Road trials to determine the effect of de-icers on skid resistance

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ROAD TRIALS TO INVESTIGATE THE EFFECT OF DE-ICERS ON SKID RESISTANCE

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Client: Network Management Policy (SSR), Highways Agency (Mr C Plumb)

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## EXECUTIVE SUMMARY

This report presents the results of a study on the skid resistance of roads treated with various types of salt and de-icing agents. The study aimed to assess the effectiveness of different measurement techniques and to identify any potential risks associated with the application of these treatments.

## ABSTRACT

The study involved the measurement of skid resistance on various road surfaces treated with different types of salt and de-icers. The results showed significant differences in skid resistance levels, with some treatments leading to a reduction in safety. Recommendations for future treatment strategies are also provided.

## INTRODUCTION

The importance of skid resistance in road safety cannot be overstated. This section introduces the background and scope of the project, including an overview of the methods used.

### 2.1 Tyre/road friction and skid resistance

Tyre/road friction is a critical factor in road safety, and skid resistance is a measure of a road's ability to resist slipping under braking conditions.

### 2.2 Measurement of road-tyre friction and skid resistance

The measurement of road-tyre friction and skid resistance is essential for assessing the safety of road surfaces.

#### 2.2.1 Police friction measurements ("Skidman")

Police friction measurements are a common method for assessing skid resistance.

#### 2.2.2 Measurement of skid resistance

This involves the use of various equipment to measure skid resistance under controlled conditions.

### 2.3 Potential risks from frost and the application of de-icers

The application of de-icers can lead to reduced skid resistance, which poses a risk to road users.

### 2.4 Project scope

The project scope includes the measurement of skid resistance on a range of road surfaces treated with different types of salt and de-icers.

## METHODOLOGY

The methodology section outlines the choice of measurement techniques and the planned trials, providing a detailed plan for the study.

### 3.1 Choice of measurement techniques

This includes the selection of the most appropriate methods for measuring skid resistance.

### 3.2 Planned trials - identification of trial sites and de-icer types

The selection of trial sites and de-icer types is crucial for the success of the study.

### 3.3 Planned trials - pattern of skid resistance tests

This includes the design of the test patterns for the GripTester and PFT tests.

#### 3.3.1 PFT test pattern

The PFT test pattern is designed to assess skid resistance under controlled conditions.

#### 3.3.2 GripTester test pattern

The GripTester test pattern is another method for assessing skid resistance.

#### 3.3.3 Test sequence

The sequence of tests is important for ensuring a fair comparison of results.

### 3.4 Planned trials - de-icing operations and skid resistance measurements

This includes the testing of different de-icing operations and the assessment of skid resistance.

#### 3.4.1 Tests on the A69

Tests on the A69 road are conducted to assess the effectiveness of different de-icing treatments.

#### 3.4.2 Tests on the A421

Tests on the A421 road are conducted for a similar purpose.

### 3.5 Planned trials - ambient test conditions

The ambient test conditions are an important factor in assessing skid resistance.

### 3.6 Background skid resistance measurements

These measurements provide a baseline for comparison.

### 3.7 Reactive tests on Sites E and F

Reactive tests are conducted on Sites E and F after treatment with Safecote treated salt.

## RESULTS AND INITIAL ANALYSIS OF THE SKID RESISTANCE MEASUREMENTS

This section presents the results of the planned trials and initial analysis of the skid resistance measurements.

### 4.1 Overview of the planned trials results

An overview of the results is presented, including typical PFT locked-wheel friction measurements.

#### 4.1.1 Typical PFT locked-wheel friction measurements

These measurements provide a basis for comparing the effectiveness of different treatments.

#### 4.1.2 GripTester measurements

GripTester measurements are also presented for comparison.

### 4.2 Differences between the PFT and GripTester measurements

Comparisons are made between the results obtained using the PFT and GripTester methods.

### 4.3 General comments on the planned trial results

Comments are provided on the overall results of the planned trials.

### 4.4 Reactive measurements on Site E and F after treatment with Safecote treated salt

These measurements are conducted after the application of Safecote treated salt on Sites E and F.

## FURTHER ANALYSIS

This section delves deeper into the analysis of the results, focusing on changes in skid resistance.

### 5.1 Change in skid resistance with type and level of salt and surfacing type

An analysis is made of the impact of different types and levels of salt and surfacing on skid resistance.

### 5.2 Effect of localised heavy salting

The effect of localised heavy salting on skid resistance is also examined.

## DISCUSSION

The discussion section provides insights into the implications of the findings and recommendations for future research.

### 6.1 Methodology

A discussion of the methodology used in the study is presented, including measurement methods, planned trials, and reactive testing.

#### 6.1.1 Measurement methods

These methods are discussed in detail, including their strengths and limitations.

#### 6.1.2 Planned trials

The planning of the trials is analysed in terms of their effectiveness.

#### 6.1.3 Reactive testing

The reactive testing is discussed, including its role in assessing the effectiveness of different treatments.

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Executive summary

Highway authorities have a duty to keep highways free of ice and snow and endeavour to meet this duty through winter service operations. The savings associated with the reduction in accidents and the resultant congestion are significantly greater than the cost of de-icing operations and the impact of de-icers on vehicles, highway infrastructure and the environment.

However, concerns have been expressed by some road users that de-icing operations, particularly repeated operations when de-icers can build up on the road surface, can adversely affect the skid resistance. While it is unlikely that the de-icers will reduce grip to levels that would occur with ice or frost on the road, grip might be reduced enough to increase the risk of skidding accidents compared with that in normal conditions. If that were so, highway authorities would need to guard against applying de-icers in excess of that required to keep the surface free of ice, frost or snow.

Many factors must be taken into account to assess the relative risks of skidding, including residual salt level and the water film thickness (governing the temperature at which brine solution on the road surface will freeze), the road surface temperature and the underlying condition of the road surface.

In December 2006, the Highways Agency (HA) commissioned TRL to carry out work during the winter of 2006/2007 to make an initial investigation of the effect of de-icing operations on skid resistance. It was recognised from the outset that the project would not be able to cover all aspects of this complex topic in the short timescale, so the work would try to assess the scope of the problem with three broad objectives:

- To identify where and when a reduction in skid resistance due to repeated de-icing operations has been experienced on the Agency’s network and any common factors (e.g. surfacing material and condition, de-icer type, weather conditions, prior treatment regime);
- To determine the most appropriate test methodology to measure the effect of de-icing operations on skid resistance for a series of road trials; and
- To determine the effects of de-icing operations on the skid resistance of different types of road surface, including negatively textured surfaces, after repeated treatments with different de-icers (including dry salt, pre-wetted salt and salt treated with agricultural by-products (ABPs)).

A separate report, PPR220, Crinson et al (2008), deals with the first objective. This report deals with the work to address the second and third objectives. The primary purpose of the study was to assess the effectiveness of the measurement methods on road surfaces subject to different levels of salting but in the event it was possible to make a wider range of measurements using the different types of de-icers at different application levels.

Two routes were chosen (parts of the A69 in Northumberland and the A421 near Bedford) that would allow four different de-icers to be compared, namely:

- Dry untreated rock salt: 10mm Cleveland Potash rock salt.
- Rock salt treated with Eco-Thaw: 10mm Cleveland Potash rock salt treated with Eco-Thaw (3% by weight).
- Rock salt treated with SafeCote: 6.3mm Thawrox+.
- Pre-wetted untreated 6.3mm rock salt (dry rock salt and brine in proportion 70:30 by weight).

The Highways Agency’s Pavement Friction Tester (PFT) was used for the bulk of the work, allowing planned trials to assess the effect of de-icer on skid resistance over a range of speeds. This was supplemented by tests with a GripTester, to assess whether that device might be suitable for additional “reactive” tests on a wider scale in response to normal de-icing operations.

The test programme was carried out over a three week period in January and early February 2007. Most of the tests were made overnight. In the first week, a preliminary set of tests were made on the A69 to establish the working practice and test methodology and these were followed during the
second week with further measurements with increased spread rates. The work on the A421 in the third week followed the principles established on the A69 but also included a special set of tests with very high spread rates.

In spite of external constraints limiting the extent of the work, a wider range of tests were made than had been anticipated at the outset. It proved possible to examine the effects of four de-icers on examples of the two types of surfacing most commonly found on the trunk road network (rolled asphalt and proprietary thin surfacing) at different application rates and with different levels of residual salt, including extremely heavy applications. The weather conditions did not permit the exploration of effects such as the potential build-up of marl or residual salt on the surfaces in prolonged cold, but generally dry, weather.

