Thin Surfacing Performance Review (2013)

Final Report

Highways Agency

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Executive summary

This report summarises Atkins' efforts to:

1. Carry out visual condition assessments of forty motorway and trunk road sites with thin surfacings; and,
2. Use the results from the above sample to make an estimation of the overall condition of all thin surfacings on the Highways Agency network.

The Task represented a repeat of a similar study which Atkins previously undertook in 2012. An innovative approach was developed to undertake the visual condition assessments. The use of video survey technology enabled data to be collected in a safe, reliable and efficient manner. The video footage from the forty sites was then reviewed by an Inspection Panel in a workshop forum. Statistical analyses were then undertaken to produce network-wide estimations of visual condition.

The Inspection Panel workshops followed an established methodology that defines visual condition on the following scale:

● Excellent ● Good ● Moderate ● Acceptable ● Suspect ● Poor ● Bad

In comparison to last year's performance review, it was found that the average condition score for the sample sites had increased from 5.18 to 5.36. Both scores relate to a condition rating of between 'Good/Moderate' and 'Moderate'. Using the Central Limit Theorem, it was estimated that the current average condition rating for all thin surfacings (in lane 1) across the network lies between:

1. 'Good' and 'Moderate' with 99.2% confidence.
2. 'Good/Moderate' and 'Moderate/Acceptable' with 82.6% confidence.
3. 'Good' and 'Moderate/Acceptable' with 99.99% confidence.

96.5% of all thin surfacing in lane 1 across the network was rated as 'Satisfactory' (i.e. condition categories 'Excellent' to 'Acceptable/Suspect') with the remaining 3.5% being rated as 'Unsatisfactory' (i.e. condition categories 'Suspect' to 'Bad'). This compares with a 'Satisfactory' figure of 87% in 2012.

1. Introduction

This report summarises research undertaken by Atkins on behalf of the Highways Agency ('the Agency') under Lot 2 of the Department for Transport framework contract for the provision of Transport-Related Technical and Engineering Advice and Research (Package order reference 209[4/45/12]). The Pavements Team of the Highways Agency's Network Services (NetServ) Directorate appointed Atkins to produce an updated estimate of the condition profile of thin surfacings across the motorway and trunk road network.

1.1. Background

Thin surface course systems (TSCS), or thin surfacings as they are more commonly described, are proprietary systems in which a hot bituminous bound mixture is machine-laid with a controlled screed paver onto a bond coat to form, after compaction and cooling, a textured surface course less than 50mm in thickness. Further background is provided in IAN 157 [Ref 1] – which revised Chapter 6 of HD 37/99 [Ref 2] in December 2011.

Thin surfacings were originally developed in mainland Europe and the technology was adapted and first transferred to the UK strategic road network in the early 1990s. The subsequent success and popularity of these materials is reflected by the fact that they are the only permitted option for surface course which can be used without restriction in England (see HD 36/06 [Ref. 3]).

The in-service performance of thin surfacings has been subject to review during recent years and a thorough understanding of their behaviours, benefits and limitations is now emerging. An estimation of the condition profile for thin surfacings across the network was required (under this Task) for asset management purposes. This would enable future workload and funding requirements to be predicted.

1.1.1. Previous relevant studies

The following previous relevant studies are brought into reference within this report.

"*Durability of thin surfacing systems. Part 4: Final report after 9 years monitoring*" [Ref. 4]

This seminal study into the long term durability of thin surfacing materials was produced by the Transport Research Laboratory (TRL) in 2010. The output is termed 'TRL 674 [Ref. 4]' throughout the remainder of this report. Its aims were to identify:

- "*the expected length of the service lives of thin surfacing systems*"
- "*the mode(s) by which they fail*"
- "*if there are any simple means to predict their failure*".

The study focussed on detailed information for a total of 137 sites which were inspected and monitored over a period of several years. During that process sites were surveyed and assessed (on foot) using a bespoke condition classification system developed by TRL.

"*Thin surfacing performance review (2012) – State of the network*" [Ref. 5]

In 2012 Atkins were commissioned by the Agency to generate, for the first time, an estimate of the condition profile of thin surfacings across the motorway and trunk road network. The fundamental principles (from TRL 674 [Ref. 4]) for surveying and classifying sites were retained but the innovative use of video survey technology offered significant safety and efficiency benefits.

A sample selection process was developed to enable the results, from a limited number of sites, to be extrapolated to produce network-wide condition statistics. Correlations were also sought between the condition assessments and the underlying construction records for each site.

The 2013 Performance Review, described in this report, represents a direct repeat of the 2012 exercise – with some enhancements (as described in Section 3)

"*Optimum interventions for thin surfacing maintenance*" [Ref. 6]

This research task included a review of the construction records for all thin surfacing materials on the Highways Agency network. This information was extracted from the Highways Agency Pavement Management System (HAPMS) in August 2012 and subjected to detailed analysis to generate network wide statistics regarding the attributes and coverage of thin surfacings across the network.

These statistics were used in the 2012 Performance Review [Ref. 5] to select sample sites and to generate a network wide estimation of condition. Similar statistical analyses were undertaken for the 2013 Performance Review and cross-references are made, where appropriate, in the remainder of this report.

1.2. Task

The objective of this Task was:

"To carry out a visual condition assessment of thin surfacings, using an established methodology, at selection of sites on the Highways Agency network, and to subsequently make a prediction of the overall condition of all thin surfacings on the network".

The objective was to be achieved by undertaking the Sub-Tasks listed in Table 1-1.

Table 1-1 Task specification

Sub-Task	Specification	Where addressed in this Final Report
1	*"Identify a stratified, random sample of sites that have thin surfacing, representing the range of factors that may affect performance. This should include, but is not limited to, geographical location, traffic conditions, climatic conditions, stress levels, aggregate size and material supplier."*	**Section 2**
2	*"Carry out a visual inspection of these sites and assess them using the methodology described in Appendix A of TRL Report 674."* [Ref. 4]	**Section 3**
3	*"Collate and analyse the data in an electronic format and provide an estimate of the proportion of the Highways Agency network in each of the condition bands (Excellent, Good, Moderate, Acceptable, Suspect, Poor, Bad). An assessment of the statistical robustness of the prediction shall be undertaken".*	**Section 4**

The Task was awarded to Atkins on 13th September 2013 with a completion deadline of 31st January 2014.

1.3. Overall approach

Atkins' overall approach towards this Task is summarised as follows:

1. Construction records contained within HAPMS were reviewed to identify both the quantity and range of characteristics of thin surfacing materials across the Agency's network.
2. Forty representative site locations were selected.
3. Video data for each site was collected using specialist survey vehicles equipped with multiple cameras.
4. The video survey footage was reviewed in an office environment via Inspection Panel workshops and visual condition assessments were provided (utilising the TRL 674 [Ref. 4] methodology).
5. The results from the Inspection Panel workshops were analysed to produce an estimate of the condition profile for all thin surfacings across the network.

Further details are provided in the following Sections.

2. Sub-Task 1: Site Selection

2.1. Specification

The specification for this Sub-Task was:

"Identify a stratified, random sample of sites that have thin surfacing, representing the range of factors that may affect performance. This should include, but is not limited to, geographical location, traffic conditions, climatic conditions, stress levels, aggregate size and material supplier."

2.2. Approach

The 2012 Performance Review [Ref. 5] was based upon an assessment of thirty sites. Forty sites were assessed this year. The following factors informed the selection of this sample size:

- For the "*Optimum interventions*...." Task [Ref. 6], the Agency deemed that thirty sites was a suitable sample size to inform network level judgements.
- As mentioned in Section 1.2, the Task was awarded in mid-September. The timescales for the 2012 Performance Review [Ref. 5] resulted in a requirement to undertake video data collection during the winter months. Weather, daylight and road surface conditions hampered the data collection efforts and subsequent footage review. In an attempt to avoid these issues this year it was considered imperative to mobilise rapidly upon award of Task and to complete the data collection before the onset of winter. Forty sites was a practical limit that could be achieved within the restricted timescales.
- Workshops were held over two consecutive days in November 2013 (see Section 3.4). Based upon the previous year's experience, forty was considered to be the maximum number of sites that a panel could attentively review during such an event.

It should be noted that a sample size based upon a statistical design would have required significantly more sites to be considered if the full range of thin surfacing attributes, and their values, was to be included.

The methodology used for this Task included two different approaches for the downstream analysis of the Inspection Panel results and the subsequent estimation of the network condition profile:

- **Approach 1** – was to compare the Inspection Panel condition assessments with the underlying HAPMS attributes for each site and seek to identify reliable correlations. These correlations, determined at the sample site level, would then be applied to the full network.
- **Approach 2** – was to select sample sites that provided a "mini snapshot" of the network. The condition profile of the forty sites could then be extrapolated to the network level on a length basis.

Approach 2 was intended as a back-up in the event that reliable correlations could not be established in Approach 1.

Both approaches replicated the methodologies that were previously used and approved in 2012 [Ref. 5].

2.3. HAPMS review

The thin surfacing construction records contained within HAPMS were to form the basis of this Task. With reference to the Specification requirements (see Section 2.1):

- HAPMS construction records do not provide details regarding climatic conditions or stress levels.
- recent amendments to HAPMS have introduced a facility to record details of (*inter alia*) aggregate size and material supplier. However, it would appear that:
    - the uptake of this new facility by Service Providers is not yet universal.
    - the "enhanced" construction records are generally only provided for recent resurfacing schemes (i.e. there is no requirement to revisit historic schemes and record the additional construction information).
    - the "enhanced" construction records are only captured in HAPMS in free-form text fields. The way that these fields are populated by the Service Providers is inconsistent and, because they are free-form text, almost impossible to analyse on a network basis.
- as part of Atkins "*Optimum interventions...*" Task [Ref. 6] it was agreed with the Agency that the thin surfacing "Type" record within HAPMS had limited merit. This was due to the indistinct input options provided for Service Providers which lead to differences in interpretation and inconsistent population of HAPMS.

Therefore not all of the factors required by the Specification could be considered in this Task. This was agreed in writing with the Project Sponsor and mirrors the approach that was approved in the 2012 Performance Review [Ref. 5]. The HAPMS attributes that *were* considered were as follows:

- Highways Agency Area
- Age
- Cross-sectional position
- Thickness
- Season laid *(winter being defined as November to February incl.)*
- Length

Construction records for all thin surfacings in lane 1(cross sectional position CL1) across the network were downloaded from HAPMS on 23rd August 2013. The following analyses are presented in Appendix A:

- Table A-1 shows that 52% of the length of lane 1 across the Agency's network consists of thin surfacing. The total length of thin surfacing in lane 1is 6,662km. This compares with 6,179km in 2012 [Ref. 6]. This increase should be considered in the context of reported resurfacing activity amounting to 752 lane miles (1,210km lane km) during 2012-13 [Ref. 7].
- Table A-2 shows an analysis by 'carriageway function'.
- Table A-3 is a further refinement and sub-divides the thin surfacing records according to 'carriageway type' (i.e. motorway or non-motorway).
- Table A-4 shows an analysis by age.
- Table A-5 shows an analysis of season laid – where 'winter' was previously defined by the Agency [Ref. 6] as November to February inclusive.
- Table A-6 shows an analysis of both age and season laid.
- Table A-7 shows an analysis of thickness laid.

Appendix B shows how the HAPMS analyses (from Appendix A) informed the site selection process:

- Figure B-1shows how proportions that were established from the network level analyses were then applied to the sample size of forty sites.
- Figure B-2 summarises the resulting site selection criteria to ensure that the forty sample sites were representative of the wider network.

Having established the selection criteria, a logistical exercise was undertaken to identify forty sample sites that would fulfil these requirements. The results are presented in Appendix C:

- Table C-1 provides the summary list and shows the range of variables for each of the selected sites.
- Table C-2 provides the detailed construction records for each of the selected sites.

With such prescriptive selection criteria it was impossible to select forty sample sites of equal length. The maximum site length was 698m. The minimum site length was 337m. The average site length was 506m.

The average age of all thin surfacing materials included in the final selection was 8.3 years. The "Date laid" records for two of the sites pre-dated the introduction of thin surfacings to the UK and were therefore considered to be erroneous. The average age for the remaining 38 sites was 7.0 years.

