Early life skid resistance – an assessment of accident risk

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EARLY LIFE SKID RESISTANCE – AN ASSESSMENT OF ACCIDENT RISK

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Executive summary

In the mid 1990s, new road surfacing materials were introduced in the UK that provided advantages such as faster and safer construction techniques, improved ride and reduced tyre/road noise. In the years following the introduction of the new materials there was an increase in anecdotal comment related both to dry and wet skidding resistance in the first few months of service, reinforced by police comments on lower than usual dry friction found in routine stopping-distance skid tests on some relatively new surfacings.

These materials often have a thicker initial binder film than traditional materials, such as Hot Rolled Asphalt (HRA), which may cause them to exhibit different skid resistance properties compared to roads that have been in service for some time. It was thought that the binder film could mask the microtexture of the aggregate in the surfacing and could also soften at the high temperatures generated by severe braking, both of which could affect the friction available.

This report is the second in a series covering studies into the effects of decreased skid resistance on new asphalt surfacings early in their lives. Previous work has identified physical phenomena that might lead to an increase in accident risk in some circumstances. The report on that study by TRL on behalf of the Highways Agency (PPR060) made a number of recommendations, of which the first was that “Specific research into any link between new surfacings and accident risk should be carried out”.

That study has now been carried out, using a combination of:

- An analysis of accidents before and after resurfacing on the Highways Agency (HA) network.
- Collation and review of anecdotal comment from the HA’s Area Teams and Maintaining Agents, and from other Highway Authorities.

1. Accidents before and after resurfacing

The basis of the analysis was a “before and after” study of accident statistics for sections of the Highways Agency (HA) network in the periods before and after a new surface had been laid as a result of maintenance works. The objective was to determine whether any significant changes in accident numbers occurred after the new surfacing had been laid. The analysis was developed through a number of stages which are summarised below.

- Identify sections that had been resurfaced.
- Analyse accidents for all the sections over the year before and year after resurfacing, broken down by quarters to allow for different trends to be identified. This included a breakdown of accidents by road class, severity, section function and perceived accident risk (judged by skid resistance Investigatory Level).
- A more detailed analysis on those sections where modern asphalt surfacings (so-called “thin surfacings”) had been laid. This included an examination of accidents by road class, road surface condition and severity and a comparison of accidents on dry and wet/damp roads.
- The first phase had identified locations where resurfacing had occurred but not necessarily along the whole length (or on all lanes of dual carriageways) of the relevant sections. A further analysis was therefore made that was confined to those sections that had been substantially resurfaced (>80% of the lane length) with the same new surfacing material.
- The earlier work, reported by TRL in PPR060, had suggested that the physical phenomena observed on new thin surfacings might also have been present with traditional surfacings such as Hot Rolled Asphalt (HRA). To try and assess whether there was an associated increased accident risk on traditional as well as modern types of surfacing material, an analysis was made of accidents on the limited number of sections on the trunk road network treated in the study period where HRA surfacing had been used.
- General accident trends on the HA network during the analysis period were also determined to set a context for assessing the accident trends seen on the resurfaced sections.
2. **Review of anecdotal comment**

Requests for information were circulated via HA Area Performance Managers, County Material Engineers and members of the CSS Highway Condition Assessment Group with instructions to circulate it to representatives best placed to provide relevant information. A total of eight responses were received from the HA maintenance areas and 18 from other UK Highway Authorities. Follow-up meetings were also held with some of the Highway Authorities.

Other Highway Authorities were included in this element of the project because parts of their road networks are very different to those of the HA and it was felt that different issues could arise, or be more apparent, on these networks.

The main report includes detailed analysis of accident numbers in relation to the various factors and a discussion of the findings in relation to the physical phenomena observed previously.

There were some variations but overall the accident data show that on trunk roads:

(i) In the twelve months following resurfacing the accident risk is similar to or lower than before resurfacing.

(ii) There is a significant decrease in fatal accidents on the resurfaced sections.

(iii) There is a small, but statistically significant increase in accident risk in the initial months after laying modern asphalt surfacings. This is associated mainly with accidents on motorway and A(M) sections and those occurring in dry conditions.

(iv) Although accident numbers increase by a small proportion on new surfacings, the additional accidents are in the “slight” severity category.

(v) The period of increased risk appears to last for up to about six months after laying.

(vi) Some of the accident increases are also apparent on more traditional surfacings but are probably shorter lived, although the numbers of sections for which data are available are too small to provide a robust study.

(vii) In addition the accident rates on the resurfaced sections are somewhat lower than those for the entire HA network. However, the nature of the sections included within the analysis may not be indicative of the network as a whole.

The information from the anecdotal reports suggests that early life skid resistance issues are not widespread, either on the HA or other UK Highway Authority networks. However it would appear that it could be a contributory factor in a small proportion of accidents, that occur mainly on bends.

The findings from this study are generally consistent with the physical phenomena that have been measured on new asphalt surfacings.

Neither of the approaches used in the study identified widespread problems with modern asphalt surfacings in their early life but there is evidence of a small increased accident risk. Therefore, in the light of this evidence it is recommended that:

1. Current guidance on the use of warning signs for new asphalt surfacings should be reviewed and updated where justified.

2. Work to follow up the other recommendations of the previous research should continue: this should include work on methods to mitigate risks and further studies to improve understanding of the physical phenomena.

3. The need and methods for providing drivers with better information should be reviewed in the light of this report and the findings from recommendations 1 and 2 outlined above.
1 Introduction

The Highways Agency has an overriding objective to maintain the trunk road network in a safe and serviceable condition whilst minimising disruption and whole life costs. To assist in achieving this objective the Agency has developed a skid resistance policy for the trunk road network which is implemented through HD28 ‘Skidding Resistance’ in the Design Manual for Roads and Bridges (DMRB 7.3.1). The policy aims to equalise the risk of wet skidding accidents across the network by setting a level of skid resistance that is appropriate to the nature of the road environment at each location on the network. These levels are monitored routinely which enables sections of the network falling below specified levels to be identified, so that the need for maintenance to improve the skid resistance can be investigated and prioritised.

However, when an asphalt road surfacing is newly laid, the aggregate and mortar are covered with a film of bitumen binder. For some years it has been suspected that new asphalt surfaces may exhibit different friction properties compared with roads that have been in service for some time as a result of this bitumen film. Any such effects have probably always been present but, until recently, there has been no suitable equipment available to investigate them and help determine what impact they might actually have on accident risk.

In recent years, new surfacings have been introduced on the network that provide advantages such as faster and safer construction techniques, improved ride and reduced tyre/road noise. However, these materials often have a thicker initial binder film than traditional materials, which may have increased both the likelihood of different friction performance and the time that any effects last. There has also been an increase in anecdotal comment related both to dry and wet skidding resistance in the first few months of service. In addition, the police have commented on lower than usual dry friction found in their stopping-distance skid tests on some relatively new surfacings. These factors have led to a raised awareness of the topic both in the Highways Agency (HA) and in other UK Highway Authorities.

Research undertaken by TRL, on behalf of HA, has identified physical phenomena that might lead to an increase in accident risk in some circumstances. Further details of the work are provided in Section 2.

This project was commissioned by HA to investigate whether the physical phenomena identified in the earlier study did have an influence on accident risk.

Two approaches have been taken to assess the risks, namely:

1. An analysis of accidents on sections of the network where maintenance has resulted in a new surface being laid in recent years.