From the measurements made, the following broad conclusions were drawn.

1. On wet or damp surfaces treated with de-icers, skid resistance decreases with speed, an effect typically observed on untreated wet surfaces. Similar effects were observed on both surface types.

2. The tests with the PFT have shown that de-icers reduce skid resistance at low sliding speeds (20 – 40 km/h) compared with an untreated wet road, but at higher speeds (60 km/h and above) skid resistance is greater than on a normal wet road.

3. At intermediate speeds the skid resistance with de-icers varies from slightly lower to slightly higher than background levels.

4. Within the limitations of the conditions tested, there were no clear differences in behaviour between the different de-icer types, including those treated with agricultural by-products.

5. The GripTester was also included in the test programme to assess its suitability for this type of assessment for potential use in reactive tests over a wider area. The device gave generally higher skid resistance on treated surfaces than on untreated surfaces. Analysis of the PFT records to estimate skid resistance under similar test conditions indicated a similar effect. It is concluded that, as a result of its operating principle, the GripTester is not suitable for general use in detecting any adverse effects due to de-icers.

6. The extent to which skid resistance on a damp or wet road is reduced at low speed tends to increase with greater levels of residual salt, whatever type of de-icer is used. For residual salt levels less than 80g/m², the percentage decrease in friction number at 20km/h relative to the background level was up to about 20%. In tests with very heavy levels of Eco-thaw treated salt (accumulations up to 200 g/m²) the relative decrease did not exceed 25%.

7. The changes of skid resistance observed in these tests suggest that on sites which already have skid resistance well above the investigatory level, de-icers are unlikely to increase the risk of skidding.

8. On roads that are closer to investigatory level, or when there is little or no seasonal increase, de-icers may reduce skid resistance below the investigatory level so there is a small theoretical increased risk of skidding in these specific circumstances.

9. In any event, skid resistance with de-icers present will always be much greater than would be the case if they were not used and frost or ice were to form.

Further work is recommended to address potential effects of de-icers that it was not possible to include in this project, particularly in relation to:

- The potential build-up of de-icer and associated detritus during prolonged cold spells with repeated application but little rainfall.
- The potential effects of previously treated areas remaining or becoming damp when roads are otherwise dry.
- The influence of the presence of undissolved de-icer, particularly in larger concentrations, and its potential influence on vulnerable users.
Abstract

Highway authorities have a duty to keep highways free of ice and snow and endeavour to meet this duty by treating roads with de-icers. It is unlikely that de-icers will reduce grip to levels that would occur with ice or frost on the road, but concerns have been expressed by some road users that de-icers, particularly repeated applications that cause them to build up on the road surface, can adversely affect the skid resistance and increase the risk of skidding accidents compared with that in normal conditions. This report describes a study in which a test methodology was established to investigate the effect of de-icers on skid resistance. The study included measurements of skid resistance on sites with hot rolled asphalt and proprietary thin surfacings that had been treated with de-icers. Four de-icers were included in the investigation, namely dry untreated rock salt, rock salts treated with Eco-Thaw and Safecote, and pre-wetted salt (rock salt pre-wetted with brine). The measurements were made with Highway Agency’s Pavement Friction Tester (PFT) and a GripTester. The tests with the PFT showed that de-icers reduce skid resistance at low sliding speeds (20 – 40 km/h) compared with a wet road with no de-icer present, but at higher speeds (60 km/h and above) skid resistance with de-icer present is greater than on a normal wet road. The significance of these changes was assessed with reference to the seasonal increase in skid resistance from summer to winter and the investigatory level. The GripTester was found not to be suitable for general use in detecting any adverse effects due to de-icers. Since it was not possible to determine the effect of all the potential effects of de-icers on skid resistance, including a build up of de-icer and associated detritus during prolonged cold spells with repeated applications but little rain, further tests with the PFT are recommended.
1 Introduction

Highway authorities have a duty to keep highways free of ice and snow and endeavour to meet this duty through winter service operations.

Cost-benefit analyses (Thornes, 1999) have shown that there are considerable benefits if roads are treated with sodium chloride based de-icers in order to keep them free of ice and snow. The savings associated with the reduction in accidents and the resultant congestion are significantly greater than the cost of de-icing operations and the impact of de-icers on vehicles, highway infrastructure and the environment.

However, concerns have been expressed by some road users that de-icing operations, particularly repeated operations when de-icers can build up on the road surface, can adversely affect the skid resistance.

Clearly the risk of skidding due to the build up of de-icer on a road surface should not be greater than the risks due to the presence of ice and snow. While it is unlikely that the application of de-icer in the absence of ice or frost will reduce grip to levels that would occur with ice or frost on the road, there might be enough of a reduction in grip to increase the risk of skidding accidents compared with that on the untreated carriageway in normal conditions. If that were shown to be the case, highway authorities would need to guard against applying de-icers in excess of that required to keep the surface free of ice, frost or snow.

Many factors must be taken into account if the relative risks are to be assessed. Salt works as a de-icer by reducing the freezing point of water in which it is dissolved. Therefore, factors such as the residual salt level and the water film thickness (hence the freezing point temperature of the brine solution on the road surface), the road surface temperature and the underlying condition of the road surface all have the potential to affect skidding risk.

To facilitate the assessment of the relative risks, in December 2006 Highways Agency commissioned TRL to carry out work during the winter of 2006/2007 to make an initial investigation of the effect of de-icing operations on skid resistance. It was recognised from the outset that the project would not be able to cover all aspects of this complex topic in the short timescale, with the limitations of whatever weather conditions would prevail. Therefore, the work would endeavour to assess the scope of the problem with three broad objectives:

- To identify where and when a reduction in skid resistance due to repeated de-icing operations has been experienced on the Agency’s network and any common factors (e.g. surfacing material and condition, de-icer type, weather conditions, prior treatment regime);
- To determine the most appropriate test methodology to measure the effect of de-icing operations on skid resistance for a series of road trials; and
- To determine the effects of de-icing operations on the skid resistance of different types of road surface, including negatively textured surfaces, after repeated treatments with different de-icers (including dry salt, pre-wetted salt and salt treated with agricultural by-products (ABPs)).

The first objective was addressed by a desk study in which an analysis of the Stats19 injury accident data for the trunk road network was carried out to assess how accident rates vary during the winter period and on days with and without de-icing operations. This analysis was supplemented by information supplied by Agents that manage Highways Agency’s network on their local experience of accidents attributed to de-icing operations. This work has been reported separately in PPR220, Crinson et al (2008).

This report deals with the work to address the second and third objectives which has involved tests with different skid resistance measurement techniques on the A69 in Northumberland and the A421 near Bedford.
The primary purpose of the work was to assess the effectiveness of the measurement methods on road surfaces subject to different levels of salting but in the event it was possible to make a wider range of measurements using the different types of de-icers at different application levels.

This detailed technical report sets the context of the study, describes the programme of measurements made and discusses the implications of the results of the tests in the context of potential accident risk and the areas of the topic that it has not been possible to cover in this first phase of work. The body of the report concentrates on the work carried out in this study: supporting appendices provide more detailed background information.
2 Background and scope

2.1 Tyre/road friction and skid resistance

When a vehicle is braking or cornering it relies upon friction between its tyres and the road surface to provide an opposing force that enables the vehicle to slow down or follow around the curve. If the combined braking or cornering forces required by the tyre exceed the available friction, the tyre will slide over the road surface. In the extreme case, the rotating wheel may lock and the vehicle will skid or the tyre may slide sideways.

Tyre/road friction is dependent upon a number of factors, some of these relating to the road surfacing and some to the tyre itself. Friction can also be influenced by other factors such as weather conditions and local surface contamination. When a road surface is dry, the coefficient of friction is normally high and adequate for most normal manoeuvres. However, when the road is wet, road/tyre friction decreases significantly. A road described as “damp” may also show a marked reduction in friction even though it is not raining.

The term “skid resistance” is used specifically to refer to the contribution that the road surface provides to tyre/road friction. Unless indicated otherwise in a particular context, the term “skid resistance” applies to wet roads and measurements are made on a wetted surface. The Highways Agency’s skidding standards (set out in DMRB HD28/04) use the term skid resistance to apply specifically to wet conditions.

