16	55.4	54.9	55.0	0.89	55.1
20	0	-	-	-	-	-
21	16	66.7	61.8	59.4	4.03	62.6
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	11	75.7	65.4	69.1	5.39	70.1
26	0	-	-	-	-	-
27	16	62.0	77.0	66.2	7.99	68.4
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	12	53.6	51.2	54.1	2.63	53.0
31	17	64.4	58.9	63.8	3.14	62.3
32	14	50.2	49.9	50.9	1.89	50.3
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	17	55.6	52.3	54.8	2.35	54.2
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	19	42.0	43.5	43.6	1.61	43.1
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	324	59.8	57.0	59.0	3.79	58.6
Concrete 40-43	69	51.9	52.4	53.0	2.18	52.5

Table C.8 2017 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	8	75.3	58.2	70.5	8.91	68.0
2	6	75.8	54.1	60.6	11.20	63.5
3	0	-	-	-	-	-
4	5	62.8	54.0	62.3	4.97	59.7
5	2	66.6	62.7	63.7	2.13	64.3
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	9	63.2	51.1	61.5	6.57	58.6
9	13	50.8	43.0	48.5	4.46	47.4
10	17	67.9	52.9	61.1	8.10	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	18	59.6	48.8	55.1	5.54	54.5
17	15	44.9	34.7	41.4	5.28	40.3
18	9	62.5	51.2	57.2	5.75	56.9
19	16	61.7	47.1	59.3	7.88	56.0
20	0	-	-	-	-	-
21	16	61.0	52.8	61.3	5.07	58.4
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	11	72.5	58.0	65.1	7.30	65.2
26	0	-	-	-	-	-
27	16	64.4	58.4	65.1	3.86	62.6
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	12	52.3	48.0	51.6	2.67	50.6
31	17	66.5	56.6	63.0	5.14	62.0
32	14	54.0	43.6	47.6	5.34	48.4
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	17	61.7	48.5	57.9	6.79	56.0
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	19	40.4	37.1	42.6	3.03	40.0
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	324	61.8	50.5	58.3	6.28	56.9
Concrete 40-43	69	49.2	44.8	51.8	3.87	48.6

Table C.9 2018 benchmark surveys using the current defined lengths

Site	Number of 100m lengths	Average SR			Between run standard deviation	Average
		Early	Middle	Late		
1	8	76.9	64.8	70.2	6.16	70.6
2	6	71.5	62.1	62.3	5.53	65.3
3	0	-	-	-	-	-
4	5	61.4	57.2	64.8	3.95	61.1
5	2	68.4	60.6	62.6	4.15	63.9
6	0	-	-	-	-	-
7	0	-	-	-	-	-
8	9	67.6	58.7	72.8	7.48	66.4
9	13	53.9	42.7	49.9	6.38	48.8
10	17	68.2	54.7	63.9	6.95	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	18	65.0	47.5	56.0	8.87	56.2
17	15	47.7	36.2	43.5	5.96	42.4
18	9	55.9	55.9	56.3	1.13	56.0
19	16	54.0	53.9	57.0	2.13	54.9
20	0	-	-	-	-	-
21	16	62.2	53.2	62.7	5.67	59.4
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	11	68.0	66.3	68.3	1.25	67.5
26	0	-	-	-	-	-
27	16	67.8	59.6	65.0	4.29	64.1
28	0	-	-	-	-	-
29	0	-	-	-	-	-
30	12	60.8	48.3	57.0	6.49	55.3
31	17	64.3	60.4	67.3	3.57	64.0
32	14	51.4	43.6	50.7	4.68	48.6
33	0	-	-	-	-	-
34	0	-	-	-	-	-
35	17	57.0	55.6	60.2	2.51	57.6
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	19	42.0	38.1	44.0	3.39	41.4
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	324	62.8	54.4	60.4	5.41	59.2
Concrete 40-43	69	52.0	47.3	53.1	3.76	50.8

Skid resistance benchmark surveys 2019

Highways England manages levels of skid resistance on their network (the Strategic Road Network or SRN) by carrying out 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, Highways England 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 2019, and compares the results of the analysis to those from earlier years.

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