2. Gathering and collation of anecdotal comment from the Highways Agency, their Maintaining Agents and also from other UK Highway Authorities.
2 Background

In 2002, HA commissioned TRL to carry out an initial assessment of the skid resistance effects of asphalt surfacings in their early life. The project was supported with in-kind assistance and a small financial contribution from CSS (formerly the County Surveyors Society). This work led to interim advice being published in 2003 (HA, 2003), based on the initial findings of the study, that required the use of warning signs on new asphalt surfaces in some circumstances. Full details of the programme of work were published in TRL PPR060 (Roe and Lagarde-Forest, 2005).

That report provided an overview of the results of the various tests undertaken and discussed the findings in some detail, both in the context of the physical phenomena observed and the implications for accident risk.

The measurements made as part of the project demonstrated that:

- Low-speed wet friction is high, even though a binder film covers the microtexture on the aggregate.
- Wet skid resistance decreases with increasing speed, as would be expected. The new surfaces have lower wet skid resistance at higher speeds than would be expected for surfacing materials for which the aggregate is unpolished and the texture depth is good but the levels are similar to many materials after some time in service.
- Dry friction reduces with speed but does not follow the same pattern as for wet roads: the minimum level is reached at about 50km/h and does not decrease further at higher speeds.
- Compared with the high levels generally obtained on older surfaces, from which the binder film has worn off, dry friction on new asphalt can be lower, by up to about 20 percent at low speeds and by about 30-40 percent at intermediate and higher speeds.
- At low and intermediate speeds, dry friction is similar to wet friction. At very low speeds, the high level of wet friction can exceed the dry friction.
- Although sliding friction levels at high speeds on binder-coated surfaces are lower than that found on dry roads with aggregate exposed, they are nonetheless much higher than wet friction.
- The effects can be observed on any new surfacing, but the length of time for which they persist will vary depending upon local conditions and traffic levels. Typically, most effects have disappeared after six months but they may persist longer and have been observed for up to 18 months on surfaces with light traffic and thicker binder films.

On the basis of these results it was concluded that the interim advice provided by the Highways Agency in IAN 49/03 remained the best advice regarding the management of new surfacings.

However, in the light of the findings of the research, the following recommendations were made:

1. Specific research into any link between new surfacings and accident risk should be carried out.
2. Consideration should be given to alternative methods of ameliorating the residual risk in those locations where the properties of new surfacings may have a significant adverse effect. In particular, a review should be made of appropriate warning signs that will better inform drivers as to the nature of the risk.
3. Consideration should be given to improved education regarding new surfacings so that drivers are better informed. This might include additional advice in the Highway Code regarding driving on new surfaces.
4. The literature shows that other workers have found that modern new surfacings may be unusually slippery in the first few hours or days after they are laid. This effect has not been observed in this study but further research to assess this aspect more thoroughly should be considered.

This report addresses recommendation 1 to determine if there is a link between new surfacings and accident risk. Other projects are in progress, or are planned, to address recommendations 2, 3 and 4.
and also some other issues that have been identified since the publication of PPR060, such as the effects of high temperatures on skid resistance.
3 Basis of the accident analysis

During previous phases of the research into early life skid resistance, reported by TRL in PPR060 (Roe and Lagarde-Forest, 2005) physical phenomena had been identified that suggested that there was a potential for a small increase in the risk of accidents on new asphalt surfaces in some circumstances. The purpose of the accident analysis reported herein was to assess whether there was evidence for an increase in accident risk in injury accident statistics associated with new surfacings.

The basis of the analysis, therefore, was to examine accidents statistics for sections\(^1\) of the Highways Agency (HA) network in the periods before and after a new surface had been laid as a result of maintenance works. The objective was to determine whether any significant changes in accident numbers occurred after the new surfacing had been laid. The analysis was developed through a number of stages which are summarised below.

- The first stage was to identify sections that had been resurfaced, the material used and when it was laid.
- This was followed by an initial accident analysis covering all the resurfaced sections, including a breakdown of accidents by road class, severity, section function and perceived accident risk (judged by skid resistance Investigatory Level).
- Awareness of the issue of possible increased risk on new surfaces has apparently been associated with the more widespread use of thin surfacings in recent years. A more detailed analysis was therefore undertaken on those sections where thin surfacings had been laid. This included an examination of accidents by road class, road surface condition and severity. Because physical phenomena had been identified that could influence accident risk in both wet and dry conditions, the accidents on dry and wet/damp roads were also assessed by road class and accident severity.
- The first phase had identified locations where resurfacing had occurred but not necessarily along the whole length (or on all lanes of dual carriageways) of the relevant sections. A further analysis was therefore made that was confined to those sections that had been substantially resurfaced (>80% of the lane length) with the same new surfacing material.
- The earlier work had suggested that the physical phenomena observed on new thin surfacings might also have been present with traditional surfacings such as Hot Rolled Asphalt (HRA). To try and assess whether there was an associated increased accident risk on traditional, as well as modern types of surfacing material, an analysis was made of accidents on the limited number of sections on the HA network treated in the study period where HRA surfacing had been used.
- General accident trends on the HA network during the analysis period were also determined to set a context for assessing the accident trends seen on the resurfaced sections.

3.1 Approach taken

3.1.1 Identifying resurfaced lengths of the HA network

As accidents are relatively rare, random events on any given length of carriageway, many resurfaced lengths need to be considered together in order to include sufficient accidents for the analysis to be robust. To achieve this, the location and dates of maintenance treatments undertaken between January 2001 and December 2004 were obtained by examining data from the Highways Agency Pavement Management System (HAPMS) and discussions with HA Maintaining Agents. The information from

\(^1\) For location referencing purposes, the HA network is divided into Sections. Each Section is typically 1-2km in length and encompasses a length of carriageway with similar features, such as number of lanes, road function, etc.
HAPMS was obtained by querying the ‘date laid’ and ‘surface type’ fields within the database. It was recognised that the information held in HAPMS is not updated on a uniform basis by the HA’s Maintaining Agents to meet the needs of this particular research. Therefore a selection of Agents were contacted to determine whether they held any more detailed records, but this approach did not produce any more detailed information. Nonetheless, it is believed that the extent and quality of the data within the analysis are sufficient to make it valid.

3.1.2 Accident data used

Accident data for the trunk road network were obtained from the STATS19 injury accident records assigned to the HA network sections within HAPMS. Due to the inherent uncertainties relating to the precise locations of accidents and the factors that caused or contributed to them, the analysis was undertaken on whole sections even if the entire section had not been resurfaced. It was assumed that for any given section the accident risk factors would remain reasonably constant in the before and after periods of the analysis, other than those relating to the part of the section that had been resurfaced.

The accident data covered the three years preceding treatment and the 12 month period following treatment in order to quantify the risk associated with the presence of newly laid asphalt surfaces. In order to estimate the period of time for which any increased risk occurs, the accidents in the 12 month ‘after’ period were examined on a quarterly basis. It should be noted that it is common when undertaking accident analysis to assess data for a three year period before or after the date that an event that may affect accident numbers, for example remodelling of a junction or deployment of safety cameras, has occurred. However as the phenomena related to skid resistance of asphalt surfaces in their early life are believed to be relatively short lived, it was decided to restrict the majority of the analysis to a period of one year before to one year after resurfacing works had taken place.

When undertaking accident analyses it is usual, if possible, to look at accident rates rather than numbers. For this analysis monthly traffic data for each section would be required for the 12 months before and after resurfacing. However, interrogation of the HA’s traffic database (TRADS2) found that complete traffic data were available only for about 2 per cent of the sections within the analysis. Further examination of the traffic data found that there were fluctuations during the year and for the same month between years, but no general trend could be applied to all the sites. However where complete data were available, they showed that the traffic flows in the one year before period and the one year after period varied by about ±6%. As such the effect on accident rates due to variations in traffic levels would be small. The majority of the data presented in this report therefore relate to accident numbers.