Skid resistance varies over the life of a road, as a result of the polishing action of traffic but it normally reaches an equilibrium level that remains essentially constant provided traffic levels remain unchanged. However, the actual level of skid resistance varies about this equilibrium through the year, being lower in the summer and higher in the winter, a phenomenon known as “seasonal variation”. For this reason, for network management purposes, skid resistance is assessed during the summer.

Skid resistance is also affected by vehicle speed, decreasing as speed increases, and this effect must be taken into account in any measurement strategy.

Further background information in relation to how skid resistance is developed and how road surfacings are designed to provide adequate skid resistance is provided in Appendix A.

2.2 Measurement of road-tyre friction and skid resistance

In Section 2.1, a distinction was drawn between road/tyre friction and skid resistance. Both are assessed by making a measurement of the coefficient of friction between a tyre and a road but there are a number of different techniques that are used for different purposes. The different methods give different results in different test conditions and therefore are not normally directly comparable. The principal measurement methods used in the UK are briefly described here: more detailed explanations of the techniques used in this study are included in Appendix A.

2.2.1 Police friction measurements (“Skidman”)

The coefficient of friction experienced by a particular vehicle in a particular situation is of greatest interest to police collision investigators, who use the information to assess the circumstances of a crash, such as deducing vehicle speeds from skid marks at an accident scene.

They therefore measure friction using a test vehicle, often a police car, by measuring the deceleration as it skids to a halt with all wheels locked. The measured average deceleration is adjusted for the gradient of the road and acceleration due to gravity to give an average coefficient of friction.

For this purpose they use a proprietary device that is typically positioned in the foot well of a vehicle. “Skidman” is the best known example of this type of device used in the UK. The measurements are
usually made in conditions similar to those thought to have been prevailing at the time of the accident. They are therefore often made on a dry road but may also be on wet or damp roads.

This method, while providing a measure of average friction during a skid, give a result that is the average for four tyres passing over different parts of the surface over a range of speeds. It provides an indication of friction conditions for a skidding vehicle at a particular time but it does not relate directly to the long-term skid resistance condition of the road surface.

### 2.2.2 Measurement of skid resistance

Skid resistance is normally measured under standardised conditions using standardised equipment. Various devices are available for measuring skid resistance of which three principal types are used in the UK, namely:

- **SCRIM** – a tanker lorry with a special fifth wheel set at an angle to the direction of travel. SCRIM is specifically designed to measure wet skid resistance. It is the standard tool used for routine monitoring of the trunk road network and a fleet of machines operates in the UK for this purpose.

- **GripTester** – a small, lightweight three-wheel trailer operating on the fixed-slip principle used by some local authorities to monitor their local networks or as an investigative tool. Like SCRIM, the GripTester is designed to measure wet road skid resistance but can be operated with the water turned off in order to make measurements on an un-wetted surface.

- **Pavement Friction Tester (PFT)** – a standard device that uses a full-sized (car) tyre to measure locked-wheel friction. This device is designed to comply with an American Standard, ASTM E274. It is designed to measure locked wheel friction on wet surfaces but can be used to measure dry surfaces also. Highways Agency owns one of two examples of this device in Europe and it is operated by TRL on their behalf, primarily for research use.

All the devices measure the force developed on a smooth (i.e. no tread pattern) rubber tyre passing over a wetted road surface and derive a value that is related to the coefficient of friction and the state of polish of the road surface. However, the results from the different devices are dependent on their operating principle and are not directly interchangeable.

### 2.3 Potential risks from frost and the application of de-icers

Notwithstanding any underlying increase in skid resistance that might occur over the winter period, it has been found that during periods of frost the formation of a layer of ice of thickness >30 microns will result in a loss of friction at the tyre-road surface interface and dangerously slippery conditions exist when the thickness of the layer is 50 microns or more (Nicolas, 1996). Therefore, little moisture need be present on a road surface for the risk of accidents to be increased significantly in freezing conditions.

To combat this, de-icers (normally based on sodium chloride in the UK) are used to prevent the formation of ice by depressing the freezing point of water on the surface. However, the de-icers themselves may also affect the friction available for vehicles in a number of possible ways.

Moisture is drawn from the atmosphere as de-icers go into solution, and this makes the road surface wet, thus bringing the lower-grip conditions of wet skid resistance into play when conditions may otherwise be dry.

The moisture may loosen detritus already on the road surface and, in prolonged dry, frosty spells, further detritus may build up on such wet surfaces over a period of time without sufficient precipitation to ‘wash’ the road surface. Impurities in de-icers, such as marl, may also build up. When salt solution on a road surface dries, the salt will leave a bloom on the surface as it recrystallises. All of these phenomena may fill the surface microtexture and hence may affect both the wet and dry
tyre/road friction. Older or heavily trafficked surfaces where the microtexture has been polished may be more susceptible to these influences than newer or more lightly-trafficked surfaces.

In summary, a de-icer has the potential to affect road/tyre friction in the following situations:

- As the de-icer goes into solution – affecting both dry and wet friction.
- When a de-icer is fully in solution – affecting wet friction.
- After repeated applications that enable a high concentration of de-icer and detritus to build up on the road surface over time – affecting dry and wet friction.
- When it first rains after a high concentration of de-icer and detritus has built up on the road surface during a dry cold spell – affecting wet friction.

### 2.4 Project scope

The project had the general aim of establishing whether anecdotal claims that the application of de-icers can lead to a reduction in skid resistance could be demonstrated in practice and then whether any effects were likely to be of practical significance in terms of increased accident risk. The desk study would use accident statistics and engineers’ experience to assess the extent of any perceived problems while practical measurements of skid resistance would indicate the scope of any physical effects.

As explained earlier, it was recognised that a great many different parameters interacting with one another would contribute to a range of possible physical phenomena and it would not be practicable to examine all the effects in this initial project.

Not only were there fundamental variables, such as surfacing characteristics, de-icer types and spread rates to consider, weather and traffic conditions would also play a significant part in the processes. It was considered important that the testing should be done as far as possible in normal winter conditions. However, while some of the factors could be controlled, at least in part, the weather certainly could not.

It was therefore decided that the approach should have two components:

- Planned trials, in which measurements of skid resistance would be made on selected sites using specific de-icers laid at controlled rates wherever possible.
- Reactive tests, in which skid resistance measurements would be made in selected areas in response to normal winter service operations.

Any practical work would require a measurement methodology that would be capable of demonstrating any effects. For this reason, a defined objective of the project was to develop a test methodology. The selection of the most appropriate tool and operating conditions for the measurements was of considerable importance.

For reasons explained in Section 3.1, it was proposed that the PFT should be used for the bulk of the testing in the planned trials. However, this device is unique in the UK and for the reactive programme it was desirable to have equipment available that could be mobilised quickly and in more than one area. It had been suggested that the GripTester, which was available to a number of service providers, might be a more convenient tool to use for this aspect of the work. It was decided, therefore, that the two devices would be used alongside one another as part of the planned trial work, thus establishing an effective working procedure for the reactive testing.

In the event, a number of external constraints limited the extent of work possible. Prior commitments for the PFT meant that it was only available to this study for a relatively short period. Also, in developing the methodology it was established that the reactive test programme using GripTester as originally conceived would not have been worthwhile, so the extent of this work was curtailed. Further, the winter turned out to be generally mild and wet: some of the conditions that it would have been interesting to include within the scope of the study did not occur.
Nevertheless, as will be described in more detail in the following sections, it proved possible to cover a wider range of tests in the “planned trials” component of the programme than had been anticipated at the outset. In spite of the various constraints, it was possible to examine the effects of four de-icers on examples of the two types of surfacing most commonly found on the trunk road network at different application rates and with different levels of residual salt, including extremely heavy applications.

The weather conditions did not permit the exploration of effects such as the potential build-up of marl or residual salt on the surfaces in prolonged cold, but generally dry, weather.
3 Methodology

3.1 Choice of measurement techniques

For this study, a measurement technique was needed that could measure the skid resistance of the surface of the road under the influence of the de-icer, typically after it had gone into solution, with the surface in its “as is” condition. The standard machines for measuring skid resistance normally wet the surface ahead of the test wheel but this would be undesirable for much of this work because this would alter the conditions by adding water and washing away the salt. Equipment was therefore needed that could be operated and make meaningful measurements without applying water to the surface.

This constraint ruled out the use of SCRIM, which is designed specifically to measure wet skid resistance under controlled conditions. Although the water feed can be turned off, the design of the equipment and experience has shown that it is inherently unsuitable for testing on dry or slightly damp roads.