3. Sub-Task 2: Visual Inspection

3.1. Specification

The specification for this Sub-Task was:

> *"Carry out a visual inspection of these sites and assess them using the methodology described in Appendix A of TRL Report 674."* [Ref. 4]

3.2. Approach

Atkins' innovative approach to this Task was to collect video survey data for the forty sample sites and to conduct visual assessments (using the TRL 674 [Ref. 4] methodology) in workshop forums.

3.3. Data collection

Inventory video collection started during the week commencing 30th September 2013. Collection and processing was completed during the week commencing 28th October 2013. This quick turnaround was made possible by:

a) Atkins working "at risk" to undertake the majority of the HAPMS analysis and site selection (see Section 2) prior to the award of Task on 13th September.
b) IBI Group's flexibility in not demanding a prolonged mobilisation period.

For all surveys, four video cameras were utilised. These covered the forward, rear, nearside and offside angles. In playback mode, footage from the rear facing camera could be targeted on the carriageway surface and this proved to be the most useful for visual condition assessment purposes.

The maximum survey speed was 80kph (22 m/sec). The frequency of the captured imagery was six frames per second (6Hz). This meant that the maximum frame spacing in the final footage was around 4m.

3.4. Inspection Panel workshops

Inspection Panel workshops were held in Atkins' Birmingham office on the 14th and 15th November 2013. The attendees are listed in Section 8. The same panel attended both days. Four out of the six panel members had previously been involved in the visual assessments included in TRL 674 [Ref. 4]. All panel members participated in the 2012 Performance Review [Ref. 5].

The TRL methodology stated that "*if the Panel consists of less than 6 members at an inspection, this fact shall be noted when reporting the results*". One panel member was otherwise engaged for the final part of the first day's session and this is recorded in Section 8. The reported results were unaffected.

The TRL 674 [Ref. 4] assessment methodology was applied throughout. An introduction/refresher exercise was undertaken on the first morning via the inspection (on foot) of a site within Birmingham city centre. The panel then reconvened to Atkins' office where the video footage (of the forty motorway and trunk road sites) was reviewed and assessments were undertaken.

Reference should be made to TRL 674 [Ref. 4] for a full description of the assessment methodology. Table D-1 in Appendix D shows the available 'Basic' marks and Table D-2 in Appendix D shows the supplementary 'Defect suffixes'. It should be noted that the '*fj*' and '*oj*' defect suffixes were not included within TRL 674 [Ref. 4] but were added, during the 2012 Performance Review [Ref. 5], at the request of the Project Sponsor - as the condition of joints is a pertinent factor in the assessment of thin surfacings.

Table D-3 in Appendix D presents the final results for the forty sites.

The following general comments summarise the feedback from the workshop:

- The video footage was of sufficient quality for all panel members to feel comfortable in undertaking assessments.
- Due principally to the effect of lighting conditions, significantly different impressions of the surface condition could be gained from the forward and rear facing cameras. "Drive-throughs" at different speeds and using both the forward and rear facing cameras were, therefore, required at most sites for panel members to be able to undertake an assessment.
- During the 2012 Performance Review [Ref. 5] much of the discussion focussed on the relative merits of Atkins' (then) innovative approach and speculation as to how the sites would have been scored if assessed on-foot. This year the survey approach was regarded as established and there were no noteworthy discussions on the subject.
- This year the video footage was projected onto a blank wall as opposed to using a 42" monitor. The general consensus was that this was an improvement.
- Surfacing joints were the focus of much debate. Examples of good and bad joint performance were highlighted. Open joints (as denoted by suffix '*oj*') were the most common defects.
- When considering the markings, the TRL 674 [Ref. 4] methodology decreed that "*any sections that warrant a suffix cannot have a basic mark of G or better*". There were numerous instances where the condition of the majority of the surfacing mat was regarded as good (or better) but defects associated with the joints "dragged down" the score for the site.
- During the 2012 Performance Review [Ref. 5] no location details were provided for the sites. This was intended to ensure that all sites were marked impartially (as Inspection Panel members may have recognised sites that they had previous involvement with – and therefore a commercial interest in assessing its performance). However, this differed to the original TRL 674 [Ref. 5] approach whereby Inspection Panel members were readily able to recognise locations as they travelled to and arrived at each site. Based upon last year's feedback it was decided to provide location maps and descriptions for each site this year. This was regarded as an improvement as Inspection Panel members were able to relay site-specific details and question the underlying HAPMS records (see bullet point below).
- The accuracy of the HAPMS construction records was the subject of numerous discussions. Table D-3 in Appendix D shows that they were regarded as questionable for twenty out of the forty sites that were assessed. This equates to a potential error (within HAPMS) of 50%. The 2012 Performance Review [Ref. 5] estimated a 20% error. Atkins' "*Optimum Interventions*" Task [Ref. 6] reported a 30% error. This data quality issue would complicate any HAPMS-based attempt to estimate the condition of all thin surfacings across the network.
- Whilst HAPMS construction records were provided for each site in the Inspection Panel members' packs, these details were not "announced" prior to viewing the footage for each site – as members said this information could influence their assessment. Discussions surrounding the accuracy of the HAPMS records were only entered into after each site had been scored.
- Video footage from forty sites was reviewed within the allotted two-day timescale for the workshop. This was an increase on last year's thirty sites. However, most Inspection Panel members considered forty to be a practical maximum number that could reasonably achieved.

4. Sub-Task 3: Data Analysis

4.1. Specification

The specification for this Sub-Task was:

"Collate and analyse the data in an electronic format and provide an estimate of the proportion of the Highways Agency network in each of the condition bands (Excellent, Good, Moderate, Acceptable, Suspect, Poor, Bad). An assessment of the statistical robustness of the prediction shall be undertaken."

4.2. Approach

As outlined in Section 2.2, the design of this Task included two different approaches to enable an estimation of the network condition profile:

- **Approach 1** – was to compare the Inspection Panel condition assessments with the underlying HAPMS attributes for each site and seek to identify reliable correlations. These correlations, determined at the sample site level, would then be applied to the full network.
  When investigating correlations between visual condition and the underlying HAPMS attributes, this year's forty sites were supplemented with last year's thirty sites to produce a larger sample size.
- **Approach 2** – was to select sample sites that provided a "mini snapshot" of the network. The condition profile of the forty sites could then be used as an approximation of the state of the network.

Approach 2 was intended as a back-up in the event that reliable correlations could not be established in Approach 1. The following Sections describe the analyses that were undertaken on the Inspection Panel results that were previously introduced in Table D-3 in Appendix D.

4.3. Analyses

In all of the following analyses, a scoring system was applied to convert the condition descriptions (from the Inspection Panel workshops) to numerical values as shown in Table 4-1. This numbering approach replicated the one used in Appendix I of TRL 674 [Ref. 4].

Table 4-1 Scoring system

Condition		Score
E	Excellent	7
E/G	Excellent/Good	6.5
G	Good	6
G/M	Good/Moderate	5.5
M	Moderate	5
M/A	Moderate/Acceptable	4.5
A	Acceptable	4
A/S	Acceptable/Suspect	3.5
S	Suspect	3
S/P	Suspect/Poor	2.5
P	Poor	2
P/B	Poor/Bad	1.5
B	Bad	1

4.3.1. General

The Inspection Panel results (presented in Table D-3 in Appendix D) were scored using the system in Table 4-1 and normalised according to their length. The following general statistics were then determined:

- The mean site score was 5.36. This represents a condition between 'Good/Moderate' and 'Moderate'.
- The standard deviation of the mean site score was 0.96.
- The average site length (CL1) was 494m. The network length of CL1 that is surfaced with TSCS is 6,662km. The Standard Error of the Mean (SEM) was therefore estimated to be 0.15.
  [Note: Contrary to HAPMS construction records, site ref. 36 consisted of two different surfacings with significantly different visual condition. Therefore they were assessed as two separate sites with lengths of 404m and 266m. The average length of the 41 assessed sites therefore became 494m. This differs to the 506m average site length of 40 sites that was reported at the Site Selection stage – see Section 2.3]
- Using the above statistics, an estimate of the average condition of TSCS in CL1 across the network was calculated using the Central Limit Theorem (CLT). The CLT states that the mean of a sufficiently large number of independent random variables is approximately normally distributed. The network average condition was calculated to lie between:
  - 'Good' and 'Moderate' with 99.19% confidence.
  - 'Good/Moderate' and 'Moderate/Acceptable' with 82.60% confidence.
  - 'Good' and 'Moderate/Acceptable' with 99.99% confidence.

Figure 4-1 provides an illustration of these statistics.

Figure 4–1 Illustration of network average condition statistics

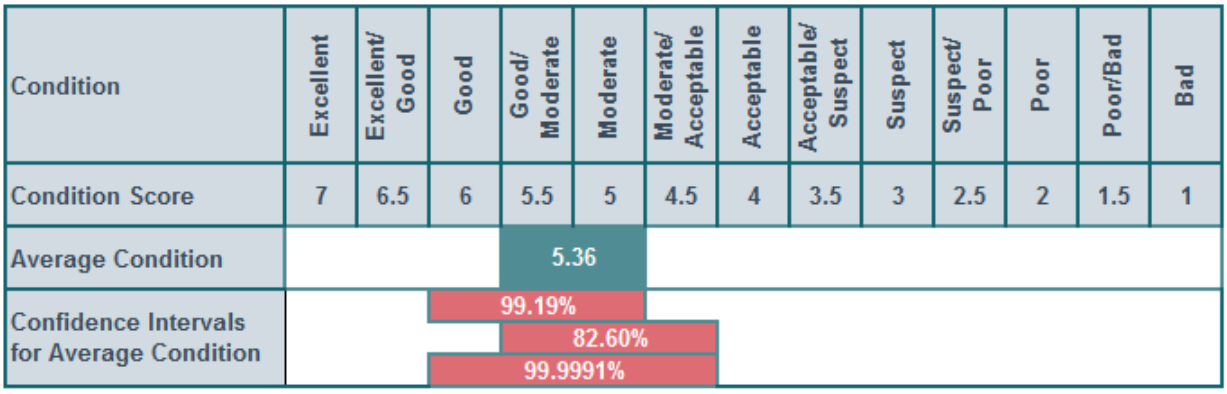


Figure E-1 in Appendix E shows the number of sites falling into each of the condition categories (Table 4-1). The following features were noted:

- There is uncertainty in the probability distribution function of the sample data (e.g. normal or long-tail) – because the sample size of forty sites is relatively small and the condition assessments were dispersed.
- Not all condition categories presented in Table 4-1 were encountered within the sample data. The following were absent:
  - 'Excellent/Good'
  - 'Suspect'
  - 'Poor/Bad'
  - 'Bad'

  The latter three of these condition categories are tending towards an unacceptable level of service on the Agency's network so they would not be expected to be prevalent. However, the fact that they were absent from the sample sites assessed under this Task does not lead to the statistical conclusion that they do not occur anywhere else on the Agency's network.

Based upon the above, it is not possible, on a statistical basis, to confidently determine the proportions of thin surfacings across the network that fall into the various condition categories.

Attempts were therefore made to investigate correlations between the condition ratings for the sample sites and the underlying HAPMS data. If reliable correlations could be established then they would be applied to all records within HAPMS to produce a current, network level estimate of condition.

4.3.2. Correlations between condition and HAPMS attributes (Approach 1)

For all of the following attempts at correlating visual condition with the underlying HAPMS attributes, this year's forty sites were supplemented with last year's thirty sites to produce a larger sample size.

Condition against age

Table F-1 in Appendix F presents the condition results for the sample sites against the age of the thin surfacing material (from HAPMS). As would be expected, the newer materials appear to have better condition ratings. However, between the age intervals there is seen to be overlap in the condition ratings.

Figure F-1 in Appendix F presents the same data in a graphical format. No convincing trend can be discerned between age and condition.

Figure F-2 in Appendix F is a refinement of Figure F-1. It shows that by excluding nine of the sites that were considered to be "outliers" from the main data set plus four sites with clearly erroneous construction records then a linear relationship between condition and age could be approximated.

Figure F-3 in Appendix F is a further refinement of Figure F-2. It shows that by additionally excluding sites which the Inspection Panel considered having questionable "Date laid" records in HAPMS then a slightly improved linear regression could be achieved.

