Road Markings Durability & Adherence on TS2010 Surfacing

Phase 2: Site Trial

Transport Scotland, Scottish Road Research Board

22 August 2016

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This document has 43 pages including the cover.

Document history

Job number: 5141906.012			**Document ref: 0001**			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
0.0	Draft for comment	JR/RA	QV	LT	PM	03/06/16
1.0	For client review	RA	QV	LT	PM	24/06/16
2.0	Final version	RA	QV	LT	PM	22/08/16

Client signoff

Client	Transport Scotland, Scottish Road Research Board
Project	Road Markings Durability & Adherence on TS2010 Surfacing
Document title	Road Markings Durability & Adherence on TS2010 Surfacing
Job no.	5141906.012
Copy no.	0001
Document reference	0001

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Executive summary

The TS2010 surfacing specification was developed by Transport Scotland's Standards Branch and issued in December 2010. TS2010 has been used regularly on the Scottish network since 2011 and is a more durable surfacing material compared to other negative textured surfacing material. This material is used more widely on the Trunk Road Network within Scotland. Operating Companies and the road marking industry have noted that the retention of road markings on negative textured surfacing material to be an issue.

The Scottish Road Research Board (SRRB) have conversed that they would like to undertake a research study into this subject. The first phase involved undertaking a consultation exercise to gauge the scale of the perceived problem and to gather the views of industry practitioners and benefit from their first-hand experience regarding potential issues and remedies. This was summarised in a Technical Note to Transport Scotland dated 10th September 2015.

Atkins would like to thank Transport Scotland, the operating companies, Scotland Transerv, Amey as well as their supply chain for accommodating Atkins onto the various construction sites to undertake the trials.

This study involved road trials to establish best practice behaviours with an aim to ensuring road marking adheres securely to the TS2010 road surfacing. Based on the input received from the consultees, and agreed with Transport Scotland, the locations for the trial sites are as follows:

- A75 Dalscone to Rail Bridge;
- A77 Minishant Holding; and
- M80 Foot o Green (SB).

The trials for A75, A77 and M80 were undertaken as part of the maintenance works that were completed on these sections on 6/7th September 2015 (M80 and A75) and 10/11th October 2015 (A77). Evaluations of the performance were undertaken on 10th February 2016 (5 and 4 months respectively after installation).

Following discussions with Transport Scotland, it was agreed that the evaluation of the M80 Foot o Green (SB) site could not be undertaken due to complications with traffic management. It was agreed that this site could potentially be evaluated at a later date and under a separate study, should it be deemed necessary.

This report, focusses on Phase 2 only of a proposal by The Scottish Road Research Board (SRRB), where Phase 1 (issued in April 2015) was 'Literary Review and Consultation'.

The study required to keep as many other influences constant and only focus on the influence of grit on the road markings. The study therefore only considered alternative construction methods. The sites were selected that at the time, stood the best chance of being constructed during good climatic conditions, and where the trial sections would be unaffected by the geometry of the site.

In summary, the key conclusions from the trials undertaken on both the A75 and A77 indicated:

- None of the alternative sections have performed conclusively better than the control section (current methodology). Therefore, based on the assessment undertaken at this point in time, it can be concluded that a reduction in the grit rate and or width of grit application, has not had a definitively improved visual condition compared to the current methodology required by Transport Scotland.
- In addition, by not sweeping off excessive grit from the road surface, this has not had a definitive adverse effect on the visual condition of the road markings compared to other trial sections.
- The Grip test results were all very similar and showed no significant difference between the different sections.

- From this assessment there would appear to be no clear advantage in altering the methodology currently stipulated within TS IAN 35/15: TS2010 Surface Course Specification and Guidance.
- At this point in time, there is therefore, no evidence to support the reasoning that the grit applied to the TS2010 surfacing has an adverse effect on the road marking performance.
- From the workshop undertaken with the Operating and Road Marking companies, prior to the trials were, 'if it failed, it failed quickly'. This issue has not been noticed on any of the two trial sites evaluated.
- Breedon Aggregates was the surfacing contractor on the A75 site and Aggregate Industries was the surfacing contractor on the A77 site. The line marking contractor was also different on both the A75 and A77 sites, with Markon being the marking contractor on the A77 site and Tim Doody being road marking contractor on the A75 site. Despite the different contractors, there were no failures to the extent where there is a 'Visual Assessment Score' of less than 3. This would therefore indicate that the method of installation (undertaken by two different contractors) is working at the time of the evaluation.

It is recommend that it may be advantageous to conduct another visual inspection after 12 months of trafficking in order to confirm the conclusions noted within this report. It would also be recommend that the M80 be included within the 12 month evaluations. Should the M80 be evaluated, this would be required to be undertaken under traffic management closures. The M80 includes a section of Hot Rolled Asphalt (positive textured surface course) constructed over a bridge deck which would be interesting to compare to the TS2010 trial sections.

1 Introduction

1.1 Background

The TS2010 surfacing specification was developed by Transport Scotland's Standards Branch and issued in December 2010. TS2010 has been used regularly on the Scottish network since 2011 is a more durable surfacing material compared to other negative textured surfacing materials. This material is used more widely on the Trunk Road Network within Scotland. Operating Companies and the road marking industry have noted that the retention of road markings on the TS2010 surfacing material appears to be an issue.

The Scottish Road Research Board (SRRB) have commissioned Atkins to undertake a research study into this perceived issue with a view to determining if this is a material issue (road marking or surfacing) or a an application issue. The approach agreed between the SRRB and Atkins was a two phased consisting of an initial desk study followed by site trials.

Phase 1 - Literature Review and Consultation' (Issued 20th April 2015) involved a consultation exercise with major role players within the road marking and asphalt construction industry in Scotland. This was undertaken in order to gauge the scale of the perceived problem and to gather the views of industry practitioners and benefit from their first-hand experience regarding potential issues and remedies.

Transport Scotland undertook a workshop at their office on the 7th October 2014. As part of this study further consultations were then undertaken in Glasgow on the 5th and 6th of August 2015 in order to obtain the views of the interested parties within Transport Scotland and their supply chain (i.e. Operating Companies, Asphalt Contractors and Marking Contractors). The finding of these workshops have been presented to Transport Scotland in a Technical Note dated 10th September 2015 and a copy is attached as Appendix E of this report.

The second phase, which is described in this report, involved road trials in order to establish best practice behaviours, with an aim to establish best practice so as to ensure the road marking adheres securely to the TS2010 road surfacing. Based on the feedback received, from the consultations with the various stakeholders in Glasgow on 5th and 6th August 2015, it was proposed and agreed with Transport Scotland that the trial options were to be undertaken on five 100m length sections. Each of the three road maintenance projects are listed in section 1.2 of this report. The trials were planned to be undertaken in September 2015 (while climatic conditions were still reasonable) and then evaluated in January 2016.

It was agreed to keep as many of the other influences constant and only focus on the influence of grit on the road markings. The study therefore considered alternative construction methods that would consider this aspect in particular, rather than focus on to many variables.

1.2 Trial site locations

A number of schemes in the 2015/16 Structural Maintenance Programme were considered for these trials, and after consultation with Transport Scotland and the Operating Companies, it was agreed to select 3 schemes of different carriageway types, i.e. single urban, single rural and motorway. As a result the following three schemes were selected:

- A75 Dalscone to Rail Bridge – single carriageway with national speed limit and AADT = 20,371 (as per DfT latest traffic count);
- A77 Minishant Holding – single carriageway with a 30mph speed limit and AADT = 12,637 (as per DfT latest traffic count); and
- M80 Foot o Green (SB) – 2-lane motorway with hard shoulder with a national speed limit and AADT = 21,327 (as per latest DfT traffic count).

These schemes were selected for the following reasons:

- they were geographically in an area that would have the best possible chance of being constructed in good climatic conditions;
- generally geometrically uniform, hence geometry will have no influence of the trial sections;
- have a spread of carriageway types that are typically encountered within the TS network;
- would be under construction as soon as possible following the consultations; and
- previous TS2010 studies have been undertaken on the M80 during the development of TS2010.

Location plans for each scheme are presented in Figure 1-1 to Figure 1-3 inclusive and more detailed scheme extents drawings can be found in Appendix A at the back of this report.

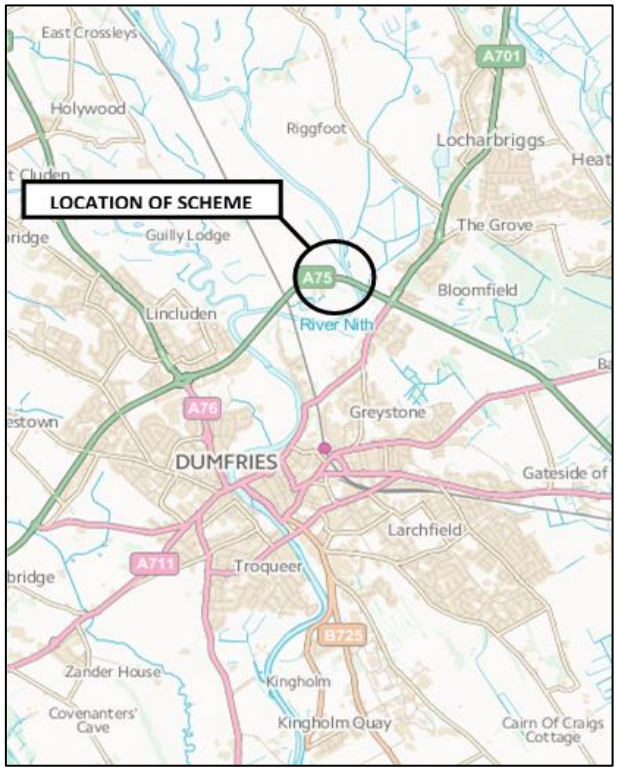


Figure 1-1 Location Plan - A75

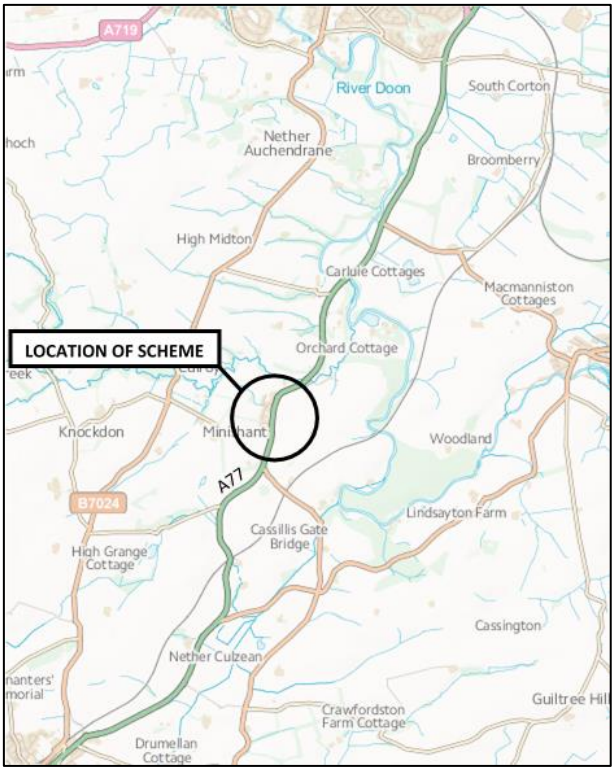


Figure 1-2 Location Plan - A77

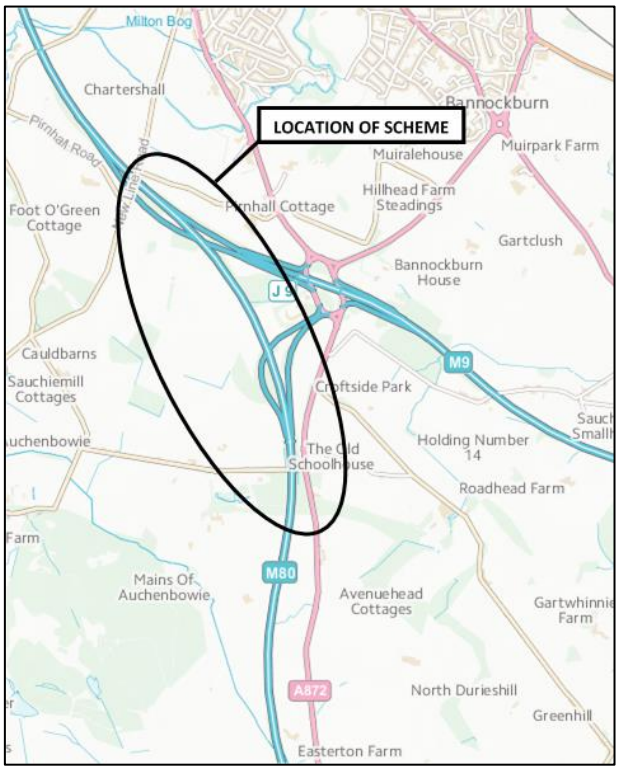


Figure 1-3 Location Plan - M80

1.3 Scope of Trials

Each of the three trial sites were split into five sections; one for each of the identified methodologies. A description of the intended methodologies are summarised and shown in Table 1-1.