However some of the analysis has used accident rates per km of road as this provides a better indication of accident risk at different types of site.

3.2 Number and range of the resurfaced sections included in the analysis

Accident data from the STATS19 records assigned to the HA network sections were available up to the end of 2005. Therefore, in order to have one complete year of after data, sites resurfaced between 2001 and 2004 were used for this analysis. Maintenance schemes prior to 2001 were not included as the data within HAPMS are less robust. Details of resurfacing were obtained via HAPMS for the 14 HA Maintenance Areas. Some of the sections identified were excluded from the analysis on the basis that:

- Less than 10% of the total lane length within the section had been resurfaced. Where only a small proportion of the section had been resurfaced it is unlikely that accidents could be linked to the new surfacing.
Multiple material types had been recorded as being used within a section. However, where short lengths of high friction surfacings (HFS) had been used with another surfacing, these sections were included with the material type for the section being classed as that with the majority of surfacing.

Sections classed as lay-bys.

Sections where the surfacing had been recorded as pavement quality concrete, dense bitumen macadam (DBM), high modulus roadbase (HMB) or surface dressing. These materials accounted for only a small number of sections and are not typical of surfacing materials used in maintenance schemes. Indeed DBM and HMB are no longer permitted as surface courses by HA. The concrete sections are likely to be due to bay replacements on concrete carriageways.

Sections where resurfacing had been recorded on separate dates more than 2 months apart.

This resulted in a total of 2136 sections representing 1834 carriageway-km being included in the initial analysis. The number of sections and total length of sections within each of the HA’s Maintenance Areas are shown in Table 3-1.

Table 3-1 Number and total length of sections by Area

<table>
<thead>
<tr>
<th>Area No.</th>
<th>Number of sections</th>
<th>Total section length (km)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62</td>
<td>65</td>
</tr>
<tr>
<td>2</td>
<td>97</td>
<td>81</td>
</tr>
<tr>
<td>3</td>
<td>190</td>
<td>145</td>
</tr>
<tr>
<td>4</td>
<td>194</td>
<td>177</td>
</tr>
<tr>
<td>5</td>
<td>160</td>
<td>149</td>
</tr>
<tr>
<td>6</td>
<td>131</td>
<td>116</td>
</tr>
<tr>
<td>7</td>
<td>22</td>
<td>18</td>
</tr>
<tr>
<td>8</td>
<td>306</td>
<td>291</td>
</tr>
<tr>
<td>9</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>282</td>
<td>205</td>
</tr>
<tr>
<td>11</td>
<td>109</td>
<td>85</td>
</tr>
<tr>
<td>12</td>
<td>276</td>
<td>215</td>
</tr>
<tr>
<td>13</td>
<td>167</td>
<td>174</td>
</tr>
<tr>
<td>14</td>
<td>128</td>
<td>92</td>
</tr>
<tr>
<td>Total</td>
<td>2136</td>
<td>1834</td>
</tr>
</tbody>
</table>

* Complete section may not have been resurfaced.

Table 3-2 shows the distribution of works undertaken during each month of the four years included in the analysis. The works are reasonably evenly spread. This means that any seasonal variations in traffic flows would be evened out within the accident analysis making the availability of traffic flow data less significant. In addition, the spread of works during the year would reduce the effect of seasonal weather conditions on accident numbers in the initial period after resurfacing.
Table 3-2  Section lengths by month and year resurfaced

<table>
<thead>
<tr>
<th>Year</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>6</td>
<td>19</td>
<td>40</td>
<td>1</td>
<td>0</td>
<td>41</td>
<td>26</td>
<td>41</td>
<td>12</td>
<td>20</td>
<td>11</td>
<td>43</td>
<td>258</td>
</tr>
<tr>
<td>2002</td>
<td>40</td>
<td>19</td>
<td>43</td>
<td>39</td>
<td>35</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>26</td>
<td>53</td>
<td>52</td>
<td>36</td>
<td>102</td>
</tr>
<tr>
<td>2003</td>
<td>19</td>
<td>2</td>
<td>66</td>
<td>13</td>
<td>55</td>
<td>72</td>
<td>108</td>
<td>15</td>
<td>39</td>
<td>61</td>
<td>46</td>
<td>86</td>
<td>582</td>
</tr>
<tr>
<td>2004</td>
<td>17</td>
<td>18</td>
<td>58</td>
<td>14</td>
<td>30</td>
<td>24</td>
<td>74</td>
<td>68</td>
<td>42</td>
<td>57</td>
<td>55</td>
<td>55</td>
<td>512</td>
</tr>
<tr>
<td>Total</td>
<td>81</td>
<td>58</td>
<td>208</td>
<td>67</td>
<td>119</td>
<td>155</td>
<td>226</td>
<td>150</td>
<td>146</td>
<td>190</td>
<td>148</td>
<td>286</td>
<td>1834</td>
</tr>
</tbody>
</table>

The distributions of the sections included in the analysis across road class, road function and material type are provided in Table 3-3. This shows that, as would be expected, the majority of the surfacings laid were thin surfacings. The sections were reasonably equally distributed between A class roads and A(M)/motorways (44 and 56% respectively). Details of the section lengths by road class and function are given in Table 3-4 and these show that the section lengths for the two classes of road were distributed on a similar ratio.

Table 3-3  Sections by road class, function and material type

<table>
<thead>
<tr>
<th>Road class</th>
<th>Function</th>
<th>Thin surfacing</th>
<th>Hot Rolled Asphalt (HRA)</th>
<th>High Friction Surfacing (HFS)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Main carriageway</td>
<td>691</td>
<td>30</td>
<td>32</td>
<td>753</td>
</tr>
<tr>
<td></td>
<td>Roundabout</td>
<td>40</td>
<td>3</td>
<td>14</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Slip road</td>
<td>107</td>
<td>5</td>
<td>22</td>
<td>134</td>
</tr>
<tr>
<td>M and A(M)</td>
<td>Main carriageway</td>
<td>848</td>
<td>41</td>
<td>2</td>
<td>891</td>
</tr>
<tr>
<td></td>
<td>Roundabout</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Slip road</td>
<td>242</td>
<td>29</td>
<td>25</td>
<td>296</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1932</td>
<td>109</td>
<td>95</td>
<td>2136</td>
</tr>
</tbody>
</table>

Table 3-4  Section numbers and lengths by road class and function

<table>
<thead>
<tr>
<th>Function</th>
<th>A road</th>
<th>M and A(M)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of sections</td>
<td>Length (km)</td>
</tr>
<tr>
<td>Main carriageway</td>
<td>753</td>
<td>705</td>
</tr>
<tr>
<td>Roundabout</td>
<td>57</td>
<td>15</td>
</tr>
<tr>
<td>Slip road</td>
<td>134</td>
<td>62</td>
</tr>
<tr>
<td>Total</td>
<td>944</td>
<td>782</td>
</tr>
</tbody>
</table>
4 Initial accident analysis

The purpose of the initial analysis was to determine whether any significant patterns could be observed when comparing the before and after periods of the analysis and how these related to road type, accident severity and the perceived risk level of the site.

4.1 Setting the analysis parameters

The initial analysis included all the resurfaced sections and examined the number of accidents in the three years before resurfacing and the 12 months after. In this initial analysis those accidents occurring on the ‘date laid’ recorded in HAPMS were excluded, i.e. the before period ends the day before the date laid and the after period starts the day after the date laid.

The accidents in each month before and after resurfacing were summed over all the sites. Figure 4-1 shows the number of accidents per month during the three years before and the year after resurfacing.