Drawbacks with this approach were as follows:

- There was no statistical logic for excluding the nine outliers. Discarding a relatively large proportion of such a small sample in this way is not considered to be a robust approach.
- Any correlation determined at sample site level would need to be applied to all HAPMS construction records to arrive at a network-wide estimate of condition. The regression analyses shown in Figure F-2 and F-3 are based upon filtered data. To apply this at network level, all construction records in HAPMS would have to be similarly filtered to remove errors. This would be a significant undertaking.
- When plotted against time, condition deterioration profiles normally follow an S-curve – not a linear pattern.
- The Coefficient of Determination ("R^2" value) in both Figures D-2 and F-3 does not represent a close fit.

It was concluded that no reliable correlation could be established between age and condition for the sample sites.

Condition against thickness

On its own, the thickness of a thin surfacing material would not be expected to be a determining factor in its visual condition. For completeness, Table F-2 in Appendix F shows the condition results for the sample sites against the material thickness (from HAPMS). No noteworthy trends were apparent.

Condition against thickness and season laid

Table F-3 in Appendix F shows the condition results for the sample sites against the thickness of the thin surfacing material and the season when it was laid (from HAPMS). Figure F-4 in Appendix F provides a graphical illustration of the same data. No noteworthy trends were apparent.

Condition against age and season laid

Table F-4 and Figure F-5 in Appendix F compare condition against age and season laid. Figures F-6 to F-8 in Appendix F show further attempts to investigate possible correlations for these three variables:

- Figure F-6 in Appendix F presents the condition ratings in a matrix format.
- Figure F-7 in Appendix F converts the condition ratings into scores using the system shown in Table 4-1.
- Figure F-8 in Appendix F calculates the average scores and presents the equivalent condition rating for each cell of the matrix.

Review comments for Figure F-8 in Appendix F are as follows:

- This method does show a general deterioration in condition over time.
- The condition ratings resulting from this correlation range from 'Good' to 'Acceptable/Suspect'. This is narrower than the full spectrum of condition ratings presented in Table 4-1 and is considered to be unsuitable to make a representative assessment of the network condition as a whole (because the Inspection Panel encountered condition ratings from 'Excellent' to 'Poor').
- Not all of the cells in the final matrix can be populated from the Inspection Panel results.
- The 'Season Laid' appears to have virtually no effect on the condition rating. This is contrary to industry experience. Current guidance [Ref. 1] states: "*In common with other bituminous materials it has been observed that TSCS laid during the winter period are likely to be less durable than those laid in the summer*".

Different age bandings (i.e. not just 5 year intervals) were also attempted but the outcomes were similarly inconclusive.

On the basis of the above, it was concluded that no reliable correlation between condition and age/season laid could be established from the Inspection Panel results.

Condition against age and thickness

Figures F-9 to F-12 in Appendix F illustrate attempts to investigate correlations between condition, age and thickness.

- Figure F-9 in Appendix F presents the condition ratings in a matrix format.
- Figure F-10 in Appendix F converts the condition ratings into scores using the system shown in Table 4-1.
- Figure F-11 in Appendix F calculates the average scores and presents the equivalent condition rating for each cell of the matrix.
- Figure F-12 in Appendix F is a refinement of Figure F-11 and condenses the '5 to 10 years' and '10 to 15 years' results into a single range of '5 to 15 years'.

The final correlations provided in Figure F-11 and Figure F-12 in Appendix F do not stand up to detailed scrutiny for the following reasons:

- The condition ratings resulting from these correlation range from 'Good' to 'Poor'. This is narrower than the full spectrum of condition ratings presented in Table 4-1 and is considered to be unsuitable to make a representative assessment of the network condition as a whole (because the Inspection Panel encountered condition ratings from 'Excellent' to 'Poor').
- The matrices cannot be fully populated from the Inspection Panel results.
- Comparisons between individual permutations of age and thickness reveal anomalies. Examples:
    - Figure F-11 shows that, for all materials greater than 25mm thick, an improvement in condition occur after 10 years. This is not credible.
    - Figure F-11 shows that materials less than 25mm thick have a better condition rating for the first 10 years in comparison to thicker variants. This is contrary to industry experience and current trends - whereby thicker materials are commonly specified on the grounds of improved durability.
    - Figure F-12 generally shows more logical deterioration trends but the range of condition ratings are narrower than those experienced on the network.
    - Both figures show an 'Acceptable/Suspect' condition rating between 15 and 20 years. This is considered to be optimistic as current guidance [Ref. 1] suggests that the typical serviceable life for thin surfacing is '*between 7 and 15 years'*.

On the basis of the above, it was concluded that no reliable correlation between condition and age/thickness could be established from the Inspection Panel results.

Conclusion

Based upon the above analyses, no reliable correlations could be determined between the condition ratings from the Inspection Panel workshops and the underlying HAPMS data for each site.

4.3.3. Representative network sample analysis (Approach 2)

The site selection methodology described in Section 2 was intended to produce a sample of sites that was representative of the network wide stock of thin surfacing materials in terms of their HAPMS attributes and relative occurrence. The rationale behind this designed approach was that the Inspection Panel results for this "mini snapshot" of the network would be used as a direct approximation of the condition of the full network. On this basis, Table 4-2 provides an estimation of the proportion of thin surfacing in CL1 falling within each condition category.

Table 4-2 Proportion of thin surfacing in CL1 within each condition category

Condition	Length (m)	%		
E	1,599	7.9	96.5	SATISFACTORY
E/G	~	~		
G	6,053	29.9		
G/M	3,196	15.8		
M	7,133	35.2		
M/A	499	2.5		
A	499	2.5		
A/S	546	2.7		
S	~	~	3.5	UNSATISFACTORY
S/P	266	1.3		
P	446	2.2		
P/B	~	~		
B	~	~		
	20,236	**100**		

The robustness of the above approximation cannot be determined on a statistical basis. This is because it is not possible to determine with certainty the probability distribution function of the condition of a thin surfacing site based on such a relatively small sample. Therefore, numerical confidence intervals cannot be assigned to the figures shown in Table 4-2. Only a narrative assessment of the robustness can be provided:

- The forty sample sites included in the final analysis (Table 4-2) had a total length of 20.2km. The total length of thin surfacing in CL1 across the Agency's network is 6,662km. The estimated condition profile is therefore based on a sample size that represents 0.3% of the full network coverage of thin surfacing in CL1.
- The sample size of forty sites was the practical maximum number that could be surveyed, processed and assessed within the time, budget and seasonal constraints for this Task.
- The (approved) site selection methodology delivered a sample that was representative of the thin surfacing attributes and proportions encountered across the network – as recorded in HAPMS.
- Not all of the available condition categories (from TRL 674 [Ref. 4]) were encountered within the sample sites. Five of the condition categories were only encountered once.
- The Inspection Panel results were delivered by an established and accepted methodology.
- The assessment presented in Table 4-2 represents a pragmatic and logical estimation of network condition.

5. Conclusions

With regard to the Task specification (as outlined in Section 1.2), this report summarises Atkins' efforts to:

1. Carry out visual condition assessments of thin surfacing sites using the established TRL 674 [Ref. 4] methodology; and,
2. Make an estimation of the overall condition of all thin surfacing materials on the network.

Atkins' innovative approach was again deployed to undertake the visual condition assessment element of the Task. The use of video survey technology enabled data to be collected in a safe, reliable and efficient manner. The video footage from forty sites was then reviewed by an Inspection Panel in a workshop forum.

HAPMS data was used as the basis for site selection purposes and to extrapolate the findings from the inspected sample to a network level. Of the forty selected sites; twenty were considered to have questionable construction records. On this basis, the error in the HAPMS data was estimated to be 50%.

An estimate of the average condition of all thin surfacing in CL1 across the network was calculated using the Central Limit Theorem. The network average condition was calculated to lie between:

- 'Good' and 'Moderate' with 99.2% confidence.
- 'Good/Moderate' and 'Moderate/Acceptable' with 82.6% confidence.
- 'Good' and 'Moderate/Acceptable' with 99.99% confidence.

Efforts were then made to determine the condition profile of all thin surfacings across the network by estimating the proportion falling into pre-defined categories from 'Excellent' to 'Bad'.

The first approach was to investigate correlations between the Inspection Panel condition results and the underlying HAPMS attributes for each site. The intention had been to apply successful correlations, determined at the sample level to all thin surface course records within HAPMS to arrive at a network-wide estimation. Correlations were attempted between visual condition and:

- Age
- Thickness
- Thickness and season laid
- Age and season laid
- Age and thickness

No statistically robust correlations could be established.

The second approach relied upon the fact that the site selection methodology delivered a survey sample that was representative of the thin surfacing attributes and proportions encountered across the network. In this way, the Inspection Panel workshops were delivering verdicts on a "mini snap-shot" of the full network. On this basis it was estimated that 96.5% of thin surfacing in CL1 across the network was rated as 'Satisfactory' (i.e. condition categories 'Excellent' to 'Acceptable/Suspect') with the remaining 3.5% being rated as 'Unsatisfactory' (i.e. condition categories 'Suspect' to 'Bad'). This compares with a 'Satisfactory' figure of 87% in 2012.

This approach was considered to be a pragmatic and logical method for estimating the condition of all thin surfacing materials across the network.

6. References

Table 6-1 References

Reference	Detail
1	"*Thin Surface Course Systems – Installation And Maintenance*", Interim Advice Note 157/11, Highways Agency, 2011.
2	"*Bituminous Surfacing Materials and Techniques*", HD 37/99, DMRB Volume 7, Section 5, Part 2, Highways Agency, 1999.
3	"*Surfacing materials for new and maintenance construction*", HD 36/06, DMRB Volume 7, Section 5, Part 1, Highways Agency, 2006.
4	"*Durability of thin surfacing systems. Part 4: Final report after nine years monitoring*", J C Nicholls, I Carswell, C Thomas and B Sexton, TRL Report 674, 2010.
5	"*Thin surfacing performance review*", Final report for DfT T-TEAR Package Order 071(4/45/12), Atkins, 2013.
6	*"Optimum interventions for thin surfacing maintenance",* Final report for DfT T-TEAR Package Order 022(4/45/12), Atkins, 2013.
7	*"Highways Agency: Annual report and Accounts 2012-13",* Highways Agency, 2013.

7. Abbreviations

Table 7-1 Abbreviations

Abbreviation	Expanded
CL1	Left permanent lane #1
CLT	Central Limit Theorem
DfT	Department for Transport
HAPMS	Highways Agency Pavement Management System
HRA	Hot Rolled Asphalt
NetServ	Network Services
SEM	Standard Error of Mean
TRL	Transport Research Laboratory
TSCS	Thin Surface Course System
T-TEAR	Transport-Related Technical and Engineering Advice and Research

8. Acknowledgements

Acknowledgements are due to:

- IBI Group for undertaking the video data collection and processing.
- the Inspection Panel members, and their employers, listed in Table 8-1 for their attendance and input.