The GripTester also normally operates with a controlled wetting system but, because it uses an in-line fixed slip principle, it had the potential to be used with the water turned off, relying on any moisture already on the road. The PFT can be operated with water on or off and has been used in dry conditions to assess the friction available on new surfacings.

It is important to recognise that wet skid resistance varies with speed. It was considered that an important part of the work to establish a methodology should take this into account, in order to determine whether the presence of de-icers on the surface or in solution has different effects as speed changes.

In order to measure skid resistance at different speeds, it is not simply a case of running the test vehicle faster or slower. An important aspect of any measurement technique is the “slip speed”, the speed at which the test tyre contact patch slides over the road surface. This is related both to the forward speed of the test vehicle and to the “slip ratio” which is a function of the device principle. The GripTester, for example, has a slip ratio of just below 15% which results in a slip speed of about 7 km/h at a test vehicle speed of 50 km/h. By contrast, in a locked-wheel test the PFT has a slip ratio of 100% so its slip speed is equal to the speed of the test vehicle.

The PFT, therefore, can measure skid resistance at any practical speed from about 20 km/h up to 130 km/h but GripTester is constrained to low-speed measurements by its low slip ratio. For example, at a road speed of 120 km/h the GripTester slip speed is only 18 km/h.

Another difference between the devices is that the PFT can only make measurements over discreet lengths of road, whereas the GripTester provides a continuous record of the skid resistance.

It was important, therefore, to take account of these different factors in the test programme. It was decided that the PFT would be used to assess the effect of the de-icers on skid resistance at different speeds and the GripTester would be operated at its normal standard test speed of 50 km/h to provide comparative data that would allow its suitability for use in reactive testing to be assessed.

For the tests on the A69 the GripTester was provided and operated by Northumberland County Council. On the A421 the Highways Agency machine was used, operated by TRL.

The “Skidman” technique was ruled out for this stage of the research because the test conditions are less well controlled and it covers a range of speeds during a single test. It is also impractical to use without closing the road, and is unsuitable for testing at high speeds. Further, it is difficult to relate the results to normal road assessment techniques. The latter point would be important in assessing the significance of any changes in skid resistance measured in relation to normally acceptable levels.
3.2 Planned trials - identification of trial sites and de-icer types

Working with Highways Agency during the planning phase of the project, service providers who used different de-icers were identified, together with routes that they normally covered, and that therefore might be able to offer suitable trial sites. Following direct discussions with these providers and visits to the possible trials sites, it was decided that two locations would be used for the planned trials that would allow four different de-icers to be compared, in each case on two types of surfacing, namely, hot-rolled asphalt with pre-coated chippings (HRA) and proprietary thin surfacing (TS). The two routes chosen were on the A69 in Northumberland and the A421 Bedford by-pass.

The A69 offered the possibility of using three different de-icers, applying each to a pair of sites (i.e. HRA and TS), with the three pairs of sites in relatively close proximity. It would be possible to coordinate the de-icing operations so that all six sites could be tested one after the other in a short period of time. The A421 provided a further pair of sites on which a fourth de-icer would be used. In this case, the thin surfacing had been open to traffic for less than six months, so this provided an opportunity to assess any possible adverse effects on relatively new asphalt.

The de-icers used on the A69 were:

- Dry untreated rock salt: 10mm Cleveland Potash rock salt.
- Rock salt treated with Eco-Thaw: 10mm Cleveland Potash rock salt treated with Eco-Thaw (3% by weight).
- Rock salt treated with Safecote: 6.3mm Thawrox+.

Eco-Thaw and Safecote are agricultural by-products (ABPs) that are added to de-icers to improve the salt distribution and retention on the road surface.

The de-icer used on the A421 was:

- Pre-wetted untreated 6.3mm rock salt (dry rock salt and brine in proportion 70:30 by weight).

The chloride content of the untreated 10mm and 6.3mm rock salt is typically 95% and 94%, respectively. The insoluble content is typically 3% and 4%, respectively.

Table 1 lists the specific trial site locations and the de-icers used on each. The sites were up to 4km long and chosen so that the road was reasonably straight, without steep gradients, with no junctions and a surface condition that appeared to be reasonably uniform along the site without major defects.

3.3 Planned trials - pattern of skid resistance tests

For the planned trials on the A69 and A421 a testing strategy was devised that could easily be applied to each test site and enable the two devices to make measurements in convoy where appropriate and simplify any traffic management requirements that would be necessary, both to protect the test vehicles and other traffic when operating at slow speeds and to maintain sufficient headway between the test vehicles and other traffic for higher-speed tests.

3.3.1 PFT test pattern

A standard PFT skid cycle lasts up to 5 seconds and holds the test wheel in its locked condition for 1 second. Therefore, the device tests over a discreet length of road (which varies in length depending on the test speed) and so it is necessary, particularly at the slower speeds, to make replicate measurements to sample a length of road and take account of the small variations that typically occur with this kind of measurement. In order both to assess the effect of speed and make adequate replicate measurements, the PFT would either need to make a large number of passes along the site or make measurements at different speeds in different locations.

Given that it was important to complete measurements as soon as possible after the required salting conditions had been achieved, it was decided that the most efficient and effective way to carry out the
tests was to make replicate measurements along the line of the road rather than with repeat passes. Using this technique and accelerating the machine to the next speed between each set of skids would allow a full sequence of measurements to be made in a single pass. This approach assumed that the skid resistance along each site was essentially uniform (a reasonable expectation provided that the same aggregate had been used and the same traffic conditions prevailed along the site).

Therefore, for each salting condition investigated, the PFT made a sequence of measurements at 20, 50, 80 and either 90 or 100 km/h at pre-determined distances along each site. The highest speed was dictated by safety considerations and the road geometry: 100 km/h was used on the dual carriageway sites and 90 km/h on the single carriageway locations. Table 2 shows the distances along each trial site where PFT measurements were made, together with the number of repeat measurements at each speed.

In planning the tests, provision was made for off-setting the skid positions on each repeat pass in case the skid had altered the conditions on the road (which has been observed in the past in dry tests). In practice, on the A69 it was observed that the locked-wheel skids had no effect on the road surfacing so repeat measurements could be made at the same locations along each trial site. However, on the relatively new thin surfacing on the A421 (Site H), skid marks were observed during an initial test when the road was almost dry, so the position of each skid was varied for each test run on this section to ensure no individual area of the road was tested more than once. For consistency of operation, this pattern was also followed on Site G, the HRA section.

**Table 1. Trial site location details**

<table>
<thead>
<tr>
<th>De-icer type</th>
<th>Surfacing type</th>
<th>Site ID</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated salt</td>
<td>TS</td>
<td>A</td>
<td>A69 east of Hexham. Lane 1 of eastbound carriageway from A68 junction to Styford Roundabout.</td>
</tr>
<tr>
<td></td>
<td>HRA</td>
<td>B</td>
<td>A69 east of Hexham. Lane 1 of westbound carriageway from 500m west of Styford Roundabout to A68 junction</td>
</tr>
<tr>
<td>Eco-Thaw treated salt</td>
<td>HRA</td>
<td>C</td>
<td>A69 east of Haydon Bridge. Westbound lane of single carriageway from West Wharmley to A686.</td>
</tr>
<tr>
<td></td>
<td>TS</td>
<td>D</td>
<td>A69 west of Haydon Bridge. Westbound lane of single carriageway from Lipwood to Ridley Hall</td>
</tr>
<tr>
<td>Safecote treated salt</td>
<td>HRA</td>
<td>E</td>
<td>A69, Haltwhistle By-Pass. Westbound lane of single carriageway west of river South Tyne bridge.</td>
</tr>
<tr>
<td></td>
<td>TS</td>
<td>F</td>
<td>A69 west of Haltwhistle. Westbound lane of single carriageway from top of Greenhead Bank to Shawfield junction</td>
</tr>
<tr>
<td>Pre-wetted untreated salt</td>
<td>HRA</td>
<td>G</td>
<td>A421 Bedford southern by-pass. Lane 1 of westbound carriageway from A428 junction to A603 junction</td>
</tr>
<tr>
<td></td>
<td>TS</td>
<td>H</td>
<td>A421 Bedford southern by-pass. Lane 1 of westbound carriageway from A1 to A428 junction</td>
</tr>
</tbody>
</table>

**Table 2. Distance along trial sites where PFT measurements were made on A69**

<table>
<thead>
<tr>
<th>Test speed (km/h)</th>
<th>PFT measurement start position relative to marker (m)</th>
<th>No. of measurements in sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sites A, B, G† and H†</td>
<td>Sites C, E and F</td>
</tr>
<tr>
<td>20</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>50</td>
<td>600</td>
<td>400</td>
</tr>
<tr>
<td>80</td>
<td>1600</td>
<td>1000</td>
</tr>
<tr>
<td>90 or 100</td>
<td>2600 (100)</td>
<td>1600 (90)</td>
</tr>
<tr>
<td>† On Sites G and H the starting point for each set of skids was offset by 100m further along the road for 20km/h and by 200m for the higher speeds on successive test passes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The test wheel on the PFT is mounted on the left side of the trailer, so all measurements were made in the nearside wheel path. The position at which to start the set of skids at each speed was identified using the odometer in the PFT recording system which was reset to zero at a fixed reference point (identified with cones placed at the side of the road) at the start of each run through the site.