Figure 4-1 shows that there is considerable variation in the number of accidents occurring each month and it was therefore decided to view the data on a quarterly basis to reduce these fluctuations. This approach would enable any trends in the accident numbers to be more readily distinguished from the background variation in the data. Figure 4-1 also shows an increase in accidents in the month prior to the ‘date laid’. These accidents could include those occurring in roadworks while the schemes are being undertaken, as the initial analysis only excluded the single ‘date laid’ day, i.e. no allowance was made for the time taken to complete the works.

HA Maintaining Agents were therefore consulted to clarify the date that they entered in HAPMS as the ‘date laid’ and to determine the period of time taken generally to complete maintenance schemes; obviously this will vary depending on the size of the scheme. Following these consultations it was decided to end the ‘before’ period 60 days prior to the ‘date laid’ and commence the ‘after’ period 30 days later. This effectively gave a zero quarter during which the schemes would have been
undertaken. This had the result of having to exclude sites resurfaced in December 2004 from any further analysis as the ‘year after’ accident data would extend into 2006 and these data were not available at the time of writing. Figure 4-2 shows the number of accidents by monitoring quarter.

![Graph showing number of accidents over time](image)

**Figure 4-2** Number of accidents in 3 years before and 1 year after resurfacing by quarter with zero quarter (-60 to +30 days)

### 4.2 Results of the initial analysis

#### 4.2.1 Analysis of accidents by road class and accident severity

The data were then analysed to determine the variation in accident numbers by road class and accident severity. The accident numbers in each quarter after resurfacing (calculated as annual equivalent values, i.e. the number of accidents in the quarter multiplied by four) were compared with the value for the year before resurfacing and the difference was tested for statistical significance.

For this purpose, the random nature of accidents can be described with a Poisson distribution, where the variance is equal to the mean value. The 95% confidence limit of a difference between the accidents in the year before resurfacing and the accidents per year in the analysis quarter is calculated as 1.96 multiplied by the square root of the sum of the year before value and the analysis quarter value.

The results of this analysis are presented in Table 4-1a and b and Table 4-2 for road class and accident severity respectively. Table 4-1a presents actual accident numbers while 4b presents the data in terms of accident rates (accidents per km per year). The use of accident rates enables a comparison of the values to the HA network in general.

Throughout these and later analyses, results that are statistically significantly different at at least the 5% level are highlighted in green (reduction in accidents) or orange (increase in accidents). The change has been shown as the difference in each quarter from the one year before (1YB) value, expressed as a percentage of the 1YB value.
Table 4-1a  Accidents numbers before and after resurfacing by road class

<table>
<thead>
<tr>
<th>Road class</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
<td>Q0</td>
</tr>
<tr>
<td>A</td>
<td>932</td>
<td>1000</td>
</tr>
<tr>
<td>M and A(M)</td>
<td>1369</td>
<td>1524</td>
</tr>
<tr>
<td>Total</td>
<td>2301</td>
<td>2524</td>
</tr>
</tbody>
</table>

Table 4-1b  Accidents rates before and after resurfacing by road class

<table>
<thead>
<tr>
<th>Road class</th>
<th>Accidents per km per year (annual equivalent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
</tr>
<tr>
<td>A</td>
<td>1.19</td>
</tr>
<tr>
<td>M and A(M)</td>
<td>1.30</td>
</tr>
<tr>
<td>Total</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Table 4-2  Accidents before and after resurfacing by accident severity

<table>
<thead>
<tr>
<th>Accident severity</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
<td>Q0</td>
</tr>
<tr>
<td>Fatal</td>
<td>70</td>
<td>40</td>
</tr>
<tr>
<td>Serious</td>
<td>282</td>
<td>256</td>
</tr>
<tr>
<td>Slight</td>
<td>1949</td>
<td>2228</td>
</tr>
<tr>
<td>Total</td>
<td>2301</td>
<td>2524</td>
</tr>
</tbody>
</table>

The data show that there is a statistically significant increase in the numbers of accidents during Q0 (the period during which the works will have been undertaken) and Q1 (the first three months following completion of the works), but that the numbers then reduce compared to the year before in Quarters 2 and 3. The increase in numbers in Q0 and Q1 are attributable to accidents on M and A(M) class roads but, as shown in Table 4-2, the majority of these accidents are slight in severity. It is also clear that there is a significant reduction in fatal accidents following the maintenance works.

The increase in accidents during Q0 may be associated with the traffic management for the works but could also be influenced by the new surfacing. On larger schemes, lengths of carriageway will be opened to traffic as the scheme progresses. However due to the limitations of the available data it is not possible to separate out these different phenomena.

It should also be noted that the total number of accidents in the year following resurfacing (Q1-Q4) is 2266, i.e. 1.5% lower than in the year before resurfacing. Although not a significant reduction, this demonstrates that in the longer term the overall accident risk remains sensibly constant. In addition the accident rates on the resurfaced sections are somewhat lower than those for the entire HA network, where the accident rate was 2.29 accidents per km and 1.6 accidents per km on non-junction.
lengths of carriageway during 2005 (HA, 2006). However, the nature of the sections included within the analysis may not be indicative of the network as a whole.

### 4.2.2 Analysis of accidents by section function and risk level

A further analysis was completed to determine whether the road function and perceived risk levels contributed to the changes in accident numbers. Table 4-3a and b present the accident data, in terms of numbers and rates respectively, classified by road function assigned to the section within HAPMS. Table 4-4 divides the data by the maximum Investigatory Level assigned to the section. The HA’s skid resistance standard HD28/04 requires each part of the network to be assigned an Investigatory Level of skid resistance based on the perceived level of risk at each site with higher risk sites being assigned a higher Investigatory Level. Higher risk sites include, for example, the approaches to junctions, roundabouts and pedestrian crossings, sharp bends, and steep gradients.

#### Table 4-3a Accidents before and after resurfacing by section function

<table>
<thead>
<tr>
<th>Section function</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
<td>Q0</td>
</tr>
<tr>
<td>Main c’way</td>
<td>1841</td>
<td>2064</td>
</tr>
<tr>
<td></td>
<td>12.1</td>
<td>13.6</td>
</tr>
<tr>
<td>Roundabout</td>
<td>94</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>19.1</td>
<td>-2.1</td>
</tr>
<tr>
<td>Slip road</td>
<td>366</td>
<td>348</td>
</tr>
<tr>
<td></td>
<td>-4.9</td>
<td>-24.6</td>
</tr>
<tr>
<td>Total</td>
<td>2301</td>
<td>2524</td>
</tr>
</tbody>
</table>

#### Table 4-3b Accident rates before and after resurfacing by section function

<table>
<thead>
<tr>
<th>Section function</th>
<th>Accidents per km per year (annual equivalent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
</tr>
<tr>
<td>Main c’way</td>
<td>1.17</td>
</tr>
<tr>
<td>Roundabout</td>
<td>5.22</td>
</tr>
<tr>
<td>Slip road</td>
<td>1.50</td>
</tr>
<tr>
<td>Total</td>
<td>1.25</td>
</tr>
</tbody>
</table>

#### Table 4-4 Accidents before and after resurfacing by skid resistance Investigatory Level

<table>
<thead>
<tr>
<th>Maximum IL</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
<td>Q0</td>
</tr>
<tr>
<td>&lt; 0.45</td>
<td>1221</td>
<td>1384</td>
</tr>
<tr>
<td></td>
<td>13.3</td>
<td>13.7</td>
</tr>
<tr>
<td>≥ 0.45</td>
<td>1051</td>
<td>1116</td>
</tr>
<tr>
<td></td>
<td>6.2</td>
<td>-1.8</td>
</tr>
<tr>
<td>No data</td>
<td>29</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>-17.2</td>
<td>37.9</td>
</tr>
<tr>
<td>Total</td>
<td>2301</td>
<td>2524</td>
</tr>
</tbody>
</table>
It can be seen, from the tables, that the significant increase in accident numbers in Q0 and Q1 occurs on main carriageway sections, which in terms of skid resistance Investigatory Levels would be classed as “non-event” with IL < 0.45 (note however that some higher risk single carriageway non-event sections could have an IL of 0.45). As could be expected, the accident rates are higher at the higher risk sections such as roundabouts. However, there is no significant change in the numbers of accidents at sites that would be classed as higher risk in terms of IL, although some of these sites do show an increase in accidents in Q0.