Table 8-1 Inspection Panel members

Name	Employer
Andy Berry-Fincham	Atkins Highways and Transportation
Paul Collins	Aggregate Industries
Dr Mike Gibb *(Convenor)*	Hyperion Infrastructure Consultancy
Arash Khojinian *(excl. Sites 20 to 25)*	Highways Agency
Jukka Laitinen	Nynas UK
Malcolm Simms	Mineral Products Association

Appendices

Appendix A. HAPMS analyses

Table A-1: Summary length (m) of surface course material types in CL1

Surface course material name	AREA												TOTAL LENGTH (m)	% of CL1L coverage
	1	2	3	4	6	7	8	9	10	12	13	14		
Thin Surface Course System	307,301	496,714	761,310	490,388	633,360	802,551	647,849	568,782	596,097	620,972	409,682	327,639	6,662,644	52.24%
Hot Rolled Asphalt	255,350	509,444	537,418	346,069	281,437	490,733	172,531	718,803	616,648	452,527	255,042	282,448	4,918,449	38.56%
High Friction surfacing	8,360	15,753	18,481	26,253	9,040	11,931	5,446	14,724	20,747	26,542	7,124	10,675	175,077	1.37%
PQ Concrete	15,865	883	26,317	40,880	120,892	21,985		63,926	15,823	36,635			343,206	2.69%
Dense Bituminous Macadam		2,052	1,390	557	1,325	93,838		100,764		230			200,156	1.57%
Surface dressing	25	22,041	12,367	3,525	127,630	1,488	1,850	70,354	2,286	3,631	21,592	2,217	269,006	2.11%
Retexturing - Bituminous	8,747	200	3,376	25,879	9,634	3,121	1,923		45,808			13,243	111,931	0.88%
Retexturing - Concrete			14,986		28,317				6,432				49,735	0.39%
Miscellaneous														
(blank)							111							
Concrete Block Paving					100					205				
Cement Bound Material		100	136					1,746						
Heavy Duty Macadam		32					248	1,040						
High Modulus Roadbase					22									
Mastic Asphalt		3,229				15		27				391		
Porous asphalt			578			1,805	283	5,816					24,842	0.19%
Sand asphalt						205		16						
Stone Mastic Binder Course								6,715						
"Structure"								1,176			24			
Slurry seal	119			211										
Tar Bound Macadam								380						
"Type 1 (100% primary aggregates)"								112						
	595,767	**1,050,449**	**1,376,360**	**933,762**	**1,211,758**	**1,427,672**	**830,240**	**1,554,381**	**1,303,840**	**1,140,741**	**693,464**	**636,612**	12,755,046	100.00%
	12,755,046													

TABLE A-2: Summary length (m) of TSCS in CL1 by carriageway function

Carriageway function	AREA												NETWORK	
	1	2	3	4	6	7	8	9	10	12	13	14	m	%
Main Carriageway	275,604	457,153	673,044	412,253	531,594	687,083	544,183	483,702	463,602	513,597	375,099	281,321	5,698,236	85.53%
Slip Road	29,448	34,256	79,963	69,943	76,101	91,235	92,775	65,048	127,500	97,741	27,446	39,242	830,699	12.47%
Roundabout	2,249	5,137	5,238	7,733	10,814	15,221	4,611	19,614	4,918	9,513	7,008	6,836	98,893	1.48%
Ox Bow Lay-by		168	3,065	459	14,851	9,012	6,279	417	76	120	129	240	34,816	0.52%
Grand Total	**307,301**	**496,714**	**761,310**	**490,388**	**633,360**	**802,551**	**647,849**	**568,782**	**596,097**	**620,972**	**409,682**	**327,639**	**6,662,644**	**100.00%**

TABLE A-3: Summary length (m) of TSCS in CL1 by carriageway function and type

Carriageway function and type		AREA												NETWORK	
		1	2	3	4	6	7	8	9	10	12	13	14	m	%
Main carriageway	Motorway	0	309974.1	330580.6	160337.9	92424.17	230371	193267	297937.6	403008.6	315924.9	198042	81544.95	2,613,413	46%
	Non-motorway	275604.1	147178.7	342463.3	251915.3	439170.2	456712.1	350916.2	185764.8	60593.81	197672.4	177057	199775.6	3,084,824	54%
Slip Road	Motorway	0	31071.36	38949.62	34358.75	7253	41860	41017.96	38973	114743.3	65306.25	20227	13867.67	447,628	54%
	Non-motorway	29447.87	3185	41013.52	35584.11	68847.95	49374.53	51757.39	26075.41	12756.85	32435	7219	25374.3	383,071	46%
Roundabout	Motorway	0	22	1203	246	100	729	630	660	1928	2221	0	0	7,739	8%
	Non-motorway	2249	5115	4035	7487.419	10714	14492.19	3981	18954	2990	7292	7008	6836	91,154	92%
Ox Bow layby	Motorway	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
	Non-motorway	0	168	3065	459	14851	9012.325	6279	417	76	120	129	240	34,816	100%
TOTAL		**307,301**	**496,714**	**761,310**	**490,388**	**633,360**	**802,551**	**647,849**	**568,782**	**596,097**	**620,972**	**409,682**	**327,639**	**6,662,644**	

TABLE A-4: Summary length (m) of TSCS in CL1 by age

Age range (years)		AREA												NETWORK	
		1	2	3	4	6	7	8	9	10	12	13	14	m	%
<= 4.9	m	153,054	156,300	387,171	129,961	142,447	304,343	258,263	278,249	248,569	282,012	182,543	241,724	2,764,634	41.49%
	Area %	49.81%	31.47%	50.86%	26.50%	22.49%	37.92%	39.86%	48.92%	41.70%	45.41%	44.56%	73.78%		
5 to 9.9	m	127,626	155,836	277,469	187,920	282,521	280,483	235,070	135,437	184,332	204,457	152,408	44,020	2,267,578	34.03%
	Area %	41.53%	31.37%	36.45%	38.32%	44.61%	34.95%	36.28%	23.81%	30.92%	32.93%	37.20%	13.44%		
10 to 14.9	m	26,360	98,545	72,539	166,603	194,779	200,291	152,478	19,331	139,398	120,879	71,475	30,296	1,292,974	19.41%
	Area %	8.58%	19.84%	9.53%	33.97%	30.75%	24.96%	23.54%	3.40%	23.39%	19.47%	17.45%	9.25%		
15 to 19.9	m	217	51,712	16,793	5,905	6,859	1,796	61	17,713	973	1,873	3,256	10,011	117,169	1.76%
	Area %	0.07%	10.41%	2.21%	1.20%	1.08%	0.22%	0.01%	3.11%	0.16%	0.30%	0.79%	3.06%		
>= 20	m	43	34,321	7,339	0	6,754	15,638	1,977	118,052	22,826	11,751	0	1,588	220,289	3.31%
	Area %	0.01%	6.91%	0.96%	0.00%	1.07%	1.95%	0.31%	20.76%	3.83%	1.89%	0.00%	0.48%		
TOTAL		**307,301**	**496,714**	**761,310**	**490,388**	**633,360**	**802,551**	**647,849**	**568,782**	**596,097**	**620,972**	**409,682**	**327,639**	**6,662,644**	**100.00%**

TABLE A-5: Summary length (m) of TSCS in CL1 by season laid

(Winter - November to February incl.)

Season laid		AREA												NETWORK	
		1	2	3	4	6	7	8	9	10	12	13	14	m	%
Non winter	(m)	230,279	356,611	525,626	324,442	452,901	639,583	389,271	335,605	432,556	433,626	243,594	232,986	4,597,079	69%
	Area %	74.94%	71.79%	69.04%	66.16%	71.51%	79.69%	60.09%	59.00%	72.56%	69.83%	59.46%	71.11%		
Winter	(m)	77,022	140,103	235,685	165,946	180,460	162,968	258,578	233,176	163,541	187,346	166,088	94,652	2,065,565	31%
	Area %	25.06%	28.21%	30.96%	33.84%	28.49%	20.31%	39.91%	41.00%	27.44%	30.17%	40.54%	28.89%		
Grand Total	**(m)**	**307,301**	**496,714**	**761,310**	**490,388**	**633,360**	**802,551**	**647,849**	**568,782**	**596,097**	**620,972**	**409,682**	**327,639**	**6,662,644**	

TABLE A-6: Summary length (m) of TSCS in CL1L- by age and by season laid

Age range (years)	AREA												NETWORK	
	1	2	3	4	6	7	8	9	10	12	13	14	m	%
WINTER														
<= 4.9	55,694	36,265	132,066	60,068	54,646	71,164	117,749	60,042	56,848	66,071	80,674	74,966	866,253	41.94%
5 to 9.9	15,181	42,079	75,611	59,170	47,335	66,912	65,940	49,997	50,622	53,653	46,413	8,723	581,634	28.16%
10 to 14.9	5,930	40,129	26,830	45,685	74,397	20,960	73,118	2,010	39,166	55,125	36,680	5,616	425,646	20.61%
15 to 19.9	217	3,601	396	1,023	1,301	1,796	52	17,713	0	1,824	2,321	5,348	35,592	1.72%
>= 20	0	18,029	782	0	2,780	2,136	1,718	103,415	16,906	10,673	0	0	156,440	7.57%
TOTAL	**77,022**	**140,103**	**235,685**	**165,946**	**180,460**	**162,968**	**258,578**	**233,176**	**163,541**	**187,346**	**166,088**	**94,652**	**2,065,565**	**100.00%**
NON WINTER														
<= 4.9	97,360	120,035	255,105	69,892	87,800	233,179	140,513	218,208	191,721	215,941	101,869	166,758	1,898,381	41.30%
5 to 9.9	112,445	113,757	201,858	128,750	235,186	213,571	169,129	85,440	133,710	150,804	105,995	35,297	1,685,943	36.67%
10 to 14.9	20,431	58,416	45,709	120,918	120,382	179,331	79,360	17,321	100,232	65,754	34,795	24,681	867,329	18.87%
15 to 19.9	0	48,111	16,397	4,882	5,558	0	9	0	973	49	935	4,663	81,577	1.77%
>= 20	43	16,292	6,557	0	3,974	13,502	259	14,637	5,920	1,078	0	1,588	63,849	1.39%
TOTAL	**230,279**	**356,611**	**525,626**	**324,442**	**452,901**	**639,583**	**389,271**	**335,605**	**432,556**	**433,626**	**243,594**	**232,986**	**4,597,079**	**100.00%**

TABLE A-7: Summary length (m) of TSCS in CL1 by thickness

Thickness range	AREA												NETWORK	
	1	2	3	4	6	7	8	9	10	12	13	14	m	%
0-15mm	4,370	46,643	13,456	935	1,297	435	1,070	3,372	9,797	2,490	3,466	432	87,763	1%
16-20mm	108	3,631	3,624	12,337	306	38,503	12,651	3,848	6,793	10,287	209	1,964	94,261	1%
21-25mm	19,020	10,611	30,351	31,387	186	11,534	1,080	8,362	11,658	18,268	13,272	32,943	188,672	3%
26-30mm	46,699	120,753	114,948	163,411	214,888	111,527	244,210	75,408	160,450	89,776	120,022	194,267	1,656,359	25%
31-35mm	111,114	25,819	377,592	66,899	170,609	135,712	176,998	85,858	81,932	136,729	16,010	79,670	1,464,941	22%
36-40mm	45,198	68,702	39,816	75,590	172,595	240,929	127,724	136,211	39,584	346,001	240,363	16,130	1,548,843	23%
41-45mm	78,622	6,898	76,108	17,031	2,641	19,729	2,769	197,095	19,621	12,023	4,056	225	436,817	7%
46-50mm	1,859	210,326	94,851	122,364	69,520	238,778	77,751	52,762	253,727	4,410	8,666	1,962	1,136,976	17%
>50mm	313	3,331	10,564	436	1,318	5,405	3,594	5,867	12,534	988	3,618	45	48,012	1%
TOTAL	**307,301**	**496,714**	**761,310**	**490,388**	**633,360**	**802,551**	**647,849**	**568,782**	**596,097**	**620,972**	**409,682**	**327,639**	**6,662,644**	**100.00%**

Appendix B. Site selection criteria

FIGURE B-1: Methodology behind sample site selection criteria

GEOGRAPHY

Task specification requires that sample selection should represent a range of factors including geographical location and climatic conditions.
Site selection is therefore based on one northern Area, one southern Area and one Area in the midlands

Geography	Area	No. Sites
North	10	14
South	6	13
Midlands	7	13
		40

CARRIAGEWAY FUNCTION

Table A-2 shows the following proportions at network level:

Carriageway function		
Main Carriageway	86%	
Slip Road	12%	
Roundabout	1%	*Ignore*
Ox Bow Lay-by	1%	*Ignore*

Apply these proportions to the 40 sample sites:

Carriageway function	No. Sites
Main Carriageway	35
Slip Road	5
	40

CARRIAGEWAY TYPE

Table A-3 shows the following proportions at network level:

Carriageway function	Carriageway Type		
Main carriageway	Motorway	46%	
	Non-motorway	54%	
Slip Road	Motorway	54%	
	Non-motorway	46%	

Apply these proportions to the 40 sample sites:

Carriageway function	Carriageway Type	No. Sites	
Main carriageway	Motorway	35	16
	Non-motorway		19
Slip Road	Motorway	5	3
	Non-motorway		2
		40	**40**

AGE

Table A-4 shows the following proportions at network level:

Age	
0 to 5 years	41.49%
5 to 10 years	34.03%
10 to 15 years	19.41%
15 to 20 years	1.76%
> 20 years	3.31%

Apply these proportions to the 40 sample sites:

Age	No. Sites
0 to 5 years	16
5 to 10 years	14
10 to 15 years	8
> 15 years	2
	40

AGE & SEASON LAID

Table A-5 shows the following proportions at network level:

Season laid	
Winter	31%
Non-winter	69%

Apply these proportions to the 40 sample sites:

Season laid	No. Sites
Winter	12
Non-winter	28
	40

Table A-6 shows the following proportions at network level:

Age (years)	Winter laid	Non-winter laid
<10	70.10%	77.97%
>10	29.90%	22.03%

Apply these proportions to the 40 sample sites:

	Winter laid	Non-winter laid
Age (years)	No. Sites	No. Sites
<10	8	22
>10	4	6
	12	**28**
	40	

THICKNESS

Table A-7 shows the following proportions at network level:

Thickness		
0-15mm	1%	6%
16-20mm	1%	
21-25mm	3%	
26-30mm	25%	70%
31-35mm	22%	
36-40mm	23%	
41-45mm	7%	24%
46-50mm	17%	
>50mm	1%	

Apply these proportions to the 40 sample sites:

	No. sites
<= 25mm	2
26 to 30mm	10
31 to 35mm	9
36 to 40mm	9
> 40mm	10
	40

FIGURE B-2: Summary of sample site selection criteria

GEOGRAPHY		
North (Area 10)	South (Area 6)	Midlands (Area 7)
14	13	13
40		

CARRIAGEWAY FUNCTION AND TYPE			
Main carriageway		Slip road	
Motorway	Non-motorway	Motorway	Non-motorway
16	19	3	2
35		5	
40			

AGE			
0 to 5 (yrs)	5 to 10 (yrs)	10 to 15 (yrs)	> 15 (yrs)
16	14	8	2
40			

AGE AND SEASON LAID			
Winter		Non-Winter	
< 10 yrs	> 10 yrs	< 10 yrs	> 10 yrs
8	4	22	6
12		28	
40			

THICKNESS				
=<25 (mm)	26 to 30 (mm)	31 to 35 (mm)	36 to 40 (mm)	> 40 (mm)
2	10	9	9	10
40				

REQUIRED NUMBER OF SITES

Appendix C. Selected sites

TABLE C-1: Summary list of selected sites

Ref.	Road Number	GEOGRAPHY			CARRIAGEWAY FUNCTION AND TYPE				AGE				THICKNESS					SEASON LAID AND AGE			
					Main carriageway		Slip road											Winter		Non-Winter	
		North (Area 10)	South (Area 6)	Midlands (Area 7)	Motorway	Non-motorway	Motorway	Non-motorway	0 to 5 (yrs)	5 to 10 (yrs)	10 to 15 (yrs)	> 15 (yrs)	=<25 (mm)	26 to 30 (mm)	31 to 35 (mm)	36 to 40 (mm)	> 40 (mm)	< 10 yrs	> 10 yrs	< 10 yrs	> 10 yrs
1	A5	~	~	x	~	x	~	~	x	~	~	~	~	~	~	~	x	x	~	~	~
2	M60	x	~	~	~	~	x	~	~	x	~	~	~	~	~	~	x	~	~	x	~
3	M62	x	~	~	x	~	~	~	~	~	~	x	~	~	~	~	x	~	x	~	~
4	M6	x	~	~	x	~	~	~	~	~	x	~	~	~	~	~	x	~	x	~	~
5	M56	x	~	~	x	~	~	~	~	~	~	x	~	~	~	~	x	~	~	~	x
6	M67	x	~	~	x	~	~	~	~	~	x	~	~	~	~	~	x	~	x	~	~
7	A120	~	x	~	~	x	~	~	~	x	~	~	~	x	~	~	~	~	~	x	~
8	M1	~	~	x	x	~	~	~	~	~	x	~	~	~	~	~	x	~	x	~	~
9	A43	~	~	x	~	x	~	~	x	~	~	~	~	~	~	~	x	~	~	x	~
10	M61	x	~	~	x	~	~	~	x	~	~	~	~	~	~	~	x	~	~	x	~
11	A50	~	~	x	~	x	~	~	x	~	~	~	~	~	~	~	x	x	~	~	~
12	A494	x	~	~	~	~	~	x	x	~	~	~	~	~	x	~	~	x	~	~	~
13	A55	x	~	~	~	~	~	x	x	~	~	~	~	x	~	~	~	~	~	x	~
14	A627M	x	~	~	~	~	x	~	x	~	~	~	~	x	~	~	~	~	~	x	~
15	M57	x	~	~	~	~	x	~	x	~	~	~	~	x	~	~	~	~	~	x	~
16	A556	x	~	~	~	x	~	~	x	~	~	~	x	~	~	~	~	x	~	~	~
17	A43	~	~	x	~	x	~	~	~	~	x	~	x	~	~	~	~	~	~	~	x
18	M45	~	~	x	x	~	~	~	~	x	~	~	~	~	~	x	~	x	~	~	~
19	A550	x	~	~	~	x	~	~	x	~	~	~	~	~	x	~	~	x	~	~	~
20	A47	~	x	~	~	x	~	~	~	x	~	~	~	~	~	x	~	x	~	~	~
21	M45	~	~	x	x	~	~	~	~	x	~	~	~	~	~	x	~	x	~	~	~
22	M57	x	~	~	x	~	~	~	~	~	x	~	~	~	x	~	~	~	~	~	x
23	A1	~	~	x	~	x	~	~	~	~	x	~	~	~	~	x	~	~	~	~	x
24	A12	~	x	~	~	x	~	~	~	~	x	~	~	~	x	~	~	~	~	~	x
25	M11	~	x	~	x	~	~	~	~	~	x	~	~	x	~	~	~	~	~	~	x
26	M602	x	~	~	x	~	~	~	x	~	~	~	~	x	~	~	~	~	~	x	~
27	M1	~	~	x	x	~	~	~	x	~	~	~	~	~	x	~	~	~	~	x	~
28	A47	~	x	~	~	x	~	~	x	~	~	~	~	~	x	~	~	~	~	x	~
29	A14	~	~	x	~	x	~	~	x	~	~	~	~	x	~	~	~	~	~	x	~
30	M69	~	~	x	x	~	~	~	x	~	~	~	~	~	~	x	~	~	~	x	~
31	M1	~	~	x	x	~	~	~	x	~	~	~	~	~	~	x	~	~	~	x	~
32	A120	~	x	~	~	x	~	~	~	x	~	~	~	x	~	~	~	~	~	x	~
33	A47	~	x	~	~	x	~	~	~	x	~	~	~	~	~	x	~	~	~	x	~
34	A11	~	x	~	~	x	~	~	~	x	~	~	~	~	x	~	~	~	~	x	~
35	M11	~	x	~	x	~	~	~	~	x	~	~	~	~	x	~	~	~	~	x	~
36	A12	~	x	~	~	x	~	~	~	x	~	~	~	~	~	x	~	~	~	x	~
37	A14	~	x	~	~	x	~	~	~	x	~	~	~	~	~	~	x	~	~	x	~
38	A47	~	x	~	~	x	~	~	~	x	~	~	~	~	~	~	x	~	~	x	~
39	A120	~	x	~	~	x	~	~	~	x	~	~	~	~	~	~	x	~	~	x	~
40	M1	~	~	x	x	~	~	~	~	x	~	~	~	~	~	~	x	~	~	x	~
		14	13	13	16	19	3	2	16	14	8	2	2	10	9	9	10	8	4	22	6
		40			35		5		40				40					12		28	
					40													40			

TABLE C-2: Detailed list of selected sites

Ref.	Road Number	Section Label	Section Function Name	Operational Area Name	Direction Code	XSP Code	Start Chainage (m)	End Chainage (m)	Length (m)	Date Laid	Age (Years)	Laid in winter? (Nov to Feb incl.)	Thickness (mm)
1	A5	2800A5/220	Main Carriageway	Area 7	NB	CL1L	741	1,240	499	14/01/2012	1.6	Yes	50
2	M60	4200M60/743	Slip Road	Area 10	AC	CL1L	0	499	499	06/09/2003	10.0	No	50
3	M62	0600M62/362	Main Carriageway	Area 10	WB	CL1L	601	1,100	499	01/01/1973	40.7	Yes	45
4	M6	0600M6/483	Main Carriageway	Area 10	SB	CL1L	0	501	501	01/01/1999	14.7	Yes	50
5	M56	0600M56/216	Main Carriageway	Area 10	EB	CL1L	494	999	505	01/07/1987	26.2	No	45
6	M67	4200M67/163	Main Carriageway	Area 10	EB	CL1L	800	1,400	600	04/12/2002	10.8	Yes	50
7	A120	1585A120/411	Main Carriageway	Area 6	EB	CL1L	29	365	337	01/06/2004	9.3	No	30
8	M1	2400M1/146	Main Carriageway	Area 7	SB	CL1L	136	500	364	01/01/2000	13.7	Yes	45
9	A43	2800A43/1	Main Carriageway	Area 7	NB	CL1L	0	470	470	24/09/2010	2.9	No	50
10	M61	2300M61/625	Main Carriageway	Area 10	NB	CL1L	600	1,073	473	15/09/2008	5.0	No	50
11	A50	2400A50/836	Main Carriageway	Area 7	WB	CL1L	0	482	482	06/12/2009	3.7	Yes	50
12	A494	0600A494/120	Slip Road	Area 10	SB	CL1L	0	514	514	01/12/2008	4.8	Yes	35
13	A55	0600A55/205	Slip Road	Area 10	WB	CL1L	0	549	549	18/08/2009	4.0	No	30
14	A627M	4200A627M/119	Slip Road	Area 10	SB	CL1L	0	570	570	29/07/2010	3.1	No	30
15	M57	0600M57/265	Slip Road	Area 10	SB	CL1L	0	380	380	07/05/2009	4.3	No	30
16	A556	0600A556/187	Main Carriageway	Area 10	NB	CL1L	170	550	380	30/01/2009	4.6	Yes	5
17	A43	3100A43/187	Main Carriageway	Area 7	SB	CL1L	971	1,417	446	18/09/2002	11.0	No	20
18	M45	2800M45/942	Main Carriageway	Area 7	EB	CL1L	0	494	494	23/11/2005	7.8	Yes	40
19	A550	0600A550/105	Main Carriageway	Area 10	NB	CL1L	0	506	506	01/01/2009	4.7	Yes	35
20	A47	2600A47/345	Main Carriageway	Area 6	EB	CL1L	700	1,398	698	15/12/2005	7.7	Yes	40
21	M45	2800M45/945	Main Carriageway	Area 7	EB	CL1L	0	488	488	01/12/2005	7.8	Yes	40
22	M57	0600M57/161	Main Carriageway	Area 10	NB	CL1L	0	543	543	01/03/2003	10.5	No	35
23	A1	3000A1/160	Main Carriageway	Area 7	NB	CL1L	996	1,556	560	01/06/2003	10.3	No	40
24	A12	1500A12/117	Main Carriageway	Area 6	SB	CL1L	1,328	1,958	630	01/09/2002	11.0	No	35
25	M11	1500M11/160	Main Carriageway	Area 6	NB	CL1L	651	1,342	691	03/05/2000	13.3	No	30
26	M602	4200M602/147	Main Carriageway	Area 10	EB	CL1L	0	442	442	25/08/2009	4.0	No	30
27	M1	3000M1/127	Main Carriageway	Area 7	NB	CL1L	300	836	536	31/05/2010	3.3	No	35
28	A47	2600A47/110	Main Carriageway	Area 6	EB	CL1L	733	1,205	472	25/03/2009	4.4	No	35
29	A14	2800A14/259	Main Carriageway	Area 7	WB	CL1L	0	498	498	24/03/2009	4.4	No	30
30	M69	2400M69/26	Main Carriageway	Area 7	WB	CL1L	0	374	374	18/03/2011	2.5	No	40
31	M1	3000M1/118	Main Carriageway	Area 7	SB	CL1L	234	598	364	31/05/2010	3.3	No	35
32	A120	1500A120/113	Main Carriageway	Area 6	EB	CL1L	0	479	479	07/03/2005	8.5	No	30
33	A47	2600A47/405	Main Carriageway	Area 6	WB	CL1L	0	530	530	01/07/2007	6.2	No	35
34	A11	3500A11/625	Main Carriageway	Area 6	NB	CL1L	2,002	2,548	546	01/03/2005	8.5	No	30
35	M11	1500M11/182	Main Carriageway	Area 6	SB	CL1L	3	580	577	01/05/2006	7.3	No	30
36	A12	1585A12/635	Main Carriageway	Area 6	NB	CL1L	0	670	670	01/08/2004	9.1	No	35
37	A14	3500A14/462	Main Carriageway	Area 6	WB	CL1L	0	441	441	01/06/2006	7.3	No	40
38	A47	2600A47/286	Main Carriageway	Area 6	WB	CL1L	806	1,410	604	20/10/2007	5.9	No	40
39	A120	1585A120/638	Main Carriageway	Area 6	EB	CL1L	0	574	574	14/09/2007	6.0	No	40
40	M1	1000M1/109	Main Carriageway	Area 7	NB	CL1L	157	609	452	21/09/2003	10.0	No	40