3.3.2 Griptester test pattern

The GripTester was used to make a continuous pass along the site at a standard speed of 50 km/h during each test, recording the average GripNumber for each 10 metre length of road. For ease of subsequent comparison, the reference point at the start of each site was identified in the data stream by the operator pressing a button to record the feature as the marker cones were passed.

In order to avoid the GripTester wheel dragging along the same test line as that to be followed by the PFT, the GripTester made its measurements in the offside wheel path. Experience has shown that under normal circumstances on generally straight roads there is little difference in skid resistance between the two wheel paths of the same lane.

3.3.3 Test sequence

For each test pass, the machines were operated in convoy, with the GripTester leading and traffic management vehicles protecting the rear. At the start of each run, the GripTester ran ahead at a constant speed, followed by the PFT after a short interval. The tests were timed so that the PFT had completed its fastest measurements before it caught up with the GripTester. At the end of the run, both machines slowed to allow the traffic management vehicles to catch up and the convoy to regroup before moving on to the next site on the route.

For all tests with de-icer on the road, both the GripTester and PFT were operated with their automatic watering systems turned off.

3.4 Planned trials - de-icing operations and skid resistance measurements

This section of the report describes the general procedures used for the de-icing operations and skid resistance measurements. The work was carried out in a period of unsettled weather and when traffic management teams were needed at other works, so it was not always possible for a fully logical sequence of tests to be followed. For example, there were occasions when the planned spreading run was made but heavy showers then washed off the salt, nullifying its effect, before the skid resistance measurements could be completed.

For convenience, each measurement pass was assigned a sequence number (there were 18 overall) and full details of these and the corresponding prior de-icer applications are given in Appendix B.

The test programme was carried out over a three week period in January and early February 2007. Most of the tests were made overnight. In the first week, a preliminary set of tests were made on the A69 to establish the working practice and test methodology and these were followed during the second week with further measurements with increased spread rates. The work on the A421 in the third week followed the principles established on the A69 but also included a special set of tests with very high spread rates.

3.4.1 Tests on the A69

The trial sites on the A69 were treated with de-icer either during a normal spreading run required because of the prevailing winter conditions or, as was more often the case, locally increasing the spread rate or making an additional pass specifically for the trials. In some cases, specific spreading runs were made to supplement a previous routine run. To allow for carry-over effects, any spreading
specifically for the trials started at least 500m before each trial site and, for the single carriageway sections, ceased 500m beyond the end of the site.

Separate spreaders based at separate depots were used to treat each pair of sites with one of the three de-icer types. The spreaders treated two lanes in asymmetric mode with the spread width 6m and in nearly all cases the target spread rate of 30g/m². As far as was practicable, a pattern of operation was arranged in which the three spreaders would make their runs at approximately the same time so that the skid resistance measurements could be made at a similar interval after each treatment over all six sites in turn.

After spreading, time was left for the salt to go into solution (which, in some cases, coincided with a peak traffic period). For the skid resistance measurements, the convoy began its run on the two sites east of Hexham with untreated salt, followed by the two sites with Eco-Thaw treated salt and finally the two sites with Safecote treated salt. A measurement pass following the pattern explained in Section 3.3 typically took about an hour.

There were some occasions when tests were carried out on only one or two pairs of sites, either because the spreader used to spread the Safecote treated salt was not available (it was sometimes needed for normal spreading runs in its local area), or because a sequence of tests was being made to assess the effect of repeated treatments and it was not practical to do this on all six sites.

Initial analysis of the data from the first few tests was carried out while the team was in the area in order to check that the methodology was working satisfactorily. This revealed that there was, in fact, a far larger variation in skid resistance along Site B than was expected, with the areas that coincided with the slower PFT tests being low in comparison with the rest of that site and the other HRA sites. For this reason, additional measurements were made during Test 5 at the more-uniform western end of Site B, beyond the original 100 km/h section. Immediately after it had completed its normal pass, the PFT slowed down progressively from 100 km/h to measure at 80, 50 and 20 km/h. After Test 6, extra PFT measurements were made at 50, 80 and 100 km/h on the first part of Site B to assess any speed effect there.

As well as testing similar de-icer applications along all of the sites, during the second week a separate sequence of tests (Tests 7 – 13) was made on one pair of Sites (C & D) in which six 30g/m² treatments were applied over a period of about 11 hours deliberately to build up the residual salt level. Supplementary reactive measurements were made with the GripTester alone on Sites E and F after they had been treated with Safecote during normal salting runs.

3.4.2 Tests on the A421

The two sites on the A421 were treated in one continuous run specifically for the trials, spreading starting 500m before the thin surfacing (Site H) and continuing along the carriageway until the end of the HRA (Site G). Spread rates of 20 and 40g/m² were used for the tests and the spread width was 9m to treat the two lanes. Being pre-wetted salt, approximately 25% of the de-icing material was water in the brine. The brine was manufactured from a high purity salt and 70% of the material was rock salt.

During the parallel desk study, it emerged that some Agents had reported that skid resistance appears to be lower when residual salt levels are high, such as at approaches to junctions, when localised excessive applications can occur¹. To assess this possibility, the effect of a single treatment at a very high spread rate on the skid resistance was measured as part of the test programme on the A421.

¹ The amount of salt discharged by a spreader in normal operation varies according to the vehicle speed, so the spread rate should remain constant. However, it appears that the salt distribution can be uneven when spreaders are slowing and stopped at junctions and spread rates can much higher than the target rate in small areas. Also, spreaders can be operated in ‘blast’ or ‘dump’ mode to increase the spread rate in vulnerable areas. High spread rates, and slippery road surfaces, have also been evident at approaches to depots when some drivers ‘spin-off’ their load onto the road surface to avoid the need to unload the spreader at the end of a salting run, but this poor practice normally results in disciplinary action.
Initially, a simple trial was carried out at the depot with the spreader travelling at approximately 5 mph and set to spread at 20g/m² with the “dump” button pressed (to approximately double the discharge rate). The amount of salt discharged over a known area was collected and weighed and the spread rate measured to be approximately 190g/m². The same procedure was then used to treat a short section of both the thin surfacing and HRA before the 20km/h sections of each site.

The skid resistance was measured with the PFT at a test speed of 20 km/h immediately after spreading, and after 1.5 and 3.5 hours after spreading. Immediately after spreading, measurements were also made with the PFT on untreated sections in advance of the heavily salted sections.

### 3.5 Planned trials - ambient test conditions

All salting runs and skid resistance measurements were performed at temperatures above freezing and the majority were below 10ºC; the effect of temperature variation on the results was therefore minimal. The road surfaces were never completely dry as a result of wetting from previous rainfall, the formation of dew or the absorption of moisture from the atmosphere by the salt on the road. The surface condition of each site during each test was assessed from observation as either damp or wet.

For the first few tests on each site, measurements were made approximately two hours after spreading. By this time, the de-icer in the wheel tracks was in solution as a result of trafficking. For the later tests following repeated treatments, measurements were made between 30 minutes and one hour after the spreader had passed, i.e. as the de-icer was going into solution, but it is thought that each previous treatment was fully in solution two hours after it had been spread.

During the tests, it was not possible to take direct measurements of de-icer levels on the road surface. However, to aid analysis, the residual level at the time of each skid resistance test has been estimated taking into account previous treatments, trafficking and the weather conditions, as explained in Appendix B.