A possible explanation for the trends at the higher risk sites (IL ≥ 0.45) could be that these sites are often treated with HFS. Although this may account for only a small length within a section it will be at the locations where accidents are most likely and therefore may be contributing to the slight reduction in accidents in Q1 to Q4. The effect of material type is considered in Section 5.
5 Detailed accident analysis

The data in Section 4 include sites resurfaced with HRA and HFS as well as those where thin surfacings were applied. In order to determine whether the trends seen in the previous section were common to all material types, the data were analysed by the type of surfacing applied. The results are presented in Table 5-1.

### Table 5-1 Accidents before and after resurfacing by surfacing material

<table>
<thead>
<tr>
<th>Surfacing material</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
<td>Q0</td>
</tr>
<tr>
<td>Thin surfacing</td>
<td>2073</td>
<td>2320</td>
</tr>
<tr>
<td>HRA</td>
<td>98</td>
<td>104</td>
</tr>
<tr>
<td>HFS</td>
<td>130</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>2301</td>
<td>2524</td>
</tr>
</tbody>
</table>

As could be expected, because the majority of the sections in the analysis were surfaced with thin surfacings, the trends for this surfacing are similar to those for the total number of accidents. Equivalent changes in accident numbers are not seen for the HRA and HFS sections. However, it can be seen that there were reductions in accidents in all four quarters after resurfacing for the HFS sections, although the decreases were only significant in Q0 and Q4.

5.1 Thin Surfacing Sections

For the thin surfacing sections the data were examined to investigate whether the increase in accidents in Q0 and Q1 were linked to any particular phenomena, such as the type of road, whether the surface was wet or dry or accident severity. This would give a clearer view of the types of accident that were occurring on thin surfacings in the first few months after laying.

The data are presented in Table 5-2, Table 5-3 and Table 5-4.

### Table 5-2 Accidents on thin surfacing sections before and after resurfacing by road class

<table>
<thead>
<tr>
<th>Road class</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
<td>Q0</td>
</tr>
<tr>
<td>A</td>
<td>789</td>
<td>868</td>
</tr>
<tr>
<td>M and A(M)</td>
<td>1284</td>
<td>1452</td>
</tr>
<tr>
<td>Total</td>
<td>2073</td>
<td>2320</td>
</tr>
</tbody>
</table>
### Table 5-3  Accidents on thin surfacing sections before and after resurfacing by road surface condition

<table>
<thead>
<tr>
<th>Road surface condition</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
<td>Q0</td>
</tr>
<tr>
<td>Dry</td>
<td>1329</td>
<td>1624</td>
</tr>
<tr>
<td>Wet/damp</td>
<td>706</td>
<td>672</td>
</tr>
<tr>
<td>Other/unknown</td>
<td>38</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>2073</td>
<td>2320</td>
</tr>
</tbody>
</table>

### Table 5-4  Accidents on thin surfacing sections before and after resurfacing by accident severity

<table>
<thead>
<tr>
<th>Accident severity</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
<td>Q0</td>
</tr>
<tr>
<td>Fatal</td>
<td>69</td>
<td>28</td>
</tr>
<tr>
<td>Serious</td>
<td>261</td>
<td>228</td>
</tr>
<tr>
<td>Slight</td>
<td>1743</td>
<td>2064</td>
</tr>
<tr>
<td>Total</td>
<td>2073</td>
<td>2320</td>
</tr>
</tbody>
</table>

As previously seen in Section 4.2 the significant increases in accident numbers in Q0 and Q1 are occurring on motorways and A(M) roads with a significant reduction occurring in Q3. There are no significant changes in accident numbers on A class trunk roads, although the trends in accident numbers are similar to those on the motorways.

The data show increasing accident numbers in the dry in Quarters 0 to 2, with Q0 being significant. A significant increase in accidents on roads in wet/damp conditions also occurs in Q1, but this is followed by significant decreases, compared to the year before, in Quarters 2 and 3.

Fatal accidents were significantly lower following maintenance works but there was a significant increase in slight accidents in Q0 and both slight and serious accidents increased in Q1.

However, as seen in Section 4, the total numbers of accidents in the year before and in the year after resurfacing were very similar, demonstrating that there was little change in the overall accident risk for the lengths of the network included in this analysis.

### 5.1.1  Analysis of accidents on dry and wet roads

The differences between the accidents occurring on wet and dry roads were analysed and the results are presented in Table 5-5 and Table 5-6 for dry roads and Table 5-7 and Table 5-8 for wet roads.
### Table 5-5  Accidents on thin surfacing sections on dry roads before and after resurfacing by road class

<table>
<thead>
<tr>
<th>Road class</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
<td>Q0</td>
</tr>
<tr>
<td>A</td>
<td>482</td>
<td>592</td>
</tr>
<tr>
<td>M and A(M)</td>
<td>847</td>
<td>1032</td>
</tr>
<tr>
<td>Total</td>
<td>1329</td>
<td>1624</td>
</tr>
</tbody>
</table>

### Table 5-6  Accidents on thin surfacing sections on dry roads before and after resurfacing by accident severity

<table>
<thead>
<tr>
<th>Accident severity</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
<td>Q0</td>
</tr>
<tr>
<td>Fatal</td>
<td>44</td>
<td>24</td>
</tr>
<tr>
<td>Serious</td>
<td>184</td>
<td>148</td>
</tr>
<tr>
<td>Slight</td>
<td>1101</td>
<td>1452</td>
</tr>
<tr>
<td>Total</td>
<td>1329</td>
<td>1624</td>
</tr>
</tbody>
</table>

### Table 5-7  Accidents on thin surfacing sections on wet/damp roads before and after resurfacing by road class

<table>
<thead>
<tr>
<th>Road class</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
<td>Q0</td>
</tr>
<tr>
<td>A</td>
<td>286</td>
<td>264</td>
</tr>
<tr>
<td>M and A(M)</td>
<td>420</td>
<td>408</td>
</tr>
<tr>
<td>Total</td>
<td>706</td>
<td>672</td>
</tr>
</tbody>
</table>

### Table 5-8  Accidents on thin surfacing sections on wet/damp roads before and after resurfacing by accident severity

<table>
<thead>
<tr>
<th>Accident severity</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB</td>
<td>Q0</td>
</tr>
<tr>
<td>Fatal</td>
<td>25</td>
<td>4</td>
</tr>
<tr>
<td>Serious</td>
<td>72</td>
<td>80</td>
</tr>
<tr>
<td>Slight</td>
<td>609</td>
<td>588</td>
</tr>
<tr>
<td>Total</td>
<td>706</td>
<td>672</td>
</tr>
</tbody>
</table>
These data show that the overall increases in slight accidents in Q0 and Q1 arose from increased accident numbers on dry roads and that in Q2 there was also a significant increase in accident numbers on dry roads but that this was negated by a decrease in accidents on wet roads. Also the increased accident numbers on M and A(M) roads were attributable to dry conditions in Q0 but applied equally to wet and dry roads in Q1. Although the data presented earlier in Table 5-2 show that there were no significant changes in accident numbers on A roads following resurfacing, the data in Table 5-5 show that there was a significant increase in accidents on dry A roads in Q0. This increase is offset partially by a slight decrease in accidents on wet roads.