Appendix D. Inspection panel

Table D-1: TRL 674 scoring system - Basic marks

Mark	Description	
E (excellent)	No discernible fault	Termed satisfactory
G (good)	No significant fault	
M (moderate)	Some faults but insufficient for serious problem	
A (acceptable)	Several faults but would usually be just acceptable	
S (suspect)	Seriously faulted but still serviceable in the short term	Termed unsatisfactory
P (poor)	Requires remedial treatment	
B (bad)	Requires immediate remedial treatment	

Table D-2: TRL 674 scoring system (modified) - Defect suffixes

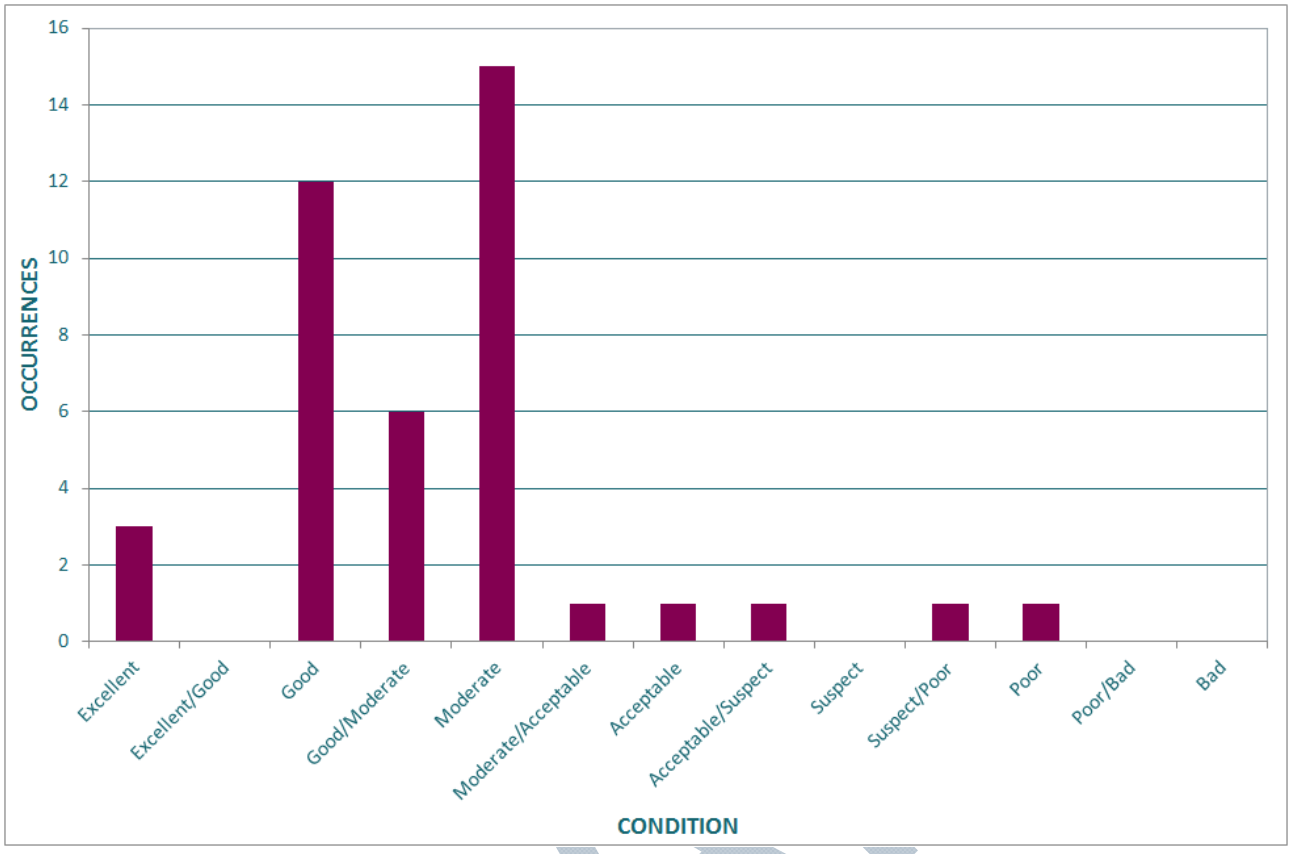
Suffix	
v	variable (Random variations from point to point within the section only, not "traffic laning" or of obvious variations from load to load)
t	variability with traffic intensity (Marked transverse differences caused by variations in traffic intensity between lanes)
+	fatting up
-	loss of aggregate
d	de-lamination from substrate
s	stripping
c	cracking
oj	open joint
fj	fretting at joint

Table D-3: Workshop results

Site Ref.	Panel Mark		General comments (unattributed)	HAPMS anomaly?
	Basic	Faults		
1	E			
2	M/A	*v - fj oj c*		
3	A	*- v fj oj c*	"Date laid" is clearly incorrect.	Yes
4	M	*oj -*	"Date laid" considered to be incorrect (judging by visual appearance).	Yes
5	M	*oj fj - c v*	"Date laid" considered to be incorrect (judging by visual appearance).	Yes
6	M	*v - fj c*		
7	G/M	*oj*	"Thickness" considered to be incorrect (panel member with first hand knowledge of scheme).	Yes
8	M	*c v -*		
9	M	*v -*	"Thickness" considered to be incorrect (binder course exposed in one location revealing the depth of surfacing to be less than 50mm).	Yes
10	G			
11	G	*oj -*		
12	G		"Date laid" considered to be incorrect. HAPMS shows this as one continuous length. Recent resurfacing near the top of the slip road suggests otherwise.	Yes
13	G			
14	E			
15	G			
16	M	*- oj fj c v*	"Thickness" is clearly incorrect.	Yes
17	P	*- c oj v t*	"Thickness" considered to be incorrect (panel member with first hand knowledge of scheme). Underlying rutting.	Yes
18	M	*c oj - v*		
19	M	*- v oj c*		
20	G		"Date laid" considered to be incorrect (judging by visual appearance).	Yes
21	G/M	*oj*	"Date laid" considered to be incorrect (judging by visual appearance).	Yes
22	G		"Date laid" considered to be incorrect (judging by visual appearance).	Yes
23	G/M	*v -*	"Date laid" considered to be incorrect (judging by visual appearance).	Yes
24	G/M	*fj*	"Date laid" considered to be incorrect (judging by visual appearance).	Yes
25	M	*c v - oj*	"Date laid" considered to be incorrect (judging by visual appearance).	Yes
26	G			
27	G		"Date laid" considered to be incorrect (panel member with first hand knowledge of scheme). See also Site ref. 31 on the opposite carriageway which was part of the same scheme but has the same "Date Laid" - despite a 2 year construction programme.	Yes
28	M	*- oj c v*		
29	G	*oj*		
30	M	*- oj v c*	"Date laid" considered to be incorrect (judging by visual appearance).	Yes
31	G		"Date laid" considered to be incorrect (panel member with first hand knowledge of scheme). See also Site ref. 27 on the opposite carriageway which was part of the same scheme but has the same "Date Laid" - despite a 2 year construction programme.	Yes
32	M	*v - oj*	HAPMS records this as a single length. Two distinct materials evident - with same visual condition hence scored together.	Yes
33	E			
34	A/S	*oj fj - c v*	Temporary surfacing for roadworks started at Ch. 2,364m. Video stopped at this point.	
35	G/M	*oj v*		
36.a.	M	*oj v - fj c*	HAPMS records this as a single length. Two distinct materials evident - with considerably different condition.	Yes
36.b.	S/P	*v - c oj fj*		
37	M	*oj*	"Date laid" considered to be incorrect (judging by visual appearance).	Yes
38	G/M	*oj v*		
39	G			
40	M	*c v -*		

Appendix E. General analysis

Figure E-1: Summary of condition ratings of inspected sites



Appendix F. Correlation analyses

Table F-1: Condition –Vs- Age

CONDITION	Age (years) 0 to 5	5 to 10	10 to 15	15 to 20
E	3 [18] 1 14	1 33		
E/G	5 [9] [15] [19] [28] [30]			
G	11 [14] [26] 10 11 12 13 15 26 27 29 31	4 [8] [12] 20 39	2 [1] 22	
G/M	2 [17] [20]	6 [21] [25] 7 21 35 38	2 23 24	
M	6 [16] 9 16 19 28 30	8 [10] [22] [29] 18 32 36a 37 40	7 [2] [3] [4] 4 6 8 25	
M/A		2 [24] 2		
A				1 [6]
A/S		1 34		1 [5]
S		1 [11]		1 [7]
S/P		1 36b		
P		1 [23]	1 17	
P/B				
B				

KEY: X = Number of sites [A] = Site ref. (2012) B = Site ref. (2013)

Notes: *Site refs. #13 and #27 from 2012 discarded (HRA not TSCS)*
Site refs. #3 and #5 from 2013 discarded ("Date laid" clearly wrong & outside of the age ranges presented above)