### 3.6 Background skid resistance measurements

For any assessment of the effect of salting on skid resistance to be made, it was necessary to know the skid resistance of the underlying surfacing without any salt present. For this purpose measurements of what has been called here “background skid resistance” were made using both the PFT and the GripTester.

Both devices carried out their normal wet skid resistance measurements, the PFT using its standard water application rate for a nominal water film thickness of 1.0mm and the GripTester its standard 0.25mm.

The background measurements were made when wet weather had washed off any residual salt from earlier tests and before further salt applications were made. The GripTester also made background measurements in the nearside wheelpath to verify that the two lines were essentially similar.

### 3.7 Reactive tests on Sites E and F

The planned trials had indicated that the “reactive” testing as originally proposed, using GripTesters in different areas, was likely to be of limited value and therefore this programme was not pursued.

However, this approach was used on a small scale to make some further measurements on the A69 in the weeks after the main planned trials.

For these tests, Northumberland County Council used the GripTester on Sites E and F after they had been treated with Safecote treated salt as part of the general salting procedures at the time. Details of the spreading and test conditions are given in Table B3 in Appendix B.
4 Results and initial analysis of the skid resistance measurements

4.1 Overview of the planned trials results

4.1.1 Typical PFT locked-wheel friction measurements

A typical plot of the variation in locked wheel friction number measured by the PFT with the test speed is shown in Figure 1. The residual salt level is given within a 5g/m² range, and the results from tests within the range with similar road surface conditions have been grouped together (e.g. Tests 2 and 4). Each point on the graph corresponds to the friction number (FN) of the individual skids: the spread in the replicate points at the different speeds is typical of measurements of this type. The trend lines plotted through the data from each test or group are based on a second-order polynomial form which previous research has shown to represent data of this type well.

![Figure 1. Typical variation in friction number with speed (A69 Site A Tests 1 to 6)](image)

The background skid resistance levels (blue line) are typical of what would be expected on most surfacings of this type using an aggregate with polishing resistance suitable for the level of traffic and with good texture depth. It can be seen that there is a marked decrease in normal wet skid resistance with increasing speed, typical of surfacings with good texture depth (see Section A.2).

The measurements from the tests carried out after de-icer treatments also showed a decrease in skid resistance with increased speed but the decrease was not so great at higher speeds. It can be seen that the skid resistance with residual salt present was lower than the normal level for a wet road at 20 km/h but higher at higher speeds. There is also a suggestion that greater residual salt levels may result in a reduction in FN.
4.1.2 GripTester measurements

Figure 2 illustrates the results from the GripTester. It shows the GripTester measurements at 10m intervals along the site for the same sequence of test passes as used in Figure 1. GripNumber (GN) is plotted against distance from the reference point. In this case, of course, the measurements were all made at the same test speed.

![Graph showing GripNumber measurements along a site](image)

**Figure 2. Illustration of variation in GripNumber along a site (A69 Site A Tests 1 to 6)**

Several points are immediately apparent from this graph:

- Although the levels differ, the different runs show a very similar pattern along the site.
- The general level of skid resistance increases by a small amount about 1200m along the site.
- The values after salting tend to be higher than the background level, in contrast to the 20 km/h PFT measurements.

4.2 Differences between the PFT and GripTester measurements

At first sight, the PFT and GripTester results are contradictory in that one test method shows a decrease in low-speed skid resistance after salting while the other shows an increase.

As explained in Section 3.1 and Appendix A, the GripTester measures at a low slip ratio (15%) and consequently the slip speed is low (about 7 km/h at a 50 km/h test speed). On the other hand, the friction number (FN) value recorded by the PFT is the average sliding friction over a 1 second period after the wheel has locked and represents the value at a slip speed equivalent to the vehicle speed.

However, during a test, the PFT records the friction at intervals of 0.01 seconds throughout the lock-and-release cycle together with the actual speed of the test wheel and the vehicle. It is therefore possible to determine the peak friction measured during the skid and, in principle, to estimate the skid resistance at any slip speed, albeit for a very short distance.

In order to explore further the apparent difference in the effects shown by the two measuring devices, the data from the individual PFT skids were analysed in detail to estimate the skid resistance at a slip...
speed of 7 km/h. There was considerable spread in the results derived in this way as might be expected. However, it was known from other work that the peak friction levels also vary with test speed so, for the purposes of this comparison, the data from the PFT skids at 50 km/h were examined separately in order to mirror as closely as was practical the conditions used by the GripTester in a 50 km/h test.

This analysis showed that, when measured at the lower slip ratio and slip speed, the PFT also indicated that skid resistance was higher after salting than on a normal wet road. A similar effect was found for the peak friction values from the 20 km/h tests. This suggested that the values recorded by the GripTester were recording a real effect under the specific test conditions of the device but that the device is unable to detect the reductions in skid resistance at higher slip speeds shown by the PFT.

### 4.3 General comments on the planned trial results

The results described in Section 4.1 were generally typical in form for of all of the sites, although on some sites with some de-icers, the skid resistance remained below the background level at 50 km/h.

The results from all of the tests are summarised and compared in a series of figures in Appendix C. Each figure shows results from a sequence of tests on one site. The graphs include the following data:

- PFT friction/speed curves, with each point representing the average of the repeat measurements at each speed.
- The average GripNumber (at 50 km/h) for each section of each site corresponding to the lengths on which the PFT made its measurements at the different speeds.
- The estimated average Friction Number at 7 km/h derived from the 50 km/h PFT skid.

Although there were differences in detail on some sites, the general pattern of results on all sites was similar to that illustrated in Section 4.1, namely that GripTester results were higher after salting than on a normal wet road and that at 20 km/h (and sometimes 50 km/h) the locked-wheel friction was reduced in the presence of a de-icer.

In viewing the figures in Appendix C, it should be borne in mind that the PFT measurements at the different speeds were made on different parts of the road, so any variation in skid resistance along the road is also affecting these measurements. For example, if the skid resistance increases over the length where the higher-speed tests were made (as occurred on Site A, for example), the PFT measurements may under-estimate the relative reduction in skid resistance.

This effect was most apparent on Site B, which had a distinct area of relatively low skid resistance that coincided with the area of the 20 km/h tests and as a result the change in skid resistance with speed was masked (Figure C2). The additional tests, however, showed that the reduction with speed did occur on the different parts of the site (Figure C7).

A further factor to take into account is the amount of water on the surface. Although it is not possible to be precise, it is known from other work that the measured friction increases as the road dries out but only small amounts of water are needed for a marked reduction in friction and for the speed effect to be observed.

There may have been some variations in the measured friction level on different occasions due to this effect. However, with the exception of one or two passes when the road was almost dry at the time of the test (these are indicated in the figures and are obvious from the high friction levels and the relatively small reduction with speed for the PFT), the surfaces were generally damp or wet as a result of prior rainfall or very light precipitation in the test period.

### 4.4 Reactive measurements on Site E and F after treatment with Safecote treated salt

The results of these additional “reactive” tests are summarised in Table 3, which gives the average GripNumber along each site for each of the test runs.
The measurements made under damp conditions showed similar results to those obtained in the planned trials series of tests. Average GripNumbers were the same as or slightly higher than the wet background level.

Under dry conditions, which had not been examined in the planned trials, the GripNumber was significantly higher than the background, as would be expected for an untreated dry road.

For the tests under dry conditions with residual salt levels of 24 to 30g/m², the salt had not gone into solution between spreading and testing. The test under dry conditions with a residual salt level of 36g/m² was made immediately after the road had dried out and the salt had recrystallised. A further 30g/m² was spread on this dry surface later in the day and would not have gone into solution before the remaining dry tests were carried out with residual salt levels of 50, 53 and 56g/m².

The results of the dry tests with the higher residual salt levels on Site F suggest that the skid resistance on the thin surfacing had reduced slightly in comparison with the earlier dry tests and the HRA section. Closer examination of the data showed that for these tests the first half of Site F had given much lower results than the second half of the site, leading to a lower average value overall. The operator’s notes also suggest that the reduced values occurred because the first part of the site was probably damp at the time, rather than as a consequence of the salting.