Table 1-1 Summary of TS2010 Road Marking Methodologies

Trial Options	Description	Section A (Control Section)	Section B	Section C	Section D	Section E
GRIT Standard Rate	Apply the grit at the standard rate	X	X			X
GRIT Reduced Rate	Apply the grit at the reduced rate			X	X	
GRIT Full Width	Apply grit over the full lane width (including road marking areas), with no overlaps or over application.	X		X		X
GRIT Reduced Width	Apply grit to lane widths, but excluding areas that will be receiving road markings (lane and edge lines only). Avoid overlaps and over application.		X		X	
No Sweeping before road marking	No sweeping to be undertaken to remove excess grit, before road marking is conducted. Grit applied over full lane widths. Only dryer / blower is to be used prior to gritting.					X*

* Note: Section E for the M80 site was not to be undertaken as it was deemed to be too high a risk for motorists.

Section A was identified as the control section and grit was applied in accordance with the specification at the standard application rate ranging between 1.0 to 1.25 kg/m^2. The grit was applied over the full width of the lane including the areas that received road markings. The grit was applied while the surface was still hot before being statically rolled. Once the surface had reached ambient temperatures the excess grit was swept and cleaned off prior to the line markings being applied.

Section B involved the application of grit at the standard rate, but excluded the areas that were to receive road markings. This allowed the methodology used by some of the contractors where they avoid the application of grit on areas that will receive line markings to be reviewed.

Section C required the application of grit over the full width of the lane but at a reduced spread rate ranging between 0.75 to 1.0 kg/m^2. This took account of the experiences noted by the contractors that a lot of excess grit is removed before applying the road markings.

Section D involved applying the grit at a reduced rate 0.75 to 1.0 kg/m^2 and excluding its application from the areas that was to receive road markings.

Section E involved applying the grit at the standard rate ranging between 1.0 and 1.25 kg/m^2, however no sweeping of the excess grit took place before the road markings were applied. This was to replicate instances where the cleaning off of excess grit before applying the road markings is not possible due to site constrains. This option was not applied to the M80 motorway trial project due to the potential risk to vehicles travelling at higher speed compared to both the other single carriageway sites on the A75 and A77. This was discussed and agreed with Transport Scotland.

2 Site Trials

2.1 Trial sections

Site trials were undertaken at the locations described in section 1.2.

2.2 Typical site trial installation process

The TS2010 trial sections for the M80 and A75 were constructed on 6/7th September 2015 and the A77 was constructed on the 10/11th October 2015 as part of planned maintenance that was undertaken at these sites. Atkins visited all 3 sites during the construction process in order to provide guidance and monitor the trials being undertaken by the Operating Company. Each of the three sites followed the same installation process which is summarised in the bullet points below:

- Each site was divided into 5 equal sections (Section A to E inclusive) of 100 metres each which was carefully marked and referenced on site (with yellow spray markings) as well as noted on the location plans included with this report. Refer to **Appendix A** for more detailed location plans for all 3 sites.

Figure 2-1 Asphalt laying operation (left - milled surface, right – laying of surface course)

- Operating companies (Scotland Transerv for A75 and A77, and Amey for M80) coordinated and informed the contracting teams during the construction of the trial sections.
  The works involved milling a total of 150mm of an aged binder and surface courses prior to laying 120mm AC20 Binder Course followed by 30mm of the TS2010 surface course.

Figure 2-2 Asphalt compaction

- The surface course was compacted by an articulated tandem steel drum roller (9 tonne).

Figure 2-3 Surface gritting application from steel drum roller

- While the surface was still hot, grit was applied from hoppers attached to rollers after the asphalt had been laid and after the initial break down compaction had been completed.
- The rolling pattern followed ensured a single application of grit and where required for the trial section, was undertaken over the full width of the carriageway (Sections A, C and E).
- The sections were then carefully bifurcated from full width to reduced width and standard grit rate to reduced grit rate on sites.
- The grit rate was calibrated by raising and lowering down selected levers of the roller which was attached with a hopper.
- At the reduced width sections (Sections B and D), the grit was applied in such a way as to avoid the areas which receive road marking on both sides of the carriageway edge and centre lines.
- The roller with hopper applied the desired rate of grit on the respective trial sections followed by another roller which compacted the surface course.

Figure 2-4 Sweeping and hot air blowing prior to marking application

- When the surface course material reached ambient temperature, any surplus grit was removed by sweeping and blowing hot air prior to the application of road markings and before the road is opened to traffic.
- During the trial installations the weather remained dry during both the day and night works.

Figure 2-5 Road Marking application

- Thermostatic paint was used for the road markings with the laying temperature of the paint kept between 200-220°C before installation.

After the road marking was completed, '301/290 3M™ Marker Series' road studs were placed at the required locations over the road surface.

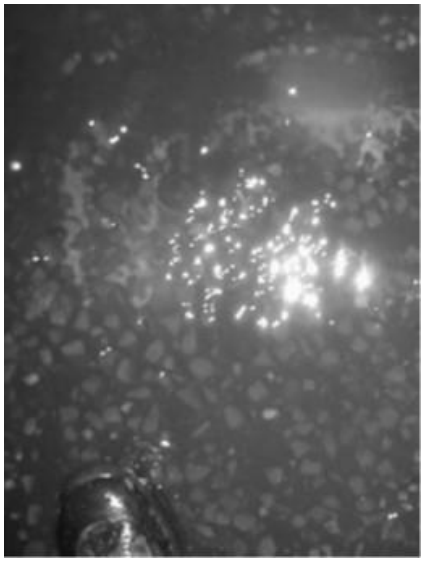
2.3 Post Construction Evaluation

After the successful construction of the trial sections at the three sites, the sections, with the exception of the M80 site (the reasons for which have already been given earlier in this report), were evaluated on 10th of February 2016 (5 months after installation for the A75 and 4 months after installation for the A77).

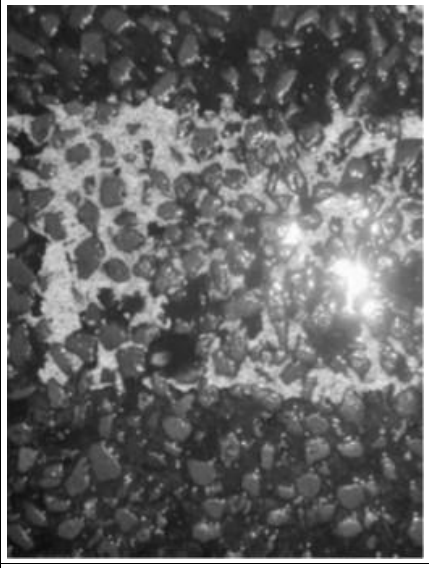
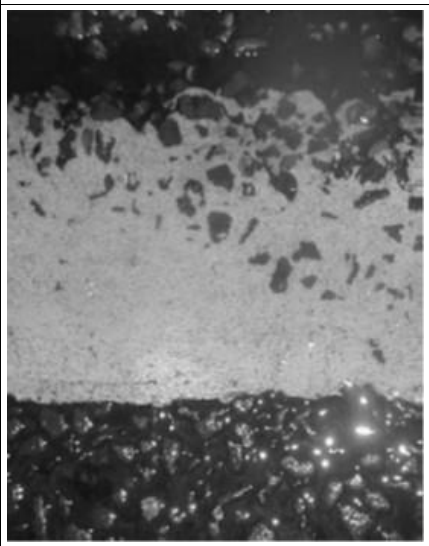
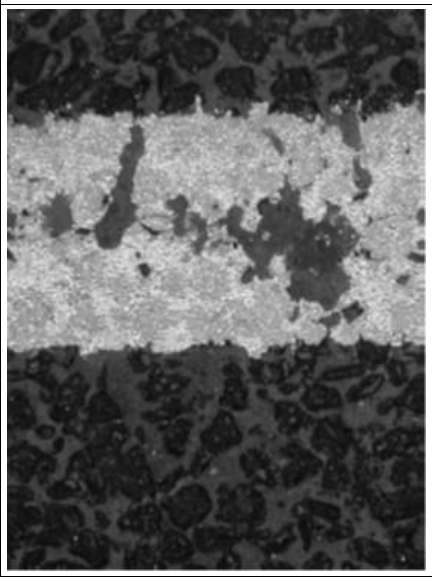
It was agreed with Transport Scotland that the performance of the road marking will be evaluated visually in accordance with the guidelines from Volume 8, Section 2 Part 2, TD 26/07 "Inspection and Maintenance of Road Markings and Road Studs on All-Purpose Trunk Roads" Annex C and D[1]. (refer to Table 2-1**)**.

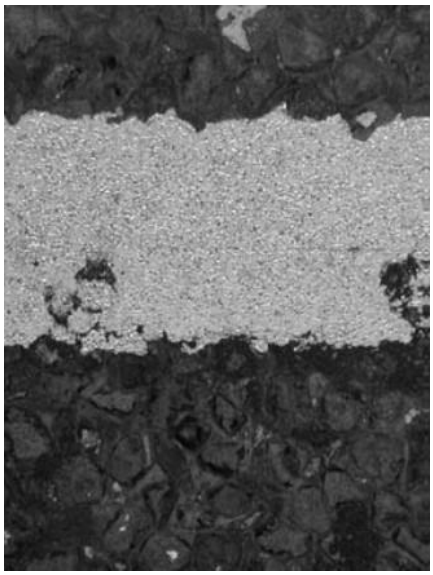
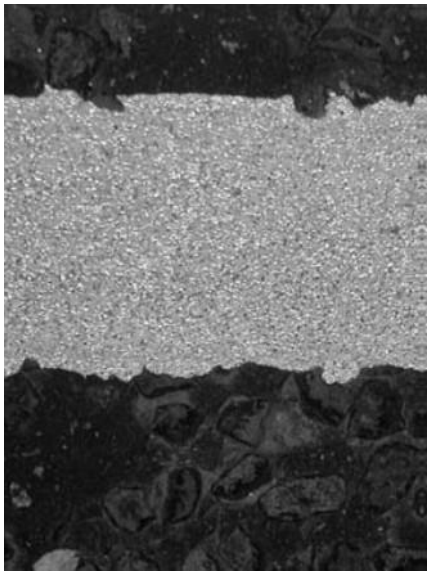
For Health and Safety reasons the post construction evaluation was undertaken during the daytime hours and as a result night time conspicuity was not part of the assessment.