Figure F-1: Condition –Vs- Age

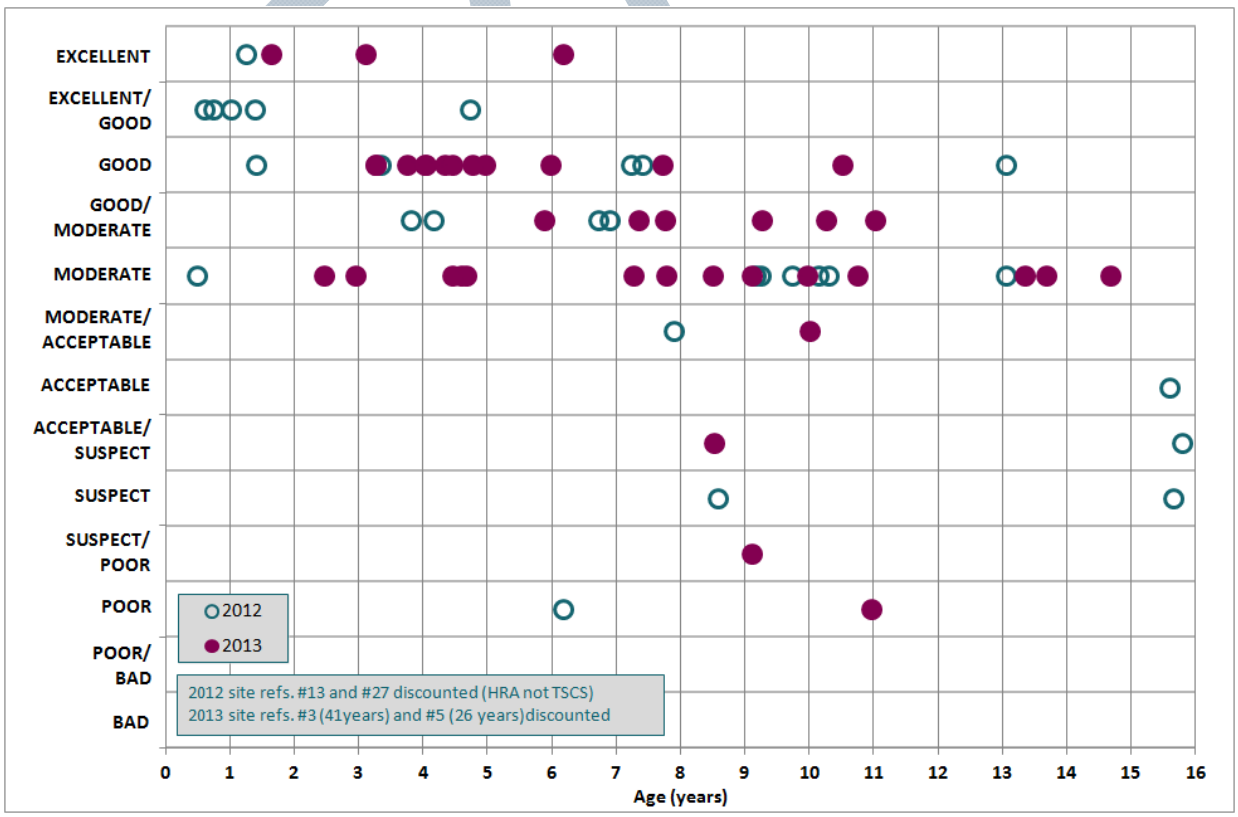


Figure F-2: Condition –Vs- Age regression analysis #1

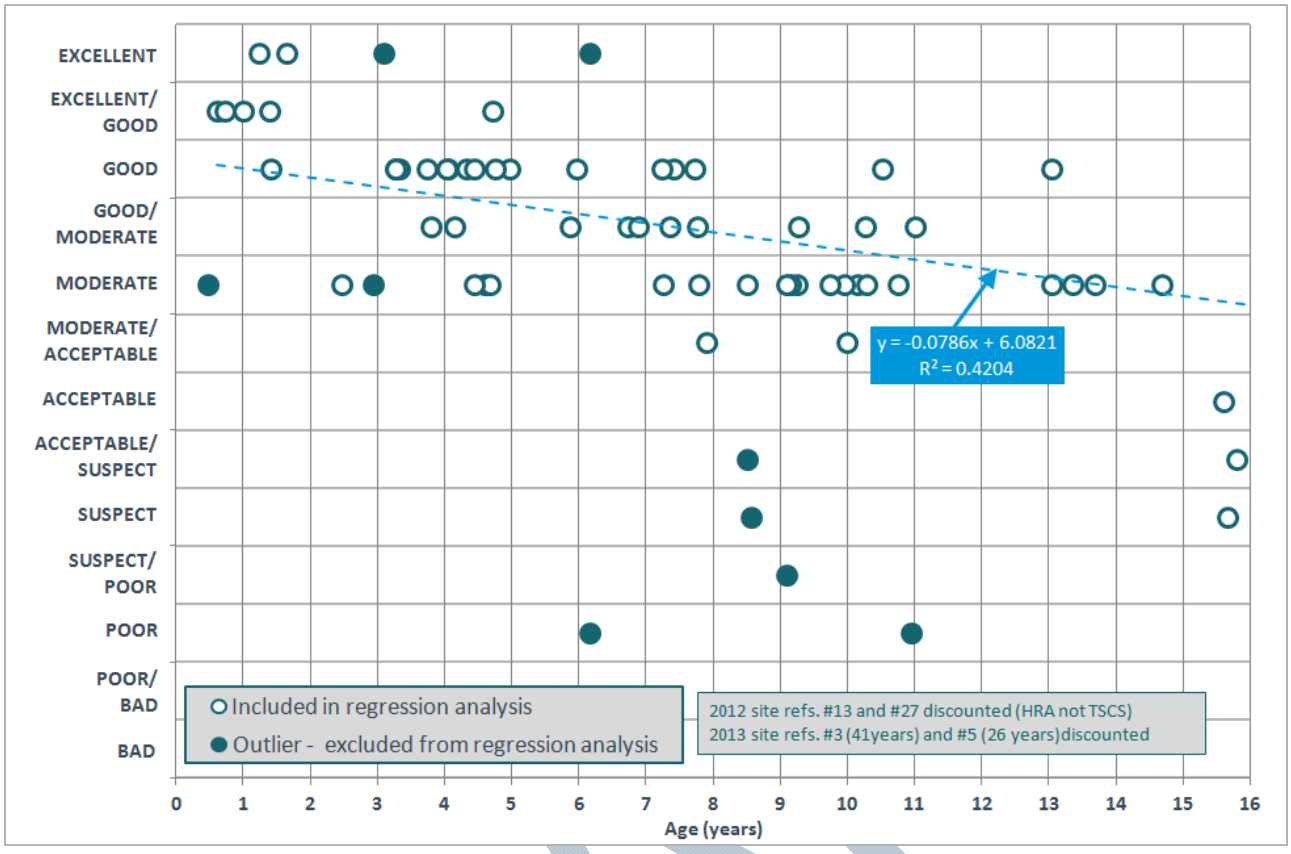


Figure F-3: Condition –Vs- Age regression analysis #2

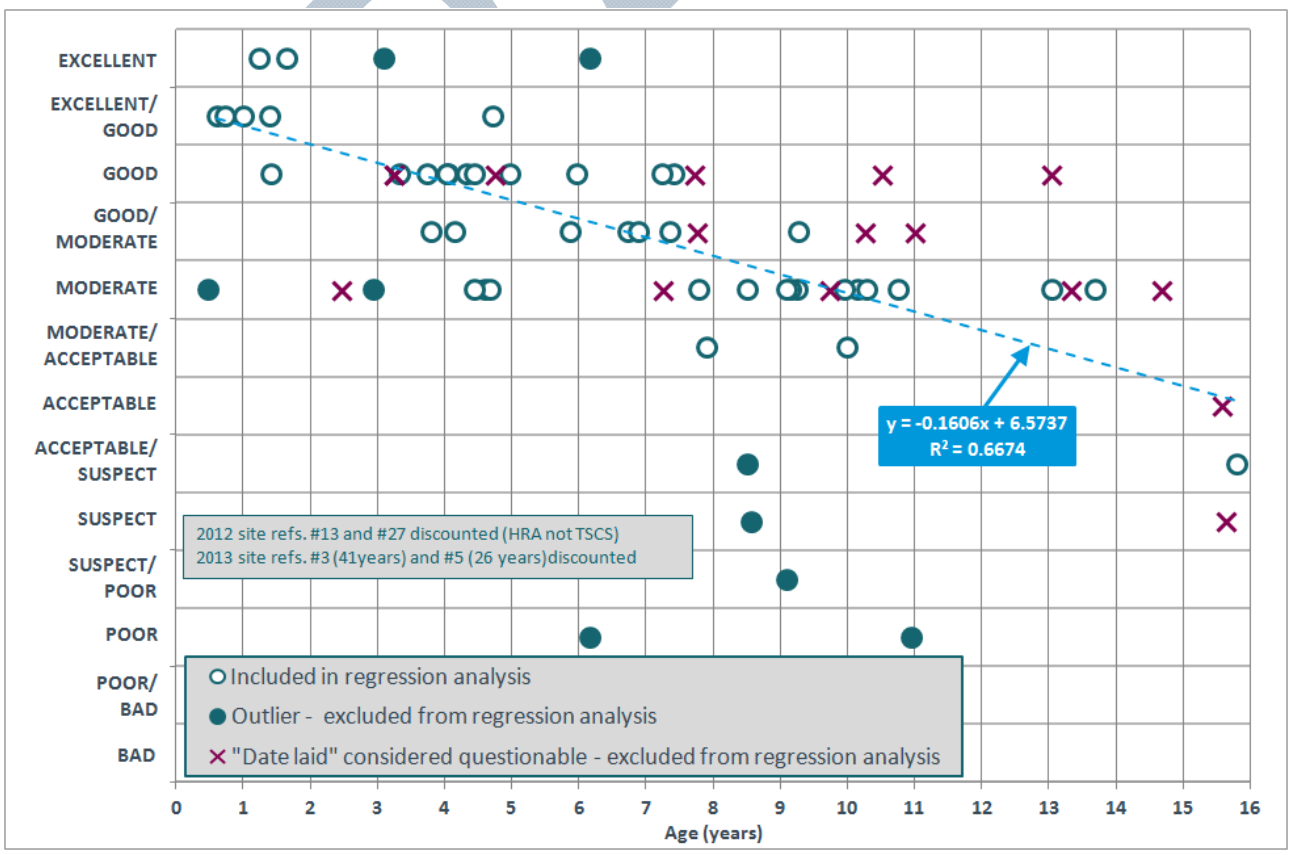


Table F-2: Condition –Vs- Thickness

CONDITION	Thickness (mm) =<25		26 to 30		31 to 35		36 to 40		> 40	
E			1	14	2	[18] 33			1	1
E/G	1	[9]			2	[19] [30]			2	[15] [28]
G	1	[8]	6	[1] [12] 13 15 26 29	5	[14] 12 22 27 31	3	[26] 20 39	2	10 11
G/M			2	7 35	3	[20] [25] 24	3	21 23 38	2	[17] [21]
M	1	16	6	[2] [3] [10] [29] 25 32	3	19 28 36a	5	[22] 18 30 37 40	7	[4] [16] 4 5 6 8 9
M/A							1	[24]	1	2
A			1	34			1	[6]	1	3
A/S					1	[5]				
S							2	[7] [11]		
S/P					1	36b				
P	1	17							1	[23]
P/B										
B										

KEY: X = Number of sites [A] = Site ref. (2012) B = Site ref. (2013)
Notes: *Site refs. #13 and #27 from 2012 discarded (HRA not TSCS)*

Figure F-4: Condition –Vs- Thickness and season laid

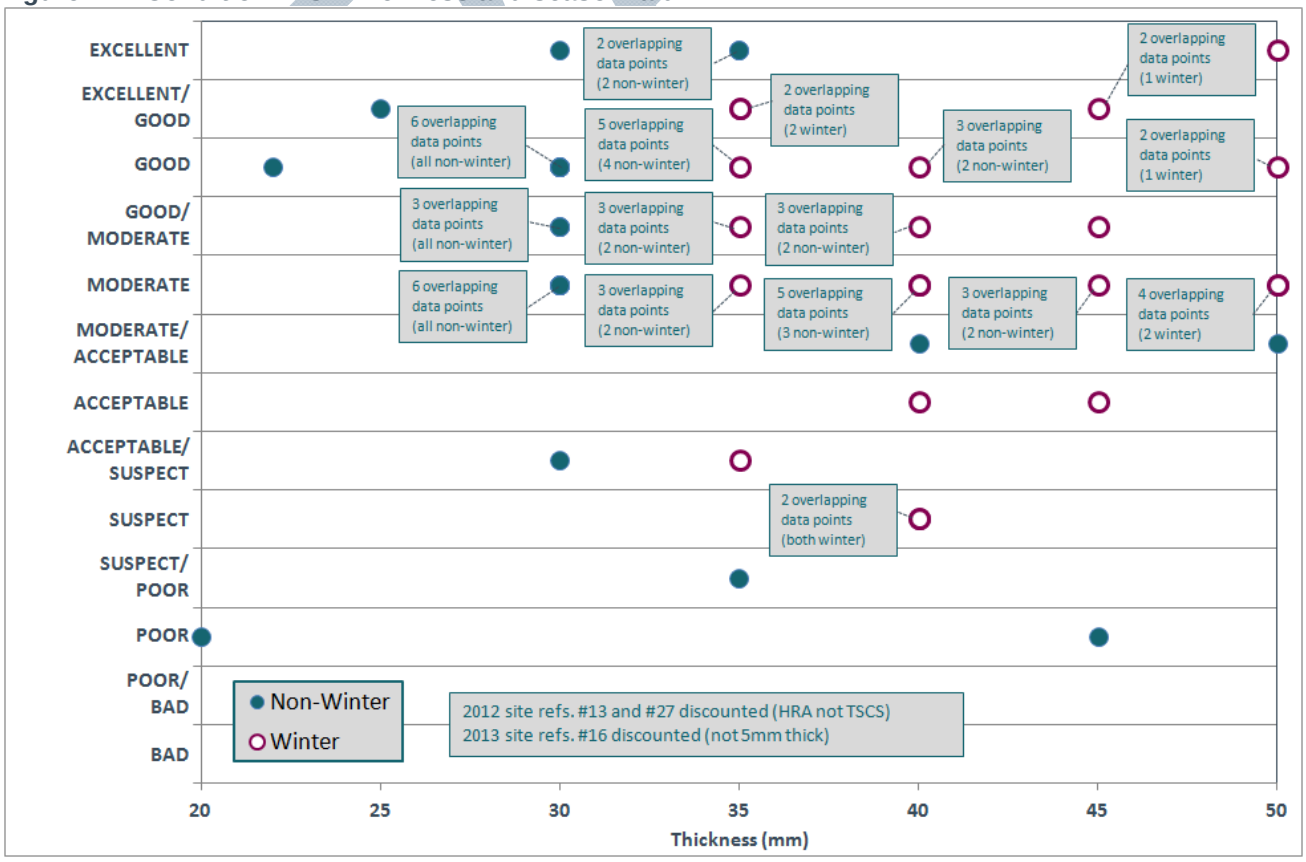


Table F-3: Condition –Vs- Thickness and season laid

CONDITION	Winter =<25	Winter 26 to 30	Winter 31 to 35	Winter 36 to 40	Winter > 40	Non-Winter =<25	Non-Winter 26 to 30	Non-Winter 31 to 35	Non-Winter 36 to 40	Non-Winter > 40
E					1 1		1 14	2 [18] 33		
E/G			2 [19] [30]		1 [28]	1 [9]				1 [15]
G			1 12	1 20	1 11	1 [8]	6 [1] [12] 13 15 26 29	4 [14] 22 27 31	2 [26] 39	1 10
G/M			1 [20]	1 21	1 [21]		3 [17] 7 35	2 [25] 24	2 23 38	
M	1 16		1 19	2 [22] 18	3 4 6 8		6 [2] [3] [10] [29] 25 32	2 28 36a	3 30 37 40	4 [4] [16] 5 9
M/A									1 [24]	1 2
A				1 [6]	1 3					
A/S			1 [5]				1 34			
S				2 [7] [11]						
S/P								1 36b		
P						1 17				1 [23]
P/B										
B										