<table>
<thead>
<tr>
<th>Surface condition</th>
<th>Estimated residual salt (g/m²)</th>
<th>Site E (HRA)</th>
<th>Site F (TS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet</td>
<td>0 (background)</td>
<td>0.54</td>
<td>0.68</td>
</tr>
<tr>
<td>Damp</td>
<td>36</td>
<td>-</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>0.63</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>0.57</td>
<td>0.72</td>
</tr>
<tr>
<td>Dry</td>
<td>24</td>
<td>0.98</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>1.00</td>
<td>0.87</td>
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<tr>
<td></td>
<td>30</td>
<td>0.87</td>
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<tr>
<td></td>
<td>36</td>
<td>0.83</td>
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</tr>
<tr>
<td></td>
<td>50</td>
<td>0.90</td>
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</tr>
<tr>
<td></td>
<td>53</td>
<td>0.95</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>0.94</td>
<td>0.75</td>
</tr>
</tbody>
</table>
5 Further analysis

5.1 Change in skid resistance with type and level of salt and surfacing type

The overview of the results in Section 4.1 showed that at slower or intermediate speeds the PFT showed a decrease in skid resistance. There was also a suggestion that there might be a greater decrease with increased residual salt. In order to assess this further, the data were normalised to allow for the different background skid resistance levels on the different sites. For this purpose, the percentage change in FN or GN relative to the wet background level was calculated for all the de-icer and surfacing combinations.

The percentage changes in friction number for the two surfacing types at 20 km/h are shown in Figure 3 and Figure 4, and at 50 km/h in Figure 5 and Figure 6. The graphs include the results from the tests on Sites C and D from the repeated applications of Eco-Thaw in tests 7 – 13.

Equivalent graphs for GN are in Figure 7 and Figure 8. These two graphs show the average GripNumbers for the complete sites.

![Figure 3. Relative change in FN at 20 km/h with residual salt for thin surfacings](image-url)
Figure 4. Relative change in FN at 20 km/h with residual salt for HRA surfacings

Figure 5. Relative change in FN at 50 km/h with residual salt for thin surfacings
Figure 6. Relative change in FN at 50 km/h with residual salt for HRA surfacings

Figure 7. Relative change in GN with residual salt for thin surfacings
Figure 8. Relative change in GN with residual salt for HRA surfacings

5.2 Effect of localised heavy salting

Table 4 shows the average friction number measured at 20 km/h on the heavily-salted sections on the A421. The estimated residual salt levels are shown in parenthesis.

Table 4. Friction number measured at 20 km/h at heavily salted section and change relative to background

<table>
<thead>
<tr>
<th>Surface type</th>
<th>Average friction number (estimated residual salt level in g/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Background</td>
</tr>
<tr>
<td>TS</td>
<td>80.7 (0)</td>
</tr>
<tr>
<td>HRA</td>
<td>64.1 (0)</td>
</tr>
</tbody>
</table>
6 Discussion

6.1 Methodology

A major component of this project was to establish a methodology that would allow the effects that de-icer has on skid resistance to be studied objectively. The difficulty with this is that both skid resistance and the application and action of de-icers are complex subjects affected by a great many factors that are difficult to isolate or control. Within the project, therefore, it was necessary to consider measurement techniques and ways in which to create different de-icer conditions on the road.

6.1.1 Measurement methods

It was clear at the outset that conventional survey techniques, such as SCRIM, whilst entirely satisfactory for the purposes of network monitoring and management, would not be suitable for this kind of study because their operating principles would not allow appropriate combinations of factors to be assessed.

It had been suggested that the GripTester could be a good tool to use for this work, particularly for reactive tests, because it is light, easy to use and potentially a large number of road authorities have a machine available. However, it was considered that (with its operating principle of a fixed slip at a low slip ratio) it was probable that the device would be limited in what it could show.

In the event, the work has confirmed that the GripTester is not able to detect any adverse effects from adding de-icers to an already-wet or damp surface. In spite of the potential advantages, it is an inappropriate tool for this type of work, apart from providing an indication of the general level of skid resistance along a site. In fact, had it been relied upon for this study, potentially important effects would have been missed.

However, notwithstanding its limited contribution to the present study, it may be that the GripTester has the ability to detect effects that occur in situations not covered by the work so far. For example, it might be sensitive to the possible build-up of marl or salt after successive treatments in prolonged cold, but generally dry, periods. For this reason, it should not be ruled out entirely for any future work.

The PFT was included in the study because it had the potential to examine effects such as the effect of de-icers at different speeds. The work has clearly demonstrated its value for this purpose. However, there are practical difficulties with this kind of technique. The need to operate at very slow or relatively high speeds, combined with the unusual nature of the test, there is a need for traffic management in most situations and this creates an operating constraint.

Also, the need for repeat testing to provide adequate sampling of the surface at any one speed, combined with the need to test over a range of speeds, means that a significant time can be spent measuring on any one site, during which time the conditions on the road can change.

A testing regime was devised that proved very efficient in practice but, within the time constraints for this study, there was no opportunity for detailed preliminary testing and planning. Consequently, the testing had to be based upon assumptions about the general homogeneity of the surfacings that, in the event, proved not to be true of all the sites.

These limitations have not significantly affected the broad findings of this study but they have limited the detail with which it might have been possible to analyse the results. This is especially true of areas where the effects changed, such as where the skid resistance with de-icers can be greater or less than the background level at intermediate speeds.

Nevertheless, the PFT has been shown to be a powerful tool to assess a range of conditions and it should continue to be the basis of any future studies. However, wherever possible, an advance assessment of the variation in the normal wet skid resistance and texture depth along likely sites should be made so that test locations that need to be comparable with one another really are.
6.1.2 Planned trials

An important part of the methodology for this study was the use of planned trials, where specific treatments were applied to pre-determined sites. This is an essential approach if the effect of varying major factors such as de-icer type, spread rates and surfacing type are to be compared. In practice, this approach worked reasonably well, but the work was inhibited by constraints of working on a road open to traffic using spreaders that were effectively assisting the trials in addition to their normal work in response to prevailing weather conditions.

This meant that, for example, spreading runs tended to be made just ahead of peak traffic periods and it was not possible to make measurements until after this time had passed, by which time weather and traffic had affected the salt distribution on the surfaces. This kind of problem is inevitable but, wherever possible, advance planning should be used to minimise the adverse effects, for example, by making dedicated spreaders available.

The provision of different sites using different de-icers along the same stretch of road proved a significant advantage to this study because it enabled the scope of the effects to be assessed in the one exercise. Nevertheless, the distances involved (on the A69 it took almost two hours to get from start to finish and back again) limited the number of tests that could be made and also meant that weather conditions (and hence road conditions) could vary markedly between the start and end of a test run.

For future work, planned trials will be important, but careful planning will be needed to make sure that both treatment and testing can be efficiently combined.

Even using planned trials, however, any programme will be constrained by the prevailing weather. For the tests in January 2007, the unsettled, showery, conditions meant that some treatments were abortive and the residual salt levels and wetness of the road were uncertain. The conditions were generally similar for the various tests but some other types of conditions, such as a prolonged cold dry spell were not encountered.

6.1.3 Reactive testing

The idea behind the reactive testing component of the project was to take advantage of the potential flexibility offered by the GripTester to make skid resistance measurements in response to whatever conditions prevailed on selected areas of the network, particularly if there was likely to be a build-up of salt.

However, this aspect of the work was not pursued because the planned trials had demonstrated that the GripTester was not able to measure any significant effects. Also, the winter was unusually mild and wet so there was no opportunity to make any constructive measurements.

Reactive testing might be appropriate in future work if suitable combinations of weather conditions and salt applications would make it worthwhile and if it can be demonstrated that the GripTester can measure an effect under those conditions. However, it is likely that tests with the PFT would be more appropriate. In that case, an element of planning will be necessary. It will be important to identify sites in advance on which tests would be made in response to prevailing conditions and to put in place the necessary support arrangements, so that issues such as traffic management are also responsive to the need for tests at short notice.

6.2 Key observations

The work within this study was designed to assess the scope of possible adverse effects of de-icers on skid resistance rather than cover every eventuality. Although it has not been possible to study some effects in detail, some important general observations can be made, namely:

- At very low slip speeds, on damp or wet surfaces, de-icers do not appear to adversely affect skid resistance.
o At low slip speeds, around 20 km/h, on wet or damp surfaces, de-icers tend to reduce locked-wheel friction.

o Increased residual salt levels tend to lead to a greater decrease in skid resistance, to about 20% of the background level, but continued applications on wet roads to very heavy concentrations approaching 200g/m² do not show decreases markedly greater than this.

o At higher slip speeds, over about 80 km/h, the skid resistance of damp or wet surfaces with de-icers present appears to be greater than it would be without the de-icer.

o There were no obvious differences in behaviour (within the limits of the conditions tested) that could be attributed either to surfacing type or de-icer type.