Table 2-1 Photographic Examples to Visual Assessment Scoring System (TD26/07 Annex C & D)

Score	Example	Assessment
0		Non-existent

[1] TD26/07

Score	Example	Assessment
1		Barely visible
2		Visible, but has bare spots and low night time conspicuity
3		Marginal – some visible wear and/or fair night time conspicuity characteristics

Score	Example	Assessment
4		Very little wear and good night time conspicuity and
5		No wear and good night time conspicuity and

Note: The evaluations were undertaken during daytime, therefore no night time conspicuity assessment was undertaken. This study focused on the adherence of the road marking to the underlying surface course.

2.3.1 A75 Dalscone to Rail Bridge

The evaluation of the A75 site was undertaken on 10th February 2016 (5 months after installation). Figure 2-6 shows the layout sketch of the trial sections with the relevant chainage from sections A to E. The visual assessment was undertaken in accordance with the guidelines provided in DMRB Volume 8, Section 2 Part 2 TD26/07[2]. Whilst undertaking the visual assessment, there was a light rain shower (drizzle) which soon stopped and did not result in any standing water during road marking or gritting operations.

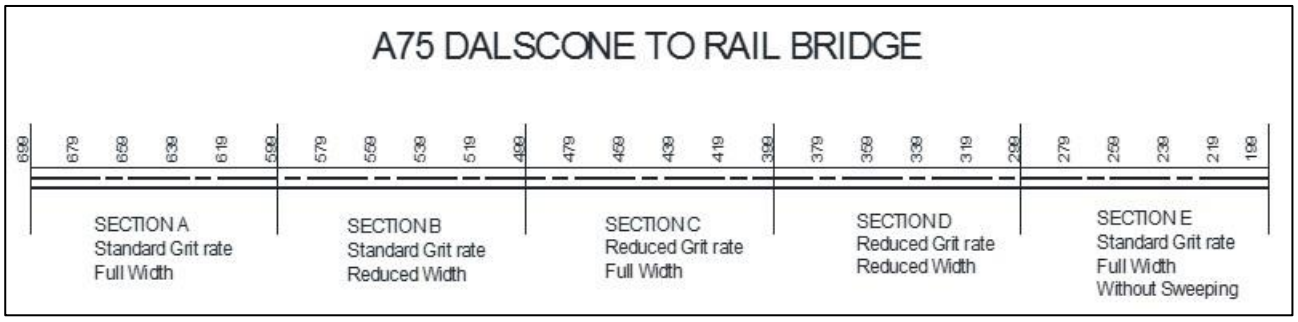


Figure 2-6 Layout sketch of A75 trial section

The visual assessment involved work carried out in a live carriageway, and so to avoid any potential health and safety risk, a team of two members were formed to conduct the visual assessment/survey. The visual observation for continuous road markings were recorded from the footway/verge for both southbound and northbound lanes. The trial sections of 100 m each were subdivided into 20 m lengths and the road markings was assigned an average score per 20m section, which was then averaged over the 100 m section. With more vigilant and caution, similar observations were recorded for each broken road marking and an average score assigned over a 20 m length and averaged for the 100 m section. The summary of the visual assessment from the A75 trial sections as well as the grip test results (after 4 weeks of trafficking) are summarised in Table 2-2.

[2] TD26/07

Table 2-2 Road Marking Visual Assessment Scoring - A75

A75 - TRIAL SECTIONS ROAD MARKING - VISUAL ASSESSMENT RECORD										
Test Section	Chainage		Scoring						*Grip Test	
	Start	End	North bound Edge Lane Marking	Average Score	South bound Edge Lane Marking	Average Score	Centre Line Marking	Average Score	North bound Lane	South bound Lane
A (Standard Grit + Full width)	699	679	5	4	4	4	5	5	0.64	0.66
	679	659	5		4		5			
	659	639	4		4		5			
	639	619	4		4		5			
	619	599	4		4		5			
B (Standard Grit + Reduced width)	599	579	5	5	4	4	4	4	0.66	0.69
	579	559	5		4		4			
	559	539	5		4		4			
	539	519	4		4		4			
	519	499	5		4		4			
C (Reduced Grit + Full width)	499	479	5	4	4	4	4	4	0.69	0.69
	479	459	4		4		4			
	459	439	4		4		4			
	439	419	4		4		4			
	419	399	4		5		4			
D (Reduced Grit + Reduced width)	399	379	4	4	4	5	4	4	0.68	0.69
	379	359	4		5		4			
	359	339	4		4		4			
	339	319	4		5		4			
	319	299	4		5		4			
E (Standard Grit + Full width) without sweeping	299	279	5	5	5	5	4	4	0.73	0.74
	279	259	5		4		4			
	259	239	5		5		4			
	239	219	5		5		4			
	219	199	5		5		4			

*Grip Tester survey was undertaken on 1st October 2015 by a specialist materials testing consultant and results supplied by Scotland Transerv

2.3.2 A77 Minishant Holding

Evaluation of the A77 site was completed on 10th February 2016 (4 months after installation), Figure 2-7 shows the layout sketch of the trial sections with the relevant chainage from sections A to E for A77 road. The visual assessment was done in accordance with guidelines given in DMRB Volume 8, Section 2 Part 2 TD26/07[3]. Whilst undertaking the visual inspection, the weather was overcast and dry.

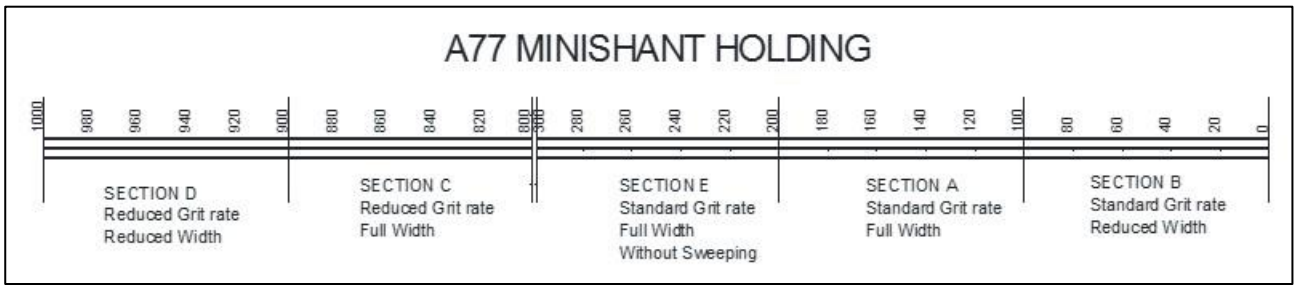


Figure 2-7 Layout sketch of A77 trial section

The visual assessment involved work carried out in a live carriageway, and so to avoid any potential health and safety risk, a team of two members were formed to conduct the visual assessment/survey. The visual observation for continuous road markings were recorded from the footway/verge for both southbound and northbound lanes. The trial sections of 100 m each were subdivided into 20 m lengths and the road markings was assigned an average score per 20 m section, which was then averaged over the 100 m section. With more vigilant and caution, similar observations were recorded for each broken road marking and an average score assigned over a 20 m length and averaged for the 100 m section. The summary of the visual assessment from the A77 trial sections as well as the grip test results (after 4 weeks of trafficking) are summarised in Table 2-3.

[3] TD26/07

Table 2-3 Road Marking Visual Assessment Scoring - A77

A77 - TRIAL SECTIONS ROAD MARKING - VISUAL ASSESSMENT RECORD										
Test Section	Chainage		Scoring						*Grip Test	
	Start	End	North bound Edge Lane Marking	Average Score	South bound Edge Lane Marking	Average Score	Centre Line Marking	Average Score	North bound Lane	South bound Lane
A (Standard Grit + Full width)	100	120	4	4	5	4	3	3	0.85	0.88
	120	140	4		5		3			
	140	160	4		4		4			
	160	180	3		4		3			
	180	200	3		4		4			
B (Standard Grit + Reduced width)	0	20	5	4	5	5	5	4	0.84	0.80
	20	40	5		5		5			
	40	60	4		5		4			
	60	80	4		4		4			
	80	100	4		4		4			
C (Reduced Grit + Full width)	800	820	3	3	3	4	5	4	0.82	0.78
	820	840	3		5		4			
	840	860	4		4		3			
	860	880	3		3		3			
	880	900	4		4		4			
D (Reduced Grit + Reduced width)	900	920	4	4	4	4	5	5	0.82	0.80
	920	940	4		5		5			
	940	960	4		5		5			
	960	980	4		5		5			
	980	1000	4		3		5			
E (Standard Grit + Full width) without sweeping	200	220	4	4	5	4	3	3	0.83	0.85
	220	240	4		5		3			
	240	260	5		4		3			
	260	280	3		4		4			
	280	300	3		3		4			

*Grip Tester survey was undertaken on 11th November 2015 by a specialist materials testing consultant and results supplied by Scotland Transerv

2.3.3 M80 Foot o Green (SB).

Due to traffic management complications we have been unable to access this site to complete the post works assessment. Following discussions with Transport Scotland it was agreed that the evaluation of this site could not be undertaken without appropriate lane closures. This report provides a basis of record should Transport Scotland decide that this section should be evaluated in the future.

3 Evaluation discussion

3.1 Site Trial Evaluation – A75 Dalscone to Rail Bridge

Results from the visual assessments and Grip Tester are illustrated graphically in Figure 3-1 and Figure 3-2 respectively.

3.1.1 Visual Assessment Scoring

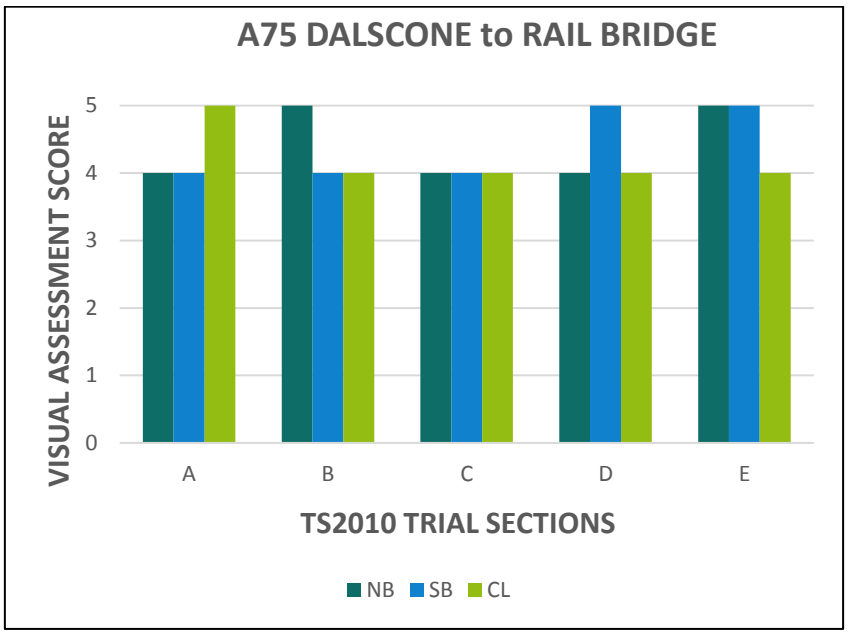


Figure 3-1 Visual Assessment Scores - A75

Summary of Trial Sections:

Section A – Standard Rate/Full Width
Section B – Standard Rate/Reduced Width
Section C – Reduced Rate/Full Width
Section D – Reduced Rate/Reduced Width
Section E – Standard Rate/Full Width/No Sweeping

The control section, (section A) indicated an average score of 4 (very little wear) for both the NB and SB edge lines. Section B, D and E have higher edge line scores in comparison to the control Section A.