It is also worth noting that the increase in serious accidents seen in Q1 was due to accidents in the wet, as on dry roads during the same period there was a slight, though not significant, decrease in serious accidents.

### 5.1.2 Sections substantially resurfaced with thin surfacing

In order to assess the extent to which the analysis was being influenced by sites where only one lane or where only part of the section had been resurfaced (with accidents potentially occurring or being initiated, in practice, on an un-resurfaced part of the road), those sections where at least 80% of the lane length was resurfaced were selected and analysed separately. Details of the number of sections meeting this criterion are provided in Table 5-9.

<table>
<thead>
<tr>
<th>Road Class</th>
<th>80% of section resurfaced?</th>
<th>Thin surfacing</th>
<th>HRA</th>
<th>High Friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>yes</td>
<td>533</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>305</td>
<td>37</td>
<td>65</td>
</tr>
<tr>
<td>M and A(M)</td>
<td>yes</td>
<td>715</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>379</td>
<td>68</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,932</td>
<td>109</td>
<td>95</td>
</tr>
</tbody>
</table>

Approximately two thirds of the thin surfacing sections were included in this further analysis, for which the results are given in Table 5-10 for division by road class, Table 5-11 for division by accident severity and Table 5-12 by surface condition. The other materials had very few sections where at least 80% of the length was resurfaced and so any analysis by surface type would not be statistically representative and was not undertaken.

### Table 5-10: Accidents on sections substantially resurfaced with thin surfacing by road class

<table>
<thead>
<tr>
<th>Road class</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB Q0 Q1 Q2 Q3 Q4</td>
<td>Q0 Q1 Q2 Q3 Q4</td>
</tr>
<tr>
<td>A</td>
<td>528 548 448 628 476 524</td>
<td>3.8 -15.2 18.9 -9.8 -0.8</td>
</tr>
<tr>
<td>M and A(M)</td>
<td>781 912 888 712 728 804</td>
<td>16.8 13.7 -8.8 -6.8 2.9</td>
</tr>
<tr>
<td>Total</td>
<td>1309 1460 1336 1340 1204 1328</td>
<td>11.5 2.1 2.4 -8.0 1.5</td>
</tr>
</tbody>
</table>
### Table 5-11: Accidents on sections substantially resurfaced with thin surfacing by accident severity

<table>
<thead>
<tr>
<th>Accident severity</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB  Q0  Q1  Q2  Q3  Q4</td>
<td>Q0  Q1  Q2  Q3  Q4</td>
</tr>
<tr>
<td>Fatal</td>
<td>42  16  36  20  36  32</td>
<td>-61.9 -14.3 -52.4 -14.3 -23.8</td>
</tr>
<tr>
<td>Serious</td>
<td>167 140 168 172 168 176</td>
<td>-16.2  0.6  3.0  0.6  5.4</td>
</tr>
<tr>
<td>Slight</td>
<td>1100 1304 1132 1148 1000 1120</td>
<td>18.5  2.9  4.4 -9.1  1.8</td>
</tr>
<tr>
<td>Total</td>
<td>1309 1460 1336 1340 1204 1328</td>
<td>11.5  2.1  2.4 -8.0  1.5</td>
</tr>
</tbody>
</table>

### Table 5-12: Accidents on sections substantially resurfaced with thin surfacing by road surface condition

<table>
<thead>
<tr>
<th>Road surface condition</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB  Q0  Q1  Q2  Q3  Q4</td>
<td>Q0  Q1  Q2  Q3  Q4</td>
</tr>
<tr>
<td>Dry</td>
<td>834  952  864  940  840 856</td>
<td>14.1  3.6  12.7  0.7  2.6</td>
</tr>
<tr>
<td>Wet/damp</td>
<td>455  488  444  380  352 452</td>
<td>7.3  -2.4 -16.5 -22.6 -0.7</td>
</tr>
<tr>
<td>Other/unknown</td>
<td>20   20   28   20   12  20</td>
<td>0  40.0  0  -40.0  0</td>
</tr>
<tr>
<td>Total</td>
<td>1309 1460 1336 1340 1204 1328</td>
<td>11.5  2.1  2.4 -8.0  1.5</td>
</tr>
</tbody>
</table>

The accidents trends for the substantially resurfaced sections were broadly similar to those shown in the analyses for all the thin surfacing sites, but some differences can be highlighted.

Although there was a significant increase in accidents during Q0 this did not continue into Q1. However the data for road type show that there was still a significant increase in accidents during Q1 on motorway/A(M) roads, as seen in the previous analysis, but this was offset by a significant decrease on A roads, which was not evident in the analysis for all the thin surfacing sections.

The data for surface condition indicate that when the road is wet there was a significant decrease in the number of accidents in Quarters 2 and 3 after resurfacing. This matches the findings for all the thin surfacing sections (Table 5-3), but in this analysis the significant increase in wet accidents in Q1, accompanied by an increase in serious accidents, is not seen.
5.2 HRA Sections

There were only 109 sections resurfaced with HRA (1,932 were resurfaced with thin surfacings). This means that the total number of accidents on those sections will be small, with greater random variation, and hence less likely to produce significant results. Nonetheless the accident data for these sections were analysed by road class, road surface condition and accident severity with the results being presented in Table 5-13 to Table 5-15 respectively.

Table 5-13 Accidents on HRA sections before and after resurfacing by road class

<table>
<thead>
<tr>
<th>Road class</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB Q0 Q1 Q2 Q3 Q4 Q0 Q1 Q2 Q3 Q4</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>31 40 36 28 32 48 29.0 16.1 -9.7 3.2 54.8</td>
<td></td>
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<tr>
<td>M and A(M)</td>
<td>67 64 44 48 56 52 -4.5 -34.3 -28.3 -16.4 -22.4</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>98 104 80 76 88 100 6.1 -18.4 -22.4 -10.2 2.0</td>
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Table 5-14 Accidents on HRA sections before and after resurfacing by road surface condition

<table>
<thead>
<tr>
<th>Road surface condition</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
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<tr>
<td></td>
<td>1YB Q0 Q1 Q2 Q3 Q4 Q0 Q1 Q2 Q3 Q4</td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td>58 84 64 52 56 80 -44.8 10.3 -10.3 -3.4 37.9</td>
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<td>Wet/damp</td>
<td>37 20 16 20 28 16 -45.9 -56.8 -45.9 -24.3 -56.8</td>
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</tr>
<tr>
<td>Other/unknown</td>
<td>3 0 0 4 4 4 -100 -100 33.3 33.3 33.3</td>
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</tr>
<tr>
<td>Total</td>
<td>98 104 80 76 88 100 6.1 -18.4 -22.4 -10.2 2.0</td>
<td></td>
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Table 5-15 Accidents on HRA sections before and after resurfacing by accident severity

<table>
<thead>
<tr>
<th>Accident severity</th>
<th>No. of accidents per year (annual equivalent)</th>
<th>Percentage change per year from 1YB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1YB Q0 Q1 Q2 Q3 Q4 Q0 Q1 Q2 Q3 Q4</td>
<td></td>
</tr>
<tr>
<td>Fatal</td>
<td>0 8 0 0 0 0 800 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Serious</td>
<td>8 24 4 4 12 8 200 -50.0 -50.0 50.0 0</td>
<td></td>
</tr>
<tr>
<td>Slight</td>
<td>90 72 76 72 76 92 -20.0 -15.6 -20.0 -15.6 2.2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>98 104 80 76 88 100 6.1 -18.4 -22.4 -10.2 2.0</td>
<td></td>
</tr>
</tbody>
</table>

The data show that the overall numbers of accidents did not vary significantly between the before and after periods. However, although not significant, there was an increase in accidents during Q0 which was linked to a significant increase in accidents on dry roads. The increase in accidents on dry roads was also seen on the thin surfacing sections but on those sections it persisted into Q1. There were significant reductions in accidents occurring on wet/damp roads (Q0, 1, 2 and 4). Again this differs
slightly to the data for thin surfacings where significant decreases occurred only in Q2 and 3 and were preceded by a significant increase in Q1.