KEY: X = Number of sites [A] = Site ref. (2012) B = Site ref. (2013)

Notes: *Site refs. #13 and #27 from 2012 discarded (HRA not TSCS)*

Table F-4: Condition –Vs- Age and season laid

CONDITION	Winter <= 10 years	Winter > 10 years	Non-Winter <= 10 years	Non-Winter > 10 years
E	1 *1*		3 *[18] 14 33*	
E/G	3 *[19] [28] [30]*		2 *[9] [15]*	
G	3 *11 12 20*		12 *[8] [12] [14] [26] 10 13 15 26 27 29 31 39*	2 *[1] 22*
G/M	3 *[20] [21] 21*		5 *[17] [25] 7 35 38*	2 *23 24*
M	4 *[22] 16 18 19*	3 *4 6 8*	10 *[10] [16] [29] 9 28 30 32 36a 37 40*	5 *[2] [3] [4] 5 25*
M/A			2 *[24] 2*	
A		2 *[6] 3*		
A/S		1 *[5]*	1 *34*	
S	1 *[11]*	1 *[7]*		
S/P			1 *36b*	
P			1 *[23]*	1 *17*
P/B				
B				

KEY: X = Number of sites [A] = Site ref. (2012) B = Site ref. (2013)
Notes: *Site refs. #13 and #27 from 2012 discarded (HRA not TSCS)*

Figure F-5: Condition –Vs- Age and season laid

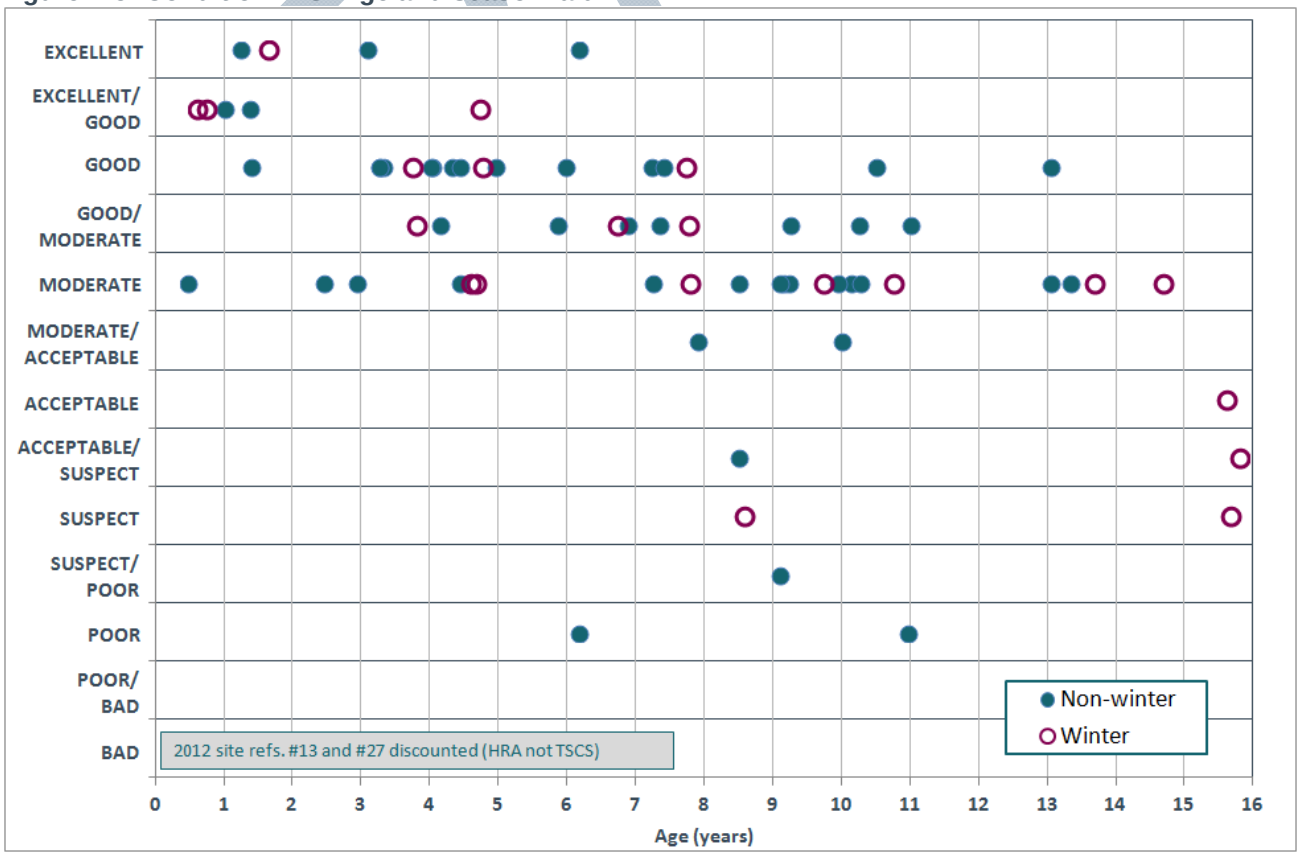


Figure F-6: Condition –Vs- Age and season laid. Matrix approach – individual condition results

Season		Age (years) 0 to 5				5 to 10				10 to 15				15 to 20			
Winter		E/G [19]	G/M [20]	E/G [28]	E/G [30]	S [11]	G/M [21]	M [22]	M 18	M 4	M 6	M 8		A/S [5]	A [6]	S [7]	
		E 1	G 11	G 12	M 16	G 20	G/M 21										
		M 19															
Non-winter		E/G [9]	G [14]	E/G [15]	M [16]	G [8]	M [10]	G [12]	P [23]	G [1]	M [2]	M [3]	M [4]				
		G/M [17]	E [18]	G [26]	M 9	M/A [24]	G/M [25]	M [29]	M/A 2	P 17	G 22	G/M 23	G/M 24				
		G 10	G 13	E 14	G 15	G/M 7	M 32	E 33	A/S 34	M 25							
		G 26	G 27	M 28	G 29	G/M 35	M 36a	S/P 36b	M 37								
		M 30	G 31			G/M 38	G 39	M 40									

KEY:

E G M A S P B = Condition marks (2012)
E G M A S P B = Condition marks (2013)
[1] to [30] = Site reference number (2012)
1 to 40 = Site reference number (2013)

Notes:
2012 site refs. #13 and #27 discounted (HRA not TSCS)
2013 site refs. #3 (41years) and #5 (26 years)discounted

Figure F-7: Condition –Vs- Age and season laid. Matrix approach – individual condition scores

Season	Age (years) 0 to 5				5 to 10				10 to 15				15 to 20			
Winter	6.5	5.5	6.5	6.5	3.0	5.5	5.0	5.0	5.0	5.0	5.0		3.5	4.0	3.0	
	7.0	6.0	6.0	5.0	6.0	5.5										
	5.0															
Non-winter	6.5	6.0	6.5	5.0	6.0	5.0	6.0	2.0	6.0	5.0	5.0	5.0				
	5.5	7.0	6.0	5.0	4.5	5.5	5.0	4.5	2.0	6.0	5.5	5.5				
	6.0	6.0	7.0	6.0	5.5	5.0	7.0	3.5	5.0							
	6.0	6.0	5.0	6.0	5.5	5.0	2.5	5.0								
	5.0	6.0			5.5	6.0	5.0									

Figure F-8: Condition –Vs- Age and season laid. Matrix approach – average condition scores and equivalent condition ratings

Season	Age (years) 0 to 5	5 to 10	10 to 15	15 to 20
Winter	6.0 Good	5.0 Moderate	5.0 Moderate	3.5 Acceptable/ Suspect
Non-winter	5.9 Good	4.9 Moderate	5.0 Moderate	

Figure F-9: Condition –Vs- Age and thickness. Matrix approach – individual condition results

Thickness (mm)	Age (years) 0 to 5	5 to 10	10 to 15	15 to 20
=<25	E/G [9]; M 16	G [8]	P 17	
26 to 30	G/M [17]; G 13; E 14	M [10]; G [12]; M [29]	G [1]; M [2]; M [3]	
	G 15; G 26; G 29	G/M 7; M 32; A/S 34	M 25	
		G/M 35		
31 to 35	G/M [14]; E [18]; E/G [19]	G/M [25]; E 33; M 36a	G 22; G/M 24	A/S [5]
	G/M [20]; E/G [30]; G 12	S/P 36b		
	M 19; G 27; M 28			
	G 31			
36 to 40	G [26]; M 30	S [11]; M [22]; M/A [24]	G/M 23	A [6]; S [7]
		M 18; G 20; G/M 21		
		M 37; G/M 38; G 39		
		M 40		
> 40	E/G [15]; M [16]; E/G [28]	G/M [21]; P [23]; M/A 2	M [4]; M 4; M 6	
	E 1; M 9; G 10		M 8	
	G 11			

KEY:

E G M A S P B = Condition marks (2012)
E G M A S P B = Condition marks (2013)
[1] to [30] = Site reference number (2012)
1 to 40 = Site reference number (2013)

Notes:
2012 site refs. #13 and #27 discounted (HRA not TSCS)
2013 site refs. #3 (41years) and #5 (26 years)discounted

Figure F-10: Condition –Vs- Age and thickness. Matrix approach – individual condition scores

Thickness (mm)	Age (years) 0 to 5	5 to 10	10 to 15	15 to 20
=<25	6.5; 5.0	6.0	2.0	
26 to 30	5.5; 6.0; 7.0	5.0; 6.0; 5.0	6.0; 5.0; 5.0	
	6.0; 6.0; 6.0	5.5; 5.0; 3.5	5.0	
		5.5		
31 to 35	5.5; 7.0; 6.5	5.5; 7.0; 5.0	6.0; 5.5	3.5
	5.5; 6.5; 6.0	2.5		
	5.0; 6.0; 5.0			
	6.0			
36 to 40	6.0; 5.0	3.0; 5.0; 4.5	5.5	4.0; 3.0
		5.0; 6.0; 5.5		
		5.0; 5.5; 6.0		
		5.0		
> 40	6.5; 5.0; 6.5	5.5; 2.0; 4.5	5.0; 5.0; 5.0	
	7.0; 5.0; 6.0		5.0	
	6.0			

Figure F-11: Condition –Vs- Age and thickness. Matrix approach – average condition scores and equivalent condition ratings (#1)

Thickness (mm)	Age (years) 0 to 5	5 to 10	10 to 15	15 to 20
=<25	5.750 Good	6.000 Good	2.000 Poor	
26 to 30	6.083 Good	5.071 Moderate	5.250 Good/ Moderate	
31 to 35	5.900 Good	5.000 Moderate	5.750 Good/ Moderate	3.500 Acceptable/ Suspect
36 to 40	5.500 Good/ Moderate	5.050 Moderate	5.500 Good/ Moderate	3.500 Acceptable/ Suspect
> 40	6.000 Good	4.000 Acceptable	5.000 Moderate	

Figure F-12: Condition –Vs- Age and thickness. Matrix approach – average condition scores and equivalent condition ratings (#2)

Thickness (mm)	Age (years) 0 to 5	5 to 15	15 to 20
=<25	5.750 Good	4.000 Acceptable	
26 to 30	6.083 Good	5.136 Moderate	
31 to 35	5.900 Good	5.250 Good/ Moderate	3.500 Acceptable/ Suspect
36 to 40	5.500 Good/ Moderate	5.091 Moderate	3.500 Acceptable/ Suspect
> 40	6.000 Good	4.571 Moderate/ Acceptable	

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