The SB edge line, Section D and unexpectedly Section E has slightly higher scores compared to the control Section A. The other sections have similar scores compared to the control Section A.

The centreline for Section A has a visual score of 5 (no wear) and slightly outperforms the scores from the sections which all have a score of 4 (very little wear).

Based on the anecdotal evidence collated by the initial desk study and workshops in phase one, it would have been expected to see Section D outperform all of the other trial sections visually and Section E to be performing the poorest. However, from the visual condition assessment undertaken at this point in time (after 5 months) there does not appear to be a clear distinction between the results. Section E which was expected to have the worse score visually, compared to the control section, had in fact a slightly higher visual assessment score.

The message from the Operating companies prior to the trial was, ‘if it failed, it failed quickly’. This has not been noticed on the A75 trial site.

3.1.2 Grip Tester Results

The minimum Grip Number for each HD28 Site Category and as per TS 2010 Surface Course Specification & Guidance Issue 01 (December 2010), section 2.10.1, is shown in Table 3-1. Note: The minimum grip numbers were revised and superseded by TS Interim Amendment No. 35/15 Issue 03 (October 2015), section 2.10.1[4]. The revised (and lowered) minimum Grip Number is shown in brackets.

Table 3-1 Minimum Grip Number

Site Class	HD28 Site Category	Measuring Speed (km/h)	Min mean Grip Number (10m average)
1	A, B and C	50	0.62 (0.39)
2	R, G1 and S1	50	0.67 (0.51)
3	Q, K, G2 and S2	50	0.72 (0.56)

The grip tester results for the A75 Trial Site are illustrated in Figure 3-2.

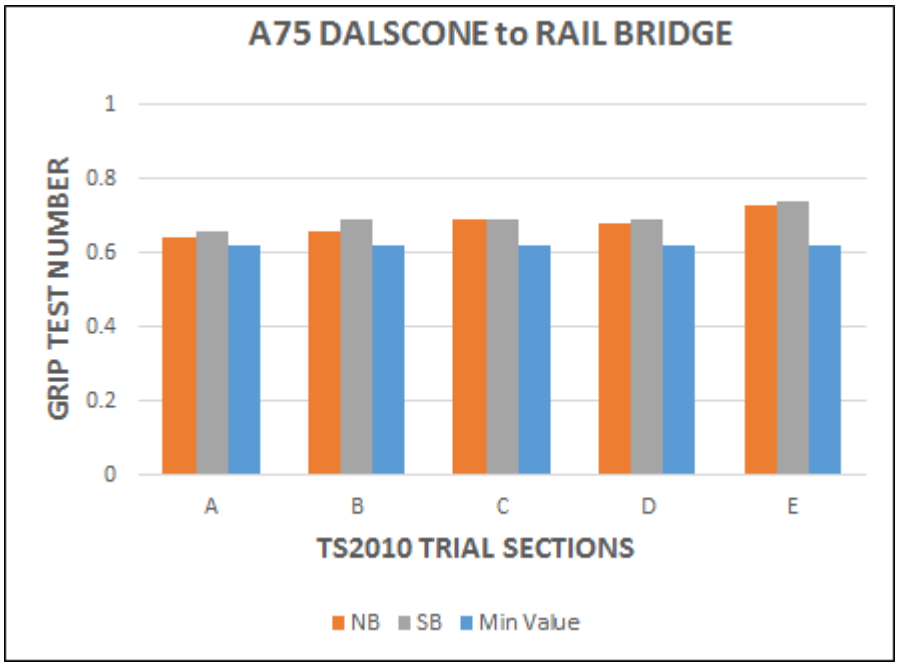


Figure 3-2 Grip Tester Results - A75

From the results shown in Figure 3-2, all of the sections indicate grip numbers exceeding the minimum required. The results indicate a maximum value of 0.74 (section E) and a minimum value of 0.64 (section A).

The Grip Tester results for section A (Control Section), show values of 0.64 (NB) and 0.66 (SB). Sections B, C and D each show very similar results of 0.69 approximately. Section E has Grip Tester values of 0.73 (N/B) and 0.74 (S/B). The section that did not receive any sweeping (Section E) had the highest grip testing results, which would appear to indicate that the excessive grit had a positive influence on the early life skid resistance.

[4] TS Interim Amendment No. 35/15

3.2 Site Trial Evaluation – A77 Minishant Holding

Results from the visual assessments and Grip Tester are illustrated graphically in Figure 3-3 and Figure 3-4 respectively.

3.2.1 Visual Assessment Scoring

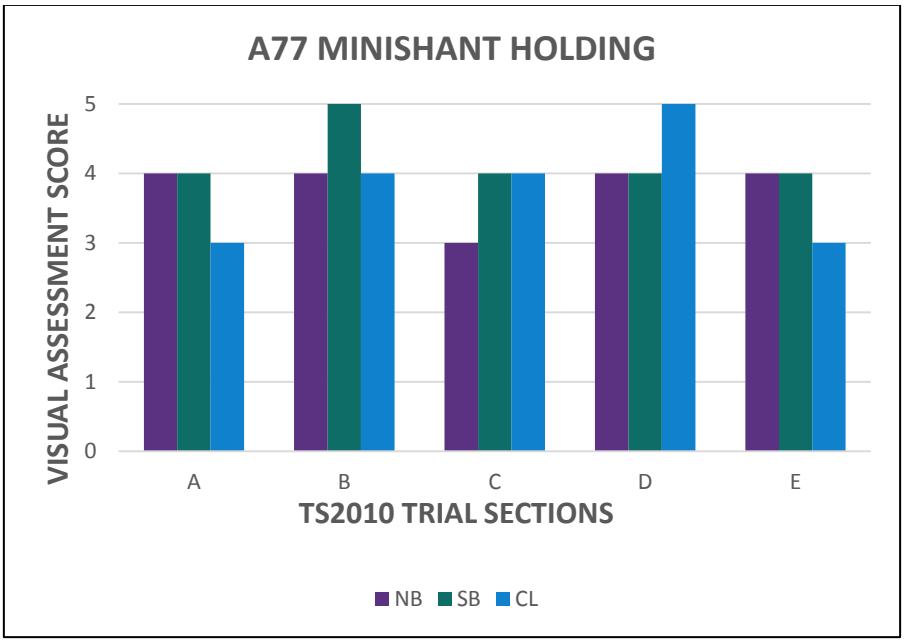


Figure 3-3 Visual Assessment Scores - A77

Summary of Trial Sections:

Section A – Standard Rate/Full Width
Section B – Standard Rate/Reduced Width
Section C – Reduced Rate/Full Width
Section D – Reduced Rate/Reduced Width
Section E – Standard Rate/Full Width/No Sweeping

The results shown in Figure 3-3, were taken after approximately 4 months of trafficking. The control Section A, indicated an average score of 4 (very little wear) for both the NB and SB edge lines, whereas the centre line has a visual condition score of 3 (marginal – some visible wear).

The NB edge line of Section C had a lower score of 3 (marginal – some visible wear) compared to the control section. All of the other sections have similar scores compared to the control section A.

The SB edge line of Section B has a visual condition score of 5 (no wear) compared to the control section. The other sections all have similar scores compared to the control Section A.

The centreline for Section D has a visual score of 5 (no wear) and outperforms the scores from the other sections. Section E's centre line score of 3 (marginal – some visible wear) was the lowest of the alternatives, however was similar to that that of the control section.

Overall the control Section A and Section E have similar visual condition scores for the centre line of 3 (marginal – some visible wear) with Section D having the highest centre line score. All of the sections have similar visual condition scores of 4 (very little wear) with the exception of the NB edge line for Section C which has a visual assessment score of 3 (marginal – some visible wear). At the time of the assessment the differences in the visual assessment scores are viewed to be marginal, with no clear definitive alternative method standing out above the rest.

The overall results would therefore indicate that no section has clearly outperformed any of the others. The main and slightly surprising result for this particular trial is that Section A (centre line) has not performed as well with as would have been expected and the reasons for this are not clear.

The message from the Operating companies prior to the trial was, 'if it failed, it failed quickly'. This has not been noticed on the A77 trial site.

3.2.2 Grip Tester Results

The minimum Grip Number for each HD28 Site Category and as per TS 2010 Surface Course Specification & Guidance Issue 01 (December 2010), section 2.10.1, is shown in Table 3-1. Note: The minimum grip numbers were revised and superseded by TS Interim Amendment No. 35/15 Issue 03 (October 2015), section 2.10.1[5]. The revised (and lowered) minimum Grip Number is shown in brackets in Table 3-1.

The grip tester results for the A77 Trial Site are illustrated in Figure 3-4

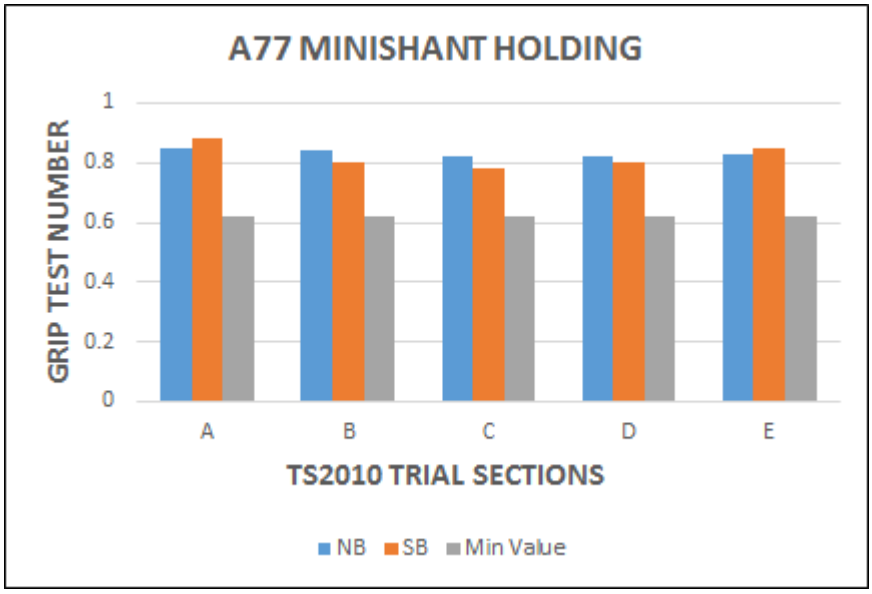


Figure 3-4 Grip Tester Results - A77

From the results shown in Figure 3-4, all of the sections indicate grip numbers in exceeding the minimum required. The results indicate a maximum value of 0.88 (Section A) and a minimum value of 0.78 (trial Section C).

The Grip Tester results for Section A (control section), show values of 0.85 (NB) and 0.88 (SB). Sections B, C and D each indicate slightly lower results varying between 0.78 and 0.84. Section E has Grip Tester values slightly higher than the other sections, although still lower than the control section. The higher test results for Section E, although not significant, confirms the trend noted for the A75.