The data also showed significant increases in fatal and serious injury accidents in Q0 but, as discussed above, the actual numbers of accidents are very small and therefore the analysis is less reliable.

5.3 General accident trends during the analysis period

As it was possible that the trends seen in the accident analysis could be linked to the general trends in accidents across the trunk road network during the period being examined, these general trends were also determined from the STATS19 database.

Figure 5-1 shows the trend nationally for trunk road accidents on motorways and A-roads. Between 2000 and 2005, accidents on motorways decreased by 10% compared with 6% for A-roads. This is however quite a recent trend; compared to the 1994-98 baseline used for assessing casualty reduction targets, motorway accidents have increased by 10%, whereas accidents on A-roads have reduced by 5%.

Figure 5-1 All trunk road accidents by road class

![Graph showing the trend nationally for trunk road accidents on motorways and A-roads.](image)

Figure 5-2 shows the national trends in accident severity. Between 2000 and 2005, serious accidents showed the greatest reduction of 16%, with slight accidents reducing by 7% and fatal accidents having the smallest decrease of 4%.

Nationally, approximately two thirds of accidents occurred on a dry road surface. The remainder were mostly on wet or damp roads, with a small percentage on roads with frost, ice, snow, or flooded. Figure 5-3 shows the trends in accidents on dry and wet/damp roads. Between 2000 and 2005, accidents on dry roads increased slightly (1%), while those on wet roads decreased by 22%. This may however be due to changing weather conditions over the period.

Further details on accident numbers and trends on the HA network are provided in “Accidents on the trunk road network – 2005” (HA, 2006).
Figure 5-2  All trunk road accidents by accident severity

![Chart showing the percentage of accidents relative to 2000 by accident severity from 2000 to 2006.]

Figure 5-3  All trunk road accidents by road surface condition

![Chart showing the percentage of accidents relative to 2000 by road surface condition from 2000 to 2006.]

6 Anecdotal evidence

6.1 Approach

Over recent years there has been an increase in anecdotal comment related both to dry and wet skidding resistance of asphalt surfacings in the first few months of service, reinforced by police comments on lower than usual dry friction found in their routine stopping-distance skid tests on some relatively new surfacings. It was therefore decided to try and capture this anecdotal evidence as part of this project so that common trends, if any, could be identified and investigated and compared to the results from the accident analysis.

Information was sought from both the HA Area Teams and Maintaining Agents, via HA Traffic Operations, and from other Highway Authorities, via the CSS and the request was structured so as to promote careful consideration of available information. The questions asked of both HA Areas and other Highway Authorities were as follows:

- Have you undertaken any systematic studies to investigate increased accident risk in the early life of asphalt surfaces?
- Are you aware of any problems with the skid resistance of modern asphalt surfacings in the first few months after they have been laid?
  - Evidence of problems may include:
    - An increase in accidents, including damage only, perhaps highlighted by your Safety Team or other personnel.
    - Comments from the police when undertaking routine stopping-distance skid tests after accidents have occurred.
    - Reports from members of the public.
    - An increase in claims from insurance companies.
- If problems are perceived, what actions have been taken to address them?
  - This could include for example:
    - The erection of warning signs.
    - The introduction of temporary speed limits.
    - The application of surface treatments.

The HA request was circulated via Area Performance Managers with instructions to forward it to members of the HA Area Team and the Maintaining Agent best placed to provide the information. The letter to other Highway Authorities was circulated to County Material Engineers and members of the CSS Highway Condition Assessment Group with similar instructions.

Other Highway Authorities were included in the search for anecdotal comment because a large proportion of their road networks are markedly different to those of the HA in terms of layout, geometry and traffic levels, and it was felt that different issues could arise, or be more obvious, on these networks.

It was also recognised that information was more likely to come from respondents who perceived problems to be occurring or those who were more aware of the issues. This could cause any problems reported to appear more serious or widespread than is actually the case. To counter this, the letters circulated stressed that null returns were valid and important to the research.

A total of eight responses were received from the HA maintenance areas and 18 from other Highway Authorities; details are provided in Appendix A. Follow-up meetings were also held with some of the Highway Authorities and these are also indicated in Appendix A.
6.2 Findings

Most of the responses from HA Maintenance Areas reported that they were not aware of any unusual incidence of accidents on new surfacings. There were only three reports of skid resistance problems having been encountered and these related to a small number of specific cases, namely:

- Loss of control accidents on the bend of a motorway slip road,
- Loss of control accidents on bends on two A class roads, and
- A vehicle skidding on the approach to a roundabout at the top of a slip road.

Slightly more varied responses were received from the other Highway Authorities, but again many reported that they were not aware of any unusual incidence of accidents on new surfacings. Where problems were believed to have been encountered, they were mainly associated with loss of control accidents on bends, sometimes at relatively moderate speeds, both in wet and dry conditions. As could be expected it was often difficult for the respondents to definitely state the surfacing as a causation factor, but they believed that it was a contributing factor.

One of the Highway Authorities felt that problems they had encountered in the early days of using thin surfacings may have been due to the material specifications used at the time: these contained higher binder contents than used commonly now.

6.3 Other data

In addition to the anecdotal comment, accident analyses were received from two of the Highway Authorities. It should be noted that these analyses were not undertaken on the same basis as those in this report. Nonetheless, they did compare accident numbers on lengths of carriageway both before and after resurfacing.

In one case the after period was one year, while the other examined all data available following resurfacing and also the initial six month period. Both sets of data showed that the number of accidents increased at some sites but reduced at others. Overall there was little change in the number of accidents before and after resurfacing.
## 7 Discussion

In summary, the accident analysis has shown that for sections resurfaced with thin surfacing:

- The overall accident risk in the year before and in the year after resurfacing shows no significant change.
- There is a significant reduction in fatal accidents following maintenance works.
- There is an increase in accident risk in the initial months (up to about 6 months) following laying.
- The majority of the increased accident numbers result in slight injuries only.
- The risks appear to be associated mainly with accidents occurring on motorways and A(M) class roads, mostly in dry conditions.
- There is an increase in the number of accidents in the wet during Q1 following resurfacing on those sections resurfaced partially with thin surfacings; there is also an increase in serious accidents during the same period. However this trend is not repeated on those sections which have been fully resurfaced with thin surfacing.

The results for sections resurfaced with HRA produced less significant results due to the limited numbers included in the analysis, but they did show a significant increase in accidents on dry roads during Q0. This could indicate that such surfacings behave in a similar manner to thin surfacings but that the physical phenomena are shorter lived.

It should be noted that there is no record of a similar accident analysis being undertaken for traditional surfacings in the past.

It is of interest to consider these results in the context of the physical effects reported in PPR060 (Roe and Lagarde-Forest, 2005). A number of possible links between the observed phenomena and the outcomes of the accident analyses can be suggested.

(i) PPR060 reported that dry friction can be lower on new asphalt compared to the high levels generally obtained on older surfaces and that this difference increases at higher speeds. These effects could therefore be contributing to the increase in accident numbers seen on high speed roads in dry conditions. These accidents tend to result in slight injuries and might therefore be linked to shunt accidents occurring due to increased stopping distances.

There is also a possibility, however, that motorists may increase their speed when travelling on the new, quieter surfacings which in turn would increase stopping distances. Whether, or to what extent, this occurs is not known at present but it is recommended that further investigation would be beneficial in relation to educating or warning drivers of the potential risks of new surfacings in their early life.

(ii) Although statistically significant increases in accidents were observed in Q0 and Q1 of the analysis, after this initial period the changes in accident numbers were either lower or not significant which would support the observation that on trunk roads, at least, the physical effects generally last for about six months. After this period, it would appear that the new surfacing reduces accident risk compared to the time before maintenance was undertaken.

(iii) PPR060 reported that the wet skid resistance was lower than expected at higher speeds. This phenomenon could be contributing to the increase in accidents in the wet during Q1. It could also be postulated that it is higher speed wet accidents that are contributing to the increase in serious accidents seen in Q1 after resurfacing. However these findings were not observed on the fully resurfaced sections so other mechanisms may also be occurring. These could include the high levels of low-speed wet friction found on thin surfacings.

(iv) Over the period considered in this accident analysis there was a general decrease in accidents at a national level. Accidents on dry roads had increased slightly during the analysis period but not to the extent seen in the results of this analysis for Q0 to Q2, which would indicate
that these increases may be linked to the new surfacing. Fatal accidents decreased during the period but not to the extent seen in this analysis, while the general decrease in slight accidents was not replicated.

The information from the anecdotal reports suggests that early life skid resistance issues are not widespread, either on the HA or other Highway Authority networks. However it would appear that it could be a contributory factor in a small proportion of accidents that occur mainly on bends.

Skid tests undertaken on thin surfacings have shown that the measured peak friction can be higher than expected for a typical in service pavement, but the sliding friction is lower than expected; i.e. there is a greater difference between peak and sliding friction on newly laid surfacings. It is possible that the loss of control on bends could be associated with this phenomenon, i.e. road users will experience a high level of grip followed by a substantial reduction once the peak friction has been exceeded, giving them little opportunity for making a correction.

The two approaches adopted in this study would appear to give somewhat conflicting results. However this may be because increases in slight accidents on ‘non-event’ lengths of highway do not raise concerns about the surfacing in the same way as a number of single vehicle loss of control accidents on bends. As such the findings may not be as divergent as they first appear.

In light of the findings from the initial stages of the work reported in PPR060, the HA issued guidance on the use of warning signs at sites which had been resurfaced (IAN 49/03). This recommends that slippery road warning signs should be erected at sites where the Investigatory Level, as defined in HD28/04, is greater than 0.5 or where the skid resistance before resurfacing was equal to 0.45 and the works were to increase the skid resistance or the skid resistance before the resurfacing was ≥ 0.5. It is recommended that the current guidance should be reviewed in the light of the accident analysis in this report and updated where justified.

However the slippery road sign that is used currently may not be the best form of warning in such situations as the public are unlikely to associate this with non-event lengths of carriageway in dry conditions. A review of the appropriateness of warning signs was also included in the recommendations of PPR060 and work in this area has been progressed by HA.

This accident analysis has considered personal injury accidents only, as reliable data are not available for damage only accidents. As the increase in accidents during the early life period appears to be attributable to slight injury accidents, it may be that damage-only accidents also increase during this time, i.e. the same physical phenomena are contributing to accidents but injuries are not occurring. If this were the case then although injuries are not being sustained there will be other disbenefits such as increased insurance claims, increased delays, etc. Increases in damage only accidents were not highlighted in the anecdotal information, but this could just be because they are not being detected or reported by highway authority personnel.
8 Conclusions and Recommendations

This report covers part of a series of studies into the effects of decreased skid resistance on new asphalt surfacings early in their lives. An earlier study in the programme identified physical phenomena that might lead to an increase in accident risk in some circumstances. The report on that study (PPR060) made a number of recommendations, of which the first was that “Specific research into any link between new surfacings and accident risk should be carried out”.

That study has been carried out, using a combination of:

- An analysis of accidents before and after resurfacing on the HA network.
- Collation and review of anecdotal comment from the Highways Agency’s Area Teams and Maintaining Agents, and from other Highway Authorities.

The accident data show that for the trunk road network:

(i) In the twelve months after resurfacing, the accident risk is similar to or less than before resurfacing.
(ii) There is a significant decrease in fatal accidents on the resurfaced sections.
(iii) There is a small increase in accident risk in the initial months after laying modern asphalt surfacings on some sections of the network.
(iv) Although accident numbers increase by a small proportion on new surfacings, the additional accidents are in the “slight” severity category.
(v) The increase in risk appears to occur mostly on Motorway and A(M) class roads rather than on A roads.
(vi) The increased risk appears to occur mostly, but not exclusively, in dry conditions.
(vii) The period of increased risk appears to last for up to about six months after laying.
(viii) Some of the accident increases are also apparent on more traditional surfacings but are probably shorter lived, although the numbers of sections for which data are available are too small to provide a robust study.
(ix) Accident rates on the resurfaced sections are somewhat lower than those for the HA network as a whole. However, the nature of the sections included within the analysis may not be indicative of the network as a whole.

The information from the anecdotal reports suggests that early life skid resistance issues are not widespread, either on the HA or other Highway Authority networks. However it would appear that it could be a contributory factor in a small proportion of accidents, that occur mainly on bends.

The findings from this study are generally consistent with the physical phenomena that have been measured on new asphalt surfacings.

Neither of the approaches used in the study identified widespread problems with modern asphalt surfacings in their early life but there is evidence of a small increased accident risk. Therefore, in the light of this evidence it is recommended that:

1. Current guidance in IAN49 should be reviewed.
2. Work to follow up the other recommendations of PPR060 should continue: this should include work on methods to mitigate risks and further studies to improve understanding of the physical phenomena.
3. The need and methods for providing drivers with better information should be reviewed in the light of this report and the findings from recommendations 1 and 2 outlined above.
Acknowledgements

The authors would like to thank the representatives from HA, HA’s Service Providers and other Highway Authorities who provided responses to the requests for anecdotal comment and who attended meetings with members of the TRL project team.

The work described in this report was carried out in the Safety and Consultancy Group of TRL Limited. The authors are grateful to Helen Viner who carried out the technical review of this report.

References


   HD28/04 - Skid Resistance. (DMRB 7.3.1).


## Appendix A. Responses to requests for anecdotal comment

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<tr>
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<td>Area 2</td>
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* Follow-up meetings undertaken.
Abstract

For some years it has been suspected that new asphalt surfacings may have different skid resistance properties to surfaces have been in service for some time. This is thought to be due to the presence of a film of bitumen binder on the new surface that is eventually removed by weathering and traffic. New types of surfacing introduced in the mid 1990s have led to concerns that the risk of early-life skid resistance problems, and the time that any effects last, may have increased. Research has identified physical phenomena that might lead to an increase in accident risk in some circumstances.

This report provides the results of a study to investigate if a link could be observed between new surfacings and accident risk. The study used a combination of an analysis of accidents before and after resurfacing on the Highways Agency (HA) network, and collation and review of anecdotal comment from the HA’s Area Teams and Maintaining Agents, and from other Highway Authorities. The findings from this study are generally consistent with the physical phenomena that have been measured on new asphalt surfacings. Neither of the approaches used in the study identified widespread problems with modern asphalt surfacings in their early life but there is evidence of a small increased accident risk in some circumstances.
Early life skid resistance – an assessment of accident risk

by M J Greene and L Crinson

Published Project Report
PPR205