[5] TS Interim Amendment No. 35/15

4 Conclusions

From the trials and subsequent visual assessments undertaken on the A75 (Dalscone to Rail Bridge) and A77 (Minishant Holding) Structural Maintenance schemes, the following conclusions can be drawn:

- At the time of the assessment, none of the alternative sections (B to D) have performed conclusively better or worse than the control sections. Based on the assessment, at this point in time, it can therefore be concluded that a reduction in the grit rate, and or width of grit application, has not had a definitively improved visual condition result compared to the current methodology required by Transport Scotland.
- Where no sweeping (Section E) was undertaken the overall visual assessment score was no worse compared for the control section. This is surprising, due to the fact that if the grit had a definitively adverse effect on the line markings, it would be expected that this section would have a significantly worse visual condition score compared to the other results.
- Overall, the visual inspection results, at this stage, would appear to be inconclusive with no particular section showing a better performance compared to the other sections. This could, however, be down to the time factor involved as the assessments were undertaken after 5 months (A75) and 4 months (A77). It may be advantageous to conduct another inspection after 12 months of trafficking has taken place.
- The Grip Tester results exceeded the minimum requirements and were all very similar for the sections on the A77 site and showed no significant difference. The A75 site, where all the results were slightly lower than the A77, again were very similar with the exception of Section E (no sweeping) which was slightly higher.
- The message from the Operating companies prior to the trial was, ‘if it failed, it failed quickly’. This has not been noticed on any of the two trial sites evaluated on the A75 & A77.
- The surfacing contractor for both the A75 and A77 sites were different. Breedon Aggregates was the surfacing contractor on the A75 site and Aggregate Industries was the surfacing contractor on the A77 site. The line marking contractor was also different on both the A75 and A77 sites, with Markon being the marking contractor on the A77 site and Tim Doody the road marking contractor on the A75 site. Despite the different contractors, there were no failures to the extent of complete failure (VCS score of less than 3). This would therefore indicate that the method of installation proving to work.

Following the assessment undertaken it is clear that, at this point in time, there is no clear advantage in altering the methodology currently required within Transport Scotland’s IAN 35/15 for TS2010 surface courses and consequently no draft code of practice is proposed at this time.

To conclude, following the assessment undertaken to date, a reduction in the grit rate or width of application (thereby missing the line markings) has not shown any clear advantages or disadvantages. In addition, by not sweeping off excessive grit from the road surface, this has not had a definitive adverse effect on the visual condition of the road markings compared to other trial sections. At this point in time there is therefore, no evidence to support the reasoning that the grit applied to the TS2010 has an adverse effect on the road marking performance.

5 Recommendations

Following the trial section evaluations undertaken on the A75 and A77 the following recommendations are made:

- It may be advantageous to conduct another inspection on the A75 and A77 after 12 months of trafficking has taken place, in order to confirm if there are any significant differences in the trial sections.
- As part of this 12 month of trafficking, it would be recommended that the M80 be evaluated. The M80 contains a section of HRA surfacing over a bridge deck constructed at the same time as the TS2010 sections. It would therefore be interesting to compare the visual condition of any line markings over this section as well. Should the M80 be evaluated, this would be required to be undertaken under traffic management closures.
- No draft code of practice is required at this time as no changes to the gritting methodology are proposed.

Appendices

Appendix A. Location Plans

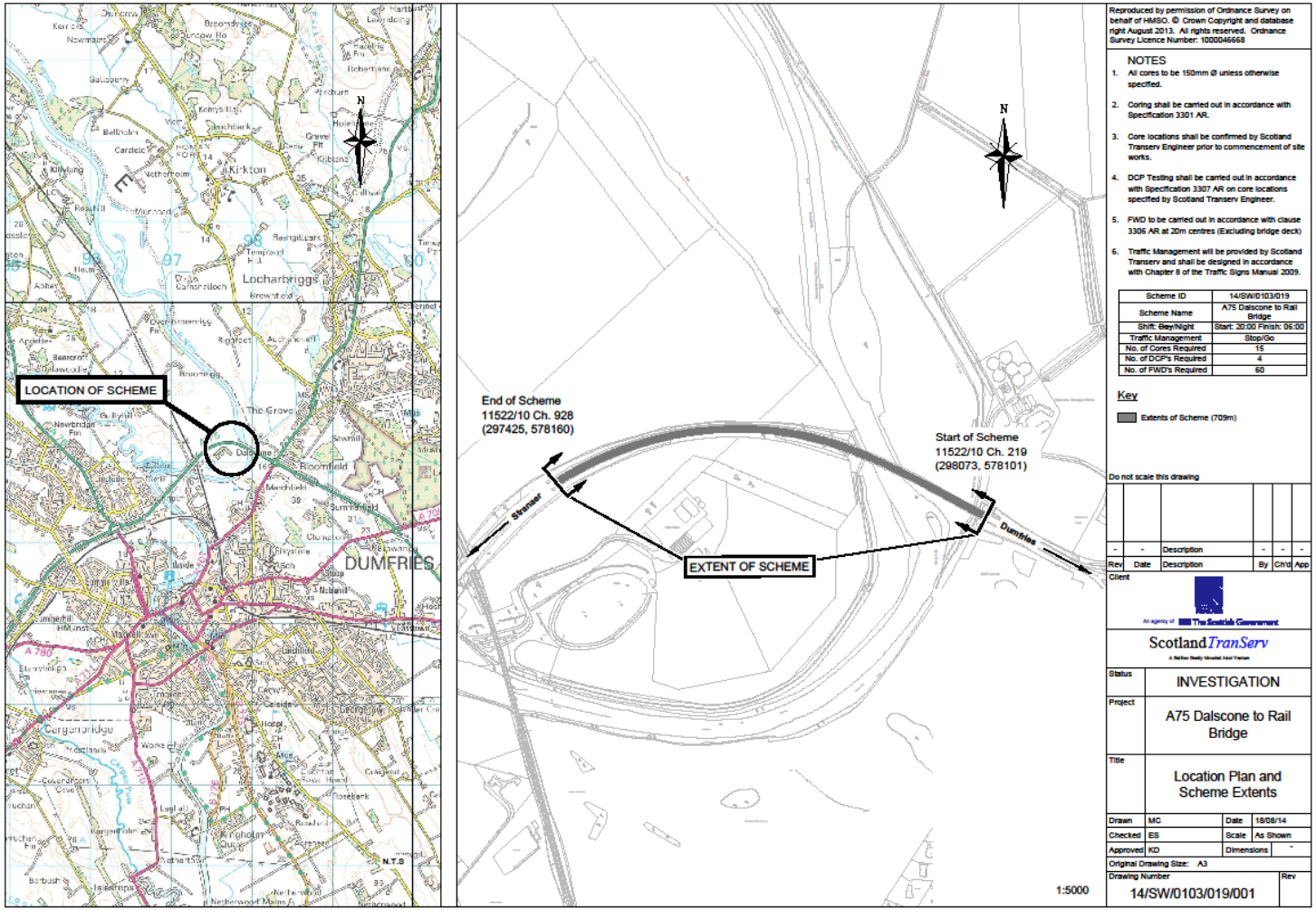


Figure A-1 Detailed Location Plan of A75 Trial Site

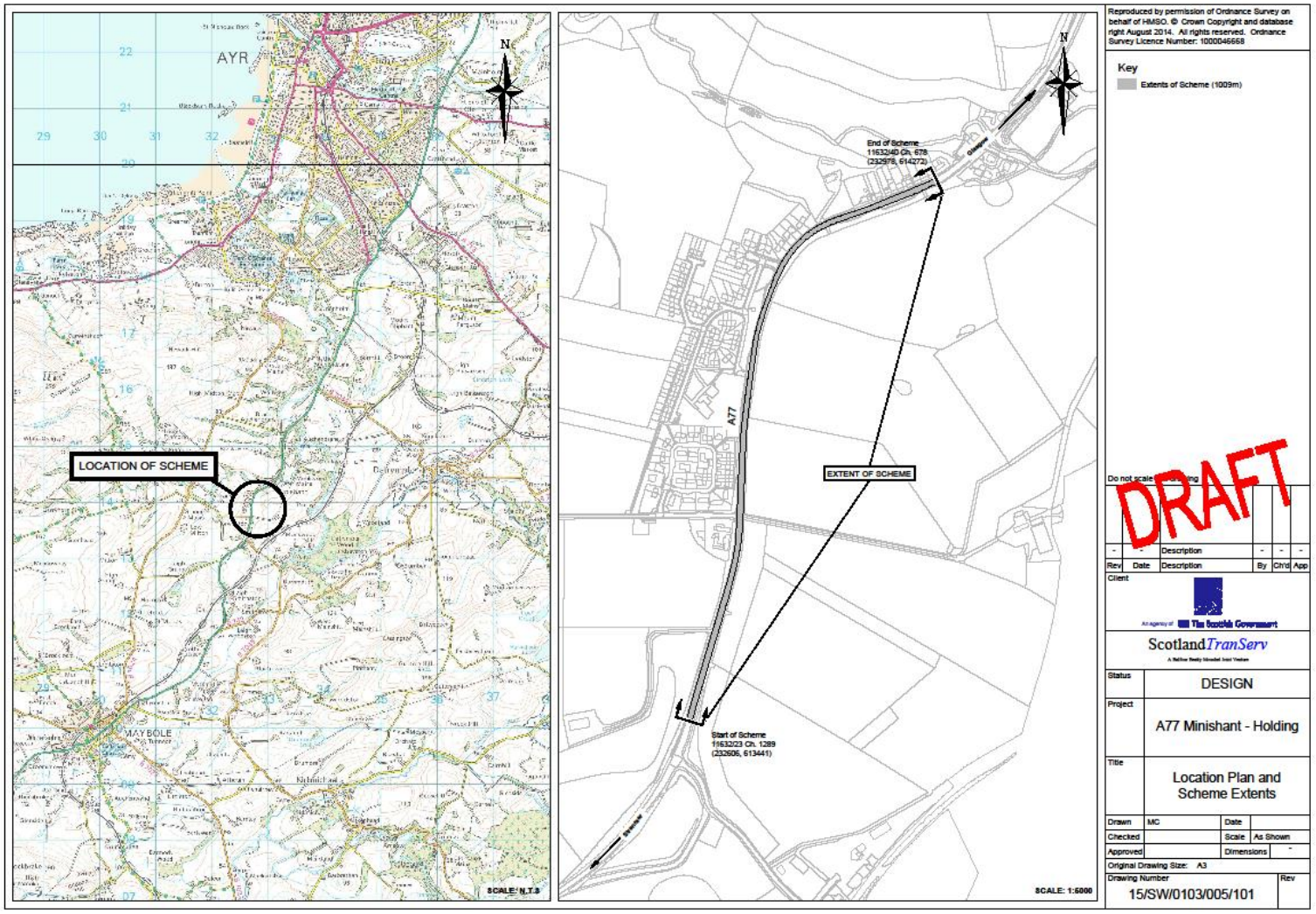


Figure A-2 Detailed Location Plan of A77 Trial Site

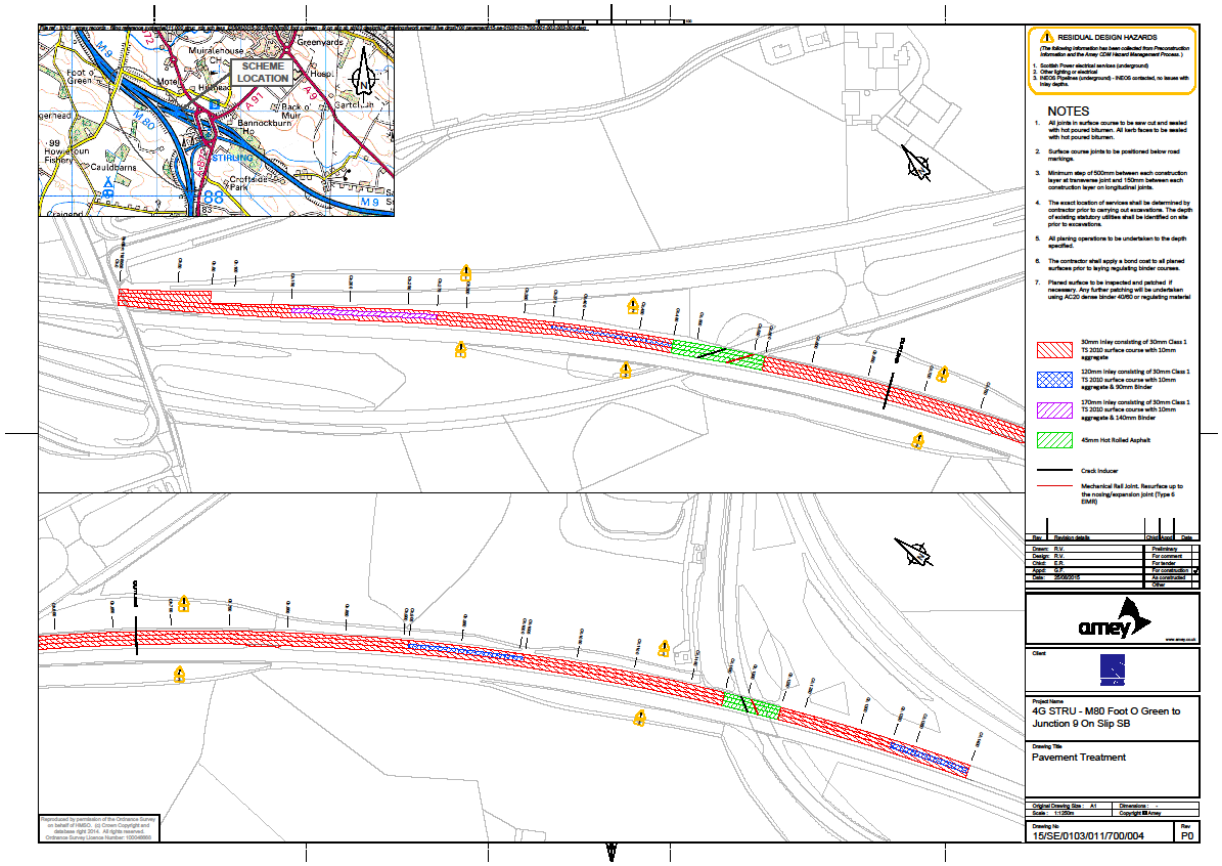


Figure A-3 Detailed Location Plan of M80 Trial Site (Part 1)

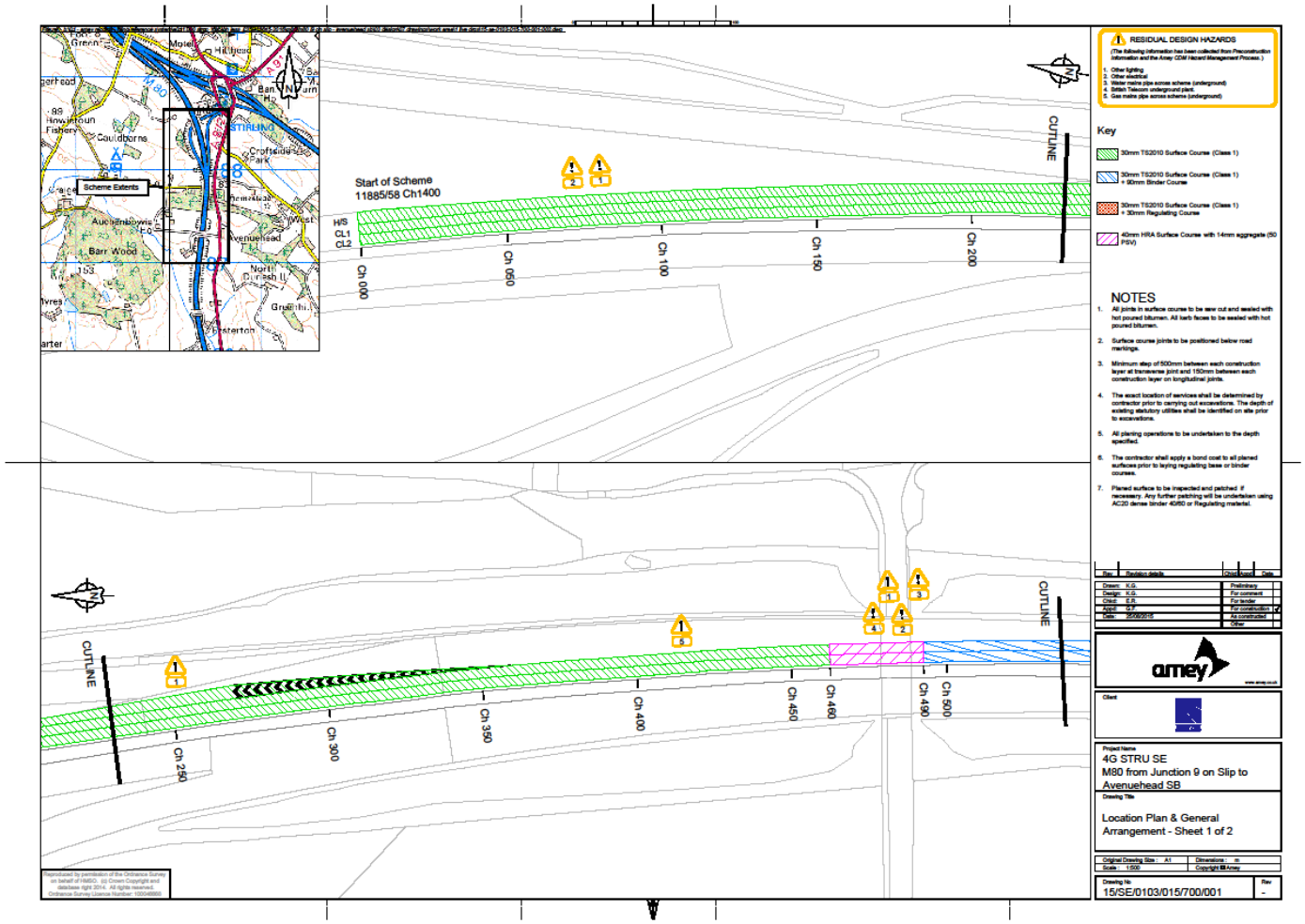


Figure A-4 Detailed Location Plan of M80 Trial Site (Part 2)

Appendix B. Grip Test Results

Scheme Name	A75 Dalscone to Rail Bridge
Scheme ID	14/SW/0103/019
Scheme Extents	11522/10 Ch. 235 - 928m
Surfacing specification	TS2010
Date of Surfacing	11/08/2015

Test	Test Date	Section Average
4 weeks CL1	01/10/2015	0.68
4 Weeks CR1	01/10/2015	0.71
6 Months CL1		
6 Months CR1		

CL1

A75 - GRIP TEST - NORTHBOUND CARRIAGEWAY				
Section Chainage	**Surfacing specification - TS2010**		**Test Date - 01/10/2015**	
	IL (GN)*	**Site Category**	**4 Weeks**	**Difference +/-**
11522/10 235-334	0.62	Single Non-Event (CM)	0.7	0.08
11522/10 335-434	0.62	Single Non-Event (CM)	0.65	0.03
11522/10 435-440	0.62	Single Non-Event (CM)	0.72	0.1
11522/10 441-540	0.72	Single <500m (S2M)	0.72	0
11522/10 541-640	0.72	Single <500m (S2M)	0.69	-0.03
11522/10 641-740	0.72	Single <500m (S2M)	0.69	-0.03
11522/10 741-840	0.72	Single <500m (S2M)	0.66	-0.06
11522/10 841-928	0.72	Single <500m (S2M)	0.64	-0.08

CR1

A75 - GRIP TEST - SOUTHBOUND CARRIAGEWAY				
Section Chainage	**Surfacing specification - TS2010**		**Test Date - 01/10/2015**	
	IL (GN)*	**Site Category**	**4 Weeks**	**Difference +/-**
11522/10 928-829	0.72	Single <500m (S2M)	0.66	-0.06
11522/10 828-729	0.72	Single <500m (S2M)	0.7	-0.02
11522/10 728-629	0.72	Single <500m (S2M)	0.69	-0.03
11522/10 628-529	0.72	Single <500m (S2M)	0.7	-0.02
11522/10 528-450	0.72	Single <500m (S2M)	0.75	0.03
11522/10 449-350	0.62	Single Non-Event (CM)	0.74	0.12
11522/10 349-250	0.62	Single Non-Event (CM)	0.72	0.1
11522/10 253-239	0.62	Single Non-Event (CM)	0.71	0.09

Figure B-1 Grip Tester results - A75 Trial Site

* The IL (GN) values shown in the above report refer to TS 2010 Surface Course Specification & Guidance Issue 01 (December 2010), section 2.10.1. The minimum grip numbers were revised and superseded by TS Interim Amendment No. 35/15 Issue 03 (October 2015). The revised numbers are shown in brackets in Table 3.1 of this report.

Scheme Name	A77 Minishant Holding
Scheme ID	13/SW/0103/046
Scheme Extents	11632/23 Ch.1289m - 11632/40 Ch. 678m
Surfacing specification	TS2010
Date of Surfacing	11/10/2015

Test	Test Date	Section Average
4 weeks CL1	11/11/2015	0.81
4 Weeks CR1	11/11/2015	0.82
6 Months CL1		
6 Months CR1		

A77 - GRIP TEST - NORTHBOUND CARRIAGEWAY

Section Chainage	Surfacing specification - TS2010		Test Date - 11/10/2015	
	IL (GN)*	Site Category	4 Weeks	Difference +/-
11632/23 1289-1388	0.62	Single Non-Event (CM)	0.84	0.22
11632/23 1389-1488	0.62	Single Non-Event (CM)	0.85	0.23
11632/23 1489-1560	0.62	Single Non-Event (CM)	0.83	0.21
11632/23 1561-1620	0.72	Approach to Junction or Roundabout (QL)	0.84	0.12
11632/40 1-10	0.72	Approach to Junction or Roundabout (QL)	0.87	0.15
11632/40 11-110	0.62	Single Non-Event (CM)	0.82	0.2
11632/40 111-210	0.62	Single Non-Event (CM)	0.62	0
11632/40 211-310	0.62	Single Non-Event (CM)	0.78	0.16
11632/40 311-340	0.62	Single Non-Event (CM)	0.72	0.1
11632/40 341-415	0.72	Approach to Junction or Roundabout (QL)	0.83	0.11
11632/40 416-515	0.62	Single Non-Event (CM)	0.88	0.26
11632/40 516-615	0.62	Single Non-Event (CM)	0.79	0.17
11632/40 616-678	0.62	Single Non-Event (CM)	0.87	0.25

A77 - GRIP TEST - SOUTHBOUND CARRIAGEWAY

Section Chainage	Surfacing specification - TS2010		Test Date - 11/10/2015	
	IL (GN)*	Site Category	4 Weeks	Difference +/-
11632/40 678-578	0.62	Single Non-Event (CM)	0.81	0.19

11632/40 577-465	0.62	Single Non-Event (CM)	0.78	0.16
11632/40 464-390	0.72	Approach to Junction or Roundabout (QL)	0.84	0.12
11632/40 389-289	0.62	Single Non-Event (CM)	0.81	0.19
11632/40 288-188	0.62	Single Non-Event (CM)	0.79	0.17
11632/40 187-60	0.62	Single Non-Event (CM)	0.80	0.18
11632/40 59-1	0.72	Approach to Junction or Roundabout (QL)	0.86	0.14
11632/23 1620-1610	0.72	Approach to Junction or Roundabout (QL)	0.83	0.11
11632/23 1609-1500	0.62	Single Non-Event (CM)	0.85	0.23
11632/23 1499-1400	0.62	Single Non-Event (CM)	0.88	0.26
11632/23 1399-1320	0.62	Single Non-Event (CM)	0.86	0.24
11632/23 1319-1289	0.72	Approach to Junction or Roundabout (QM)	0.82	0.10

Figure B-2 Grip Tester results - A77 Trial Site

* The IL (GN) values shown in the above report refer to TS 2010 Surface Course Specification & Guidance Issue 01 (December 2010), section 2.10.1. The minimum grip numbers were revised and superseded by TS Interim Amendment No. 35/15 Issue 03 (October 2015). The revised numbers are shown in brackets in Table 3.1 of this report.

Appendix C. Photos

C.1. Examples of photos taken during trial

Figure C-1 Construction of asphalt surfacing (TS2010)

Figure C-2 Close up of asphalt surfacing (TS2010)

Figure C-3 Sweeping of the longitudinal joint

Figure C-4 Compaction of surface course by Aggregate Industries

Figure C-5 Tack coat prior to surfacing

Figure C-6 Gritting prior to line marking

Figure C-7 Drying/Blowing prior to line marking application

Figure C-8 Line marking application

Appendix D. Grading of Grit Certificate

Killoch
Ochiltree
CUMNOCK
KA18 2RL

t: 01290 700 780
e: info@hts.uk.net
www.heathfield-testing.co.uk

Heathfield Testing Services

Date: 29/03/2016
Report No: BTR/13351

Client: Breedon Aggregates
Contract: Stock sample at Quarry
Material: 3mm Coated Grit
Source: Tormitchell Asphalt **Ticket:** 0
Location: Killoch Shed

Test Method: **The sample was tested in accordance with EN 12697 Binder Directly Determined**

Date Sampled: 26/02/2015 **Date Received:** 26/02/2015
Date Tested: 26/02/2015 **Temperature:** 0
Test Results: **Compliance Level:** A

Sieve Size (mm)	(%) Passing	Target	Deviation (±)	Deviation Limits (±)	Identity Specification
40					
31.5					
20					
14					
10					
6.3					
4	100	100	0		100
2.8	92	95	-3		90/100
1	12	12	0		0/25
0.5	1	5	-4		
0.25	1	3	-2		
0.125	1	2	-1		
0.063	1.1	1.0	0.1		0/2.0
Target Binder	1.2	0.7	0.5		1±0.5

Sampled by Laboratory Staff, Sampling Certificate available

UKAS TESTING 1276

Certified Electronic Copy
A M Gracie
Laboratory Manager

Appendix E. Technical Note – Phase 1: Desktop Study

Technical note

Project:	Road Markings Durability & Adherence on TS2010 Surfacing	**To:**	Graeme Low (Transport Scotland)
Subject:	Phase 1: Desktop Study	**From:**	Quintin Viljoen
Date:	10 September 2015	**cc:**	Philip Mendelson, Liam Taylor, Andy Fincham

1. Introduction

TS2010 surfacing has been introduced in Scotland as a more durable surfacing material compared to other negative textured surfacing material. This material is beginning to be used more widely on the Trunk Road Network within Scotland. Operating Companies and the road marking industry have noted that the retention of road markings on the TS2010 surfacing material to be an issue.

The Scottish Road Research Board (SRRB) have noted that they would like to undertake a research study into this subject and have proposed:

> "*The issue of retention of markings requires to be resolved. It is unclear whether this is a road markings material issue, application issue or an issue with the surface course itself, as the surface is gritted when laid i.e. whilst still hot, then, when reaching ambient temperature is swept prior to opening to traffic.*"

The first phase involved undertaking a consultation exercise to gauge the scale of the perceived problem and to gather the views of industry practitioners and benefit from their first-hand experience regarding potential issues and remedies.

Consultees have been drawn from:

- Operating Companies responsible for maintaining the Trunk Road network and specifying maintenance schemes
- Asphalt surfacing Contractors;
- Road Marking Contractors;
- Trade associations (and/or their members) such as the Road Safety Markings Association (RSMA);
- Devon County Council (more than 10 years' experience of using SMA surfacing incorporating the use of grit).

This note summarises the feedback received from the various role players to better understand the operations used in the construction of the TS2010 surface course and the subsequent application of road markings.

The next phase will involve road trials to establish best practice behaviours to ensure the road marking will adhere securely to the TS2010 road surfacing. Based on the input received from the consultees, trial proposals have been formulated and agreed with Transport Scotland. These are summarised in Section 3.

2. Discussions and Industry Feedback

2.1. Operating Companies, Asphalt and Road Marking Contractors

Consultations were undertaken in Glasgow on the 5th and 6th of August to obtain the views of the various role players. Minutes of these are provided in Appendix A.

The meetings were attended by representatives of:

- South West Operating Company (SW): Scotland Transerve;
- North West Operating Company (NW): BEAR Scotland;
- South East Operating Company (SE): Amey;
- North East Operating Company (NE): BEAR Scotland;
- Tarmac – Asphalt Contractor & supplier;
- Aggregate Industries – Asphalt Contractor & supplier;
- Breedon Aggregates – Asphalt Contractor & supplier
- Markon – Road Marking;
- Euromark GB – Road Marking.

The key elements to note from the feedback received from the abovementioned representative are:

2.1.1 The NW reported no issues with regards to the retention of thermoplastic road marking applied to TS2010. The exception being an isolated length located at the end of a maintenance scheme on the M90. It was confirmed that this was the result of unique site operational issues (end of shift, time restraints, breakdowns, proximity to junction).

2.1.2 The SE and SW reported that when TS2010 was first introduced it was reported that the road markings were not adhering to the surfacing. On closer inspection it was noted that excess grit covered the newly applied road markings, which created the impression of loss of road markings. The excess grit was subsequently removed uncovering the intact road markings.

2.1.3 Markon noted that they have experienced differences in the adhesion and bonding of thermoplastic road markings to new surface course materials used on the network compared to traditional asphalt surface courses (e.g. HRA).

2.1.4 In addition Markon also noted loss of road markings due to ravelling / fretting of surface

course materials (not TS2010 specifically) being used across the network..

2.1.5 Markon noted an issue with the compatibility of thermoplastic road markings with some new surface course materials being used on the network. This is not restricted to TS2010 and, is an area of concern to them.

2.1.6 The operating companies and asphalt suppliers were in agreement that TS2010 is believed to be a more durable material, however this still needs to be evaluated over a longer period of time. In addition, common risks to the surfacing process are still applicable as with traditional materials, for example distance from quarry, climatic conditions and depth of construction.

2.1.7 All confirmed that the TS2010 surfacing is manufactured, tested and installed within the scope of the Type Approval Installation Trial (TAIT) process which requires strict control throughout all phases from quarry to the construction.

2.1.8 Grit is applied while the surface is still hot, from the hopper of a roller, at a rate ranging from 1 to 1.25 kg/m^2 and statically rolled. The grit is lightly coated with 1% by weight of bitumen, this is undertaken to stop the material clumping and gathering dust, which can potentially reduce adhesion to the surfacing.

2.1.9 It was noted that the gritting operations varied between Operating Companies:

- One method is to grit the full width of the resurfaced area; and,
- The second method excludes grit being applied to line marking areas.
- It is understood that both of the above gritting methods have been approved during the TAIT process.

2.1.10 Once the surface course has reached ambient temperature, excess grit is removed by means of mechanical sweeping and suction prior to the end of each shift.

2.1.11 It was noted by the SW that only when time allows is the surface course swept at the end of each shift. If there is no time, the lines are installed and the road opened without sweeping operations.

2.1.12 Before road marking operations are undertaken a drier/blower incorporating hot compressed air is used in front of screed application to clean and dry the surface of debris and moisture respectively. There is however still the risk of moisture entering between the surfacing and the road marking.

2.1.13 Markon asked if it would be possible to include road marking on an existing surface or non-TS2010 surface as part the trials. It was noted that this would be considered before trials are be undertaken.

2.2. Road Safety Markings Association (RSMA)

A discussion was held with representatives of the RSMA and the following points were raised as part of the discussion:

- Feedback received from industry members noted that they have experienced adherence issues to the new types of surfacing being used on the network;
- Moisture entrapment is a key contributing factor to preventing road markings adhering to the surface;
- Texture is required to ensure mechanical keying (interlock) is achieved between the surface course and the road marking material;
- Excess grit was noted to have an influence on the early wearing off of road markings;
- The thickness that the road marking is constructed at will also have an influence on how quickly the material will wear off. Road marking contractors are under pressure to apply the road markings as quickly as possible, which could lead to some sections potentially being too thin ;
- It was asked if it would be possible to mask-off the areas that will receive road marking during the gritting operations. It was agreed that this would be considered before trials were undertaken.

2.3. Devon County Council

Devon County Council's (DCC) materials laboratory was also consulted as part of the consultation process to establish their experience. DCC have been incorporating Stone Mastic Asphalts (SMA), which is very similar to TS2010 surfacing, for more than 10 years. The SMA's that they use on their network incorporate the use of grit in order to increase the early skid resistance of the surface course.

They advised that they had not experienced problems with the adherence of thermoplastic road markings to their SMA surface courses, which are gritted. They apply the grit to the full lane width at a rate of between 0.7 and 1.0 kg/m^2. Their SMA's, similar to TS2010, incorporates the use of polymer modified bitumen (PMB) where required.

In addition they advised of, the importance of ensuring the surface is dry, clean and swept of excess grit before applying road markings.

2.4. European experience

A literature search was undertaken to establish what European experience there was with regards to any issues relating to the adherence of thermoplastic road markings on SMA type of surfacing, which incorporate the use of grit. No published studies on this matter could be obtained pertaining specifically to this matter.

Previous studies undertaken by Atkins to review Thin Surface Course Systems used in European countries considered the practices and specifications used in Germany, France, Holland, Norway and Sweden. It was noted only Germany indicated that they gritted their surface courses to provide early skid resistance.

Germany has used SMA's on their network for more than 30 years and it should be noted that the TS2010 surfacing introduced in Scotland, is based on their experience.

The current German specifications are provided in TL Asphalt-StB 07 ("*Technical Delivery Conditions for Asphalt Pavements*", 2007 edition) and ZTV Asphalt-StB 07 ("*Supplementary Specifications for Asphalt Pavements", 2007 edition*).

Stone Mastic Asphalt (SMA) designs in Germany are provided for 5, 8 and 11mm sized aggregate mixtures. Separate designations are provided for Special loads ('S'), Normal Loads ('N') and Light Loads ('L').

Lightly coated grit is applied to the Germany SMA's while the surface is still hot and statically rolled at the following application rates:

- crushed aggregate of delivered grade 1/3: 0.5 to 1.0 kg/m^2,
- crushed aggregate of delivered grade 2/5: 1.0 to 2.0 kg/m^2.

No published information pertaining to the influence of grit on thermoplastic road markings used in Germany could be found. It would have been assumed that if there had been issues with the adherence of road markings to German SMA's, published information would be available.

3. Trial Proposals

Trial options have been proposed and agreed with Transport Scotland as provided in Table 1. These options are based on feedback received from the industry.

Five trial sections (each section a 100m in length) are to be undertaken on three road maintenance projects, which will function as the trial sites, where TS2010 will be used as surface course. Trials are scheduled to be undertaken in September 2015, but could possibly change due to practicality issues relating to the maintenance scheme. Their performance will be evaluated in January 2016. The evaluation will be undertaken by conducting a visual inspection in accordance with the methodology provided in TD 26/07, Annex C (Inspection and Maintenance of Road Markings and Road Studs on Motorways and All-Purpose Trunk Roads).

Technical note

Table 1: Trial Proposals

PROPOSED TRIALS TS2010 Road Marking

Trial Options	Control Section SECTION A	SECTION B	SECTION C	SECTION D	SECTION E (exluded from M80 site)	Notes
GRIT Standard Rate: 1-1.25 kg/m2	X	X			X	Apply the grit at the standard rate 1- 1.25 kg/m2
GRIT Reduced Rate: 0.75 - 1 kg/m2			X	X		Apply the grit at the reduced rate 0.75 - 1 kg/m2
GRIT Full Width	X		X		X	Apply grit over the full lane width (including road marking areas), with no overlaps or over application.
GRIT Reduced Width (avoid road marking areas)		X		X		Apply grit to lane widths, however **Avoid applying to areas receiving road markings (lane and edge lines only)**. Avoid overlaps and over application.
No SWEEPING before Rd Marking					X	No sweeping to be undertaken to remove excess grit, before road marking is conducted. Grit applied over full lane widths. Dryer / blower is to be used only.

Notes

1 Dryer/Blower to be used as standard for all areas during the road marking installation;
2 Length of each individual trial section : 100 m (eg. Section A = 100m);
3 Grit rates shall be calibrated on site prior to application on trial sections;
4 Sections cover all lanes being treated of the M80 SB and all lanes in both directions of the Single Carriageways (A75 & A77);
5 Sections to be carefully marked and referenced on site to enable evaluation;
6 All construction activities to be recorded for example laying temperatures, grit rates, ambient conditions, surface conditions before applying road markings.
7 Grip testing to be conducted as per normal practices (typically 4 weeks after construction). Records to be made available to Transport Scotland.
8 All construction records (surfacing and road marking operations) to be made available following site operations;
9 Road marking to be applied to a dry surface course with no excessive moisture present that can't be removed by the Dryer / Blower;
11 Grit is applied (at the rate specified, following calibration) from the roller hopper, behind the paver while the TS2010 surface is still hot.
10 Visual evaluation of the condition of all Edge, Lane and Centre Lines of trial sections to be in accordance with TD 26/07;
11 Areas where grit is not be applied shall cover longitudinal road road markings only. Therefore lane line markings only.
12 M80 site excludes the "No Sweeping" trial section (Section E), as a result of a risk assessment.

	Projects where trials are to be undertaken		Target Dates	OC Area	OC Contact	Road Marking Contractor
1	M80 Foot o Green (SB)	2 lane Dual CW Motorway with hardshoulder. (Scheme length 1480 m)	04/09/2015	SE	Neil Macdonald	Euromark
2	A75 Dalscone to Rail Bridge:	Single CW - (709m length). Possible weekend closure	18/09/2015	SW	Kevin Dunn	Tim Doody Ltd
3	A77 Minishant Holding:	Single CW, (1009 m length), Semi Urban location convoy working	25/09/2015	SW	Kevin Dunn	Markon

The first section, **Section A** will be the control section and will be constructed using TS2010 surfacing and then applying grit at the standard application rate of 1 to 1.25 kg/m^2 over the full width of the lane including the areas that will receive road markings. The grit will be applied while the surface is still hot and statically rolled. Once the surface has reached ambient temperatures the excess grit will be swept and cleaned off prior to the line markings being applied.

Section B will involve the application of grit at the standard rate, but will exclude areas that will receive road markings. This is to review the influence of the methodology used by some of the contractors where they avoid the application of grit on areas that will receive line markings.

Section C involves the application of grit over the full width but at a reduced grit rate of 0.75 to 1.0 kg/m^2. This is to consider the experiences noted by the contractors that a lot of excess grit is removed before applying the road markings. This closely resembles the application rates used on the SMA's in Devon.

Section D involves applying the grit at a reduced rate 0.75 to 1.0 kg/m^2 and exclude its application from the areas that will receive line markings.

Section E involves applying the grit at the standard rate (1 – 1.25 kg/m^2), however no sweeping of the excess grit will take place before applying the road markings. This is to replicate instances where the cleaning off of excess grit before applying the road markings is not possible due to site constrains. The option would however not be applied to the motorway trial project due to the risk this poses to vehicles travelling at high speed.

For all of these sections road markings are to be applied to a dry surface course with no excessive moisture present that can't be removed by the road marking dryer or blower. This will limit the influence of other adhesion factors and therefore focus on the influence of grit on the adherence of the road markings.

Two options proposed by the road marking industry were considered, namely:

a. Masking off the areas that will receive road markings;

The masking-off of road marking areas is not practical to undertake over a 100 m trial section on edge and lane lines. In addition there are health and safety risks associated in keeping these areas masked off until road marking can be undertaken. The road markings may be undertaken at a later stage hence keeping the areas masked off while the road is open to traffic poses a risk to the travelling public.

b. Applying road markings to existing surfacing or another non-TS2010 surfacing.

This option was considered, however when applying road markings to an existing surface course this would involve removing existing road markings or potentially applying new material over existing road markings. This would therefore not be comparable with the control section which consist of a newly constructed TS2010 surface course, upon which new roads markings will be applied. The inclusion of a new non-TS2010 surface course was discussed with the various

Operating Companies and feedback suggested that this operation would not be possible due to site logistical constraints. Separate maintenance projects could be monitored where a different surface course is used.

The proposed trial sections are located in the South East and South West OC areas of Scotland and are located at:

1. M80 Foot o Green (SB). Two lane dual carriageway motorway with hard shoulder. (Scheme length 1480 m);
2. A75 Dalscone to Rail Bridge. Single carriageway. (Scheme length of 709 m);
3. A77 Minishant Holding. Single carriageway. (Scheme length of 1009 m).

The road marking trials are targeted to take place during September (could change slightly due to practicality issues) and will be evaluated in January 2016, therefore allowing traffic to travel over the new road markings for approximately three months.

4. Conclusion

A broad spectrum of role players (Operating Companies, asphalt contractors, road marking contractors, RSMA and Devon County Council) were consulted in order to get a balanced view from the industry.

The trial proposals formulated are based upon the consultations and are designed to reflect current installation operations as well as variations to try and identify their influence on the road markings. Feedback received from the Operating Companies indicated that where the road marking failed to adhere to the road surface this was observed within a short period of time (days or weeks). It would therefore be expected that should adhesion be an issue on TS2010 surfacing this should be clear when the trials are evaluated in January 2016. This should provide a suitable platform for any future studies that might be undertaken.

Appendix A
Meeting Minutes

Meeting Notes

Project:	Road Markings Durability & Adherence on TS2010 Surfacing		
Subject:	Road Marking adherence to TS2010		
Date and time:	5 & 6 Aug 2015	**Meeting no:**	1
Meeting place:	Atkins - Glasgow	**Minutes by:**	Atkins
Attendees:	Quintin Viljoen (QV) Andy Fincham (AF) Scott Yuill (SY) Will Beaumont-Smith (WBS) Jamie Finlayson (JF) Kevin Dunn (KD) Neil Macdonald (NM) David Crudge (DC) Graham Smith (GS) Garry Fitzpatrick (GF) Steven Taylor (ST)	**Representing:**	Atkins Atkins Markon Euromark Bear Scotland (NW) Scotland Transerv (SW) Amey (SE) Tarmac Breedon Aggregates Aggregate Industries Bear Scotland (NE)

ITEM	DESCRIPTION
1.0	**SCOPE OF DISCUSSIONS**
	The discussions focussed and the retention of thermoplastic road markings applied to TS2010 surface course.
2.0	**AREAS DISCUSSED**
2.1	GENERAL VIEWS • NW – No reported issues with the retention of thermoplastic road marking applied to TS2010. The exception being an isolated length located at the end of a maintenance scheme on the M90 and the NE Operating Company confirmed that this was not a result of adhesion but unique site operational issues (end of shift, time restraints, breakdowns, proximity to junction). • SW – No reported issues with the retention of thermoplastic road marking applied to TS2010. • SE & SW – When TS2010 was first introduced it was reported that excess grit covered the newly applied road markings, this created the impression of road markings loss. On closer inspection this was not the case and excess grit was removed uncovering the intact road markings. • Markon – experienced differences in the adhesion and bonding of thermoplastic road markings to new surface course materials used on the network compared to traditional asphalt surface courses (i.e. HRA). • Markon noted loss of road markings due to ravelling / fretting of new surface course materials (not TS2010) being used across the network.
2.2	MATERIALS – TS2010 • Operating Companies and Asphalt Suppliers were in agreement that TS2010 is believed to be a more durable material. However, the product still needs evaluation over a longer period of time to confirm durability. • Asphalt Suppliers noted that common risks to the surfacing process are still applicable as with traditional materials such as distance from quarry, time of year, climatic conditions and depth of new construction.
2.3	MATERIALS – THERMOPLASTIC ROAD MARKINGS • The general feedback was road markings are installed on the network using a machine applied thermoplastic screed process. Handwork is restricted to those areas where machine application is not possible.

- Markon noted an issue with the compatibility of thermoplastic road markings with some new surface course materials being used on the network, is an area of concern. This is not restricted to TS2010.

2.3 INSTALLATION OF ASPHALT

- TS2010 is constructed within the scope of the Type Approval Installation Trial (TAIT) process which requires strict control throughout during mixing, deliver and construction.
- TS2010 is paver laid and incorporates the use of grit in order to improve early life skidding resistance.
- Grit is applied while the surface is still hot, from the hopper of a roller, at a rate ranging from 1 to 1.25 kg/m^2 and statically rolled.
- The grit is lightly coated with 1% by weight of bitumen, this is undertaken to stop the material clumping and gathering dust, which can potentially reduce adhesion to the surfacing.
- It was noted that the gritting operations varied between Operating Companies:
  - One method is to grit the full width of the resurfaced area; and,
  - The second method excludes grit being applied to line marking areas.
- It is understood that both of the above gritting methods have been approved during the TAIT process.
- When the surface course has reached ambient temperature excess grit is removed by mechanical sweeping and suction prior to the end of each shift.

2.4 INSTALLATION OF ROAD MARKINGS

- Thermoplastic road markings are applied by machine using the screed process.
- A drier/blower using hot compressed air is located immediately in front of screed application as part of the same operation in order to clean and dry the surface of moisture and debris.
- It was noted that there are some locations (e.g. single carriageways and dual carriageways) where the road marking is undertaken at a later point. Following a risk assessment the road can be opened to traffic without road markings.
- Prior to the application of the delayed road markings the surface is assessed to establish if there is a need for additional sweeping.

2.5 TRIAL SITES

- Potential trial sites are being identified and discussed with the Operating Companies and will be confirmed with the individual Operating Companies.
- The potential sites being considered are:
  - NE – A92 Cowdenbeath to Crossgates SB – dual carriageway;
  - NW – A9 Badacreamh Southbound Ph1 – dual carriageway;
  - SW – A75 Lincluden Bridge to A76 Rbt – single carriageway;
  - SE – M8 – specific scheme detail to be confirmed.

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