From the limited number of tests made on dry, or almost dry, surfaces it appears that the presence of de-icers does not markedly affect skid resistance, which remains high with little effect due to speed, as would be expected on an untreated road.

6.3 Significance of the observations in relation to accident risk

The observation that skid resistance may be reduced in the presence of de-icers could represent a potential theoretical increased risk of skidding accidents. In considering this possibility, a number of issues need to be discussed.

Low or reduced skid resistance of itself does not normally cause accidents: rather, it becomes a contributory factor when combinations of other circumstance are present, for example, when a driver suddenly has to brake or swerve, or may be travelling faster round a bend than the available grip would allow. This is recognised in the UK skidding standards by the use of the concept of an “investigatory level” (IL) for the skid resistance of a site that is related to skidding accident risk for the type of location.

In this context, the skid resistance that is compared with the investigatory level is the long-term summer average skid resistance determined by regular monitoring with SCRIM, known as the Characteristic SCRIM Coefficient (CSC). This is based on a three-yearly average adjusted to take account of within-year and between-year seasonal variation. As explained in Appendix A, SCRIM measurements for this purpose are made at 50 km/h, which corresponds to a slip speed of 17 km/h.

For a skid to be initiated, the braking force must exceed the maximum (‘peak’) friction available at the time, either in reaction to braking or to side forces when cornering. The peak friction usually occurs at very low slip speeds and the results from the GripTester (supported by an examination of peak friction data from the PFT skids) suggest that the peak friction is not likely to be adversely affected by de-icers on a damp or wet surface. However, the question remains as to whether the reduction in sliding friction observed in this study represents a significantly increased risk of skidding.

As a guide, therefore, it might be argued that a reduction in skid resistance due to the presence of de-icers is unlikely to increase accident risk significantly if the skid resistance remains above acceptable summer levels. Whether this is likely to occur will depend on:

o How close the road’s summer condition is to the investigatory level.

o How much the winter skid resistance has increased in relation to the summer level due to seasonal effects.

In order to assess this for the sites studied, SCRIM measurements from summer 2006, obtained as supporting information for this project, were examined. In order to compare these values with the underlying skid resistance at the time of the tests, the background GripTester values recorded at the time of the trials were used to provide an estimate of the equivalent SCRIM Coefficient². The results of this analysis are shown in Table 5.

² Using an empirical conversion formula derived from comparative trials carried out by the GripTester User Group on the TRL track in 2004. The correlation is valid for tests carried out on straight roads at 50 km/h.
Table 5. Comparison of winter and summer skid resistance on the trial sites

<table>
<thead>
<tr>
<th>Surfacing type</th>
<th>Site</th>
<th>Summer SCRIM Coefficient</th>
<th>Winter SCRIM coefficient (Estimated GripTester Equivalent SC at time of tests)</th>
<th>% change in coefficient from summer to winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS</td>
<td>A</td>
<td>0.46</td>
<td>0.54</td>
<td>+14.8</td>
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<tr>
<td></td>
<td>D</td>
<td>0.52</td>
<td>0.58</td>
<td>+10.3</td>
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<tr>
<td></td>
<td>F</td>
<td>0.57</td>
<td>0.57</td>
<td>0</td>
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<tr>
<td></td>
<td>G</td>
<td>0.50†</td>
<td>0.62</td>
<td>+19.4</td>
</tr>
<tr>
<td>HRA</td>
<td>B</td>
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<td>0</td>
</tr>
<tr>
<td></td>
<td>C</td>
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<td>0</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>0.42</td>
<td>0.49</td>
<td>+14.3</td>
</tr>
</tbody>
</table>

† New surfacing during Summer 2006 measured in August – may have been affected by early-life skid resistance effects.

It was found that the pattern of skid resistance measured along the sites during the winter was very similar to that shown by SCRIM for most of the sites. However, although most sites, as expected, had higher skid resistance in winter, three sites had very similar levels in both seasons and one site (Site A) had two distinct sections, one which was higher than the summer level and one that was the same.

This demonstrates that, although seasonal variation occurs, it may affect locations differently and therefore it cannot necessarily be assumed that skid resistance will be higher in the winter than in the summer in every situation. It will also be noted that the relative increase from summer to winter is of a similar order to, or less than, the decrease observed in the 20 km/h tests with de-icer present.

Therefore, there remains a possibility that de-icers could offset any winter increase in skid resistance. However, provided that the summer level is sufficiently above the investigatory level (which was the case for all sites here) this should not represent an increased risk of skidding, but a small possibility remains that for sites that are close to their investigatory level in summer, there may be a greater reduction due to de-icers than has been offset by any winter recovery.

A mitigating factor for this effect is the fact that very low-speed skid resistance and higher-speed skid resistance is likely to be no worse than, or even greater than that expected for a wet road.

It must also be remembered that even though there may be a small increased skidding risk due to the presence of de-icers compared with a normal wet road, the level of skid resistance will still be much greater and the risk very much smaller than if the road had not been treated and ice or frost was present.

6.4 Limitations of the trials

The trials in this study were able to cover a useful range of conditions, including very high residual salt levels. They provide an important initial understanding of phenomena that may be observed but it must be recognised that they were limited in scope.

The results relate to the specific conditions at the time the measurements were made and depend on the underlying condition of the road surfaces themselves. Factors such as the level of trafficking at the time of the tests will have affected the rates at which salt entered solution and was lost between
spreading and testing and these influences have had to be estimated rather than measured. Also, the skid resistance measurement techniques used selected standardised conditions.

The winter of 2006/07 was unusually mild with relatively few days below freezing and high rainfall. Throughout the winter season, there were few opportunities for de-icer to build up on road surfaces from repeated de-icer treatments over several days without rainfall. Consequently, the range of conditions in which de-icers may be present and therefore have the potential to adversely affect skid resistance is greater than those which could be assessed in this short project.

In particular, road surfaces tend to stay wet for longer when de-icers are present because of the hydroscopic nature of the chemicals and the implications of this have not been systematically examined.

Further, detritus could build up on such damp or wet road surfaces and is likely to remain until washed off by rain. How much de-icer remains on such surfaces, and whether the insoluble content is dispersed at a different rate than the chloride content is likely to depend on the level of trafficking. Also, the build up of detritus may vary with the level of trafficking. The presence of such detritus, including residues from ABP additives, may have different effects on different surfacing types, especially newer surfaces, and none of these possible effects have been examined.

The tests have identified a suitable methodology to detect the effect of de-icers on skid resistance over a range of residual salt levels and further tests are recommended when worst case conditions exist.

Anecdotal evidence suggests that problems may be encountered by more vulnerable groups of road users, such as motorcyclists and pedal cyclists with some types of de-icer. Skid resistance for motorcyclists should be generally similar to those for other vehicles, although driver behaviours may vary (cornering faster, for instance). Also, motorcyclists may make more use of the central part of running lanes. These areas would be expected to have better skid resistance than the wheel paths but may also undergo periods when the salt is present in granular form for longer. These specific conditions have not been studied but the general results suggest that conditions for motorcyclists riding appropriately should be no worse with de-icers present than on a normal wet road.

Pedal cyclists ride under very different circumstances to powered vehicles. Bicycles have small, narrow wheels with very small contact patches that will be much more vulnerable to localised reductions in skid resistance than larger vehicles. Further, because they are ridden at comparatively low speeds they are operating in the speed range where reductions in skid resistance have been observed.

6.5 Further work

It is recommended that further studies should be carried out to investigate more systematically the areas that could not be covered in this project, in particular:

- The potential effects of the build-up of de-icer and associated detritus (including different de-icer types) during prolonged cold spells with repeated application of de-icers but little rainfall.
- The potential effects of previously treated areas remaining or becoming damp when roads are otherwise dry.
- Further examination of the influence of the presence of undissolved de-icer, particularly in larger concentrations and its potential influence on vulnerable users.
7 Conclusions

This initial study of the effects of de-icers on skid resistance has developed a methodology based on the Pavement Friction Tester (PFT) that allows the influence of different levels of residual salt to be assessed at a range of speeds. The technique has been used to assess the effects of spreading different de-icers on both HRA and thin surfacings, surfacing types that are typical of most of the current trunk road and motorway network. From the measurements made, the following broad conclusions can be drawn.

1. On wet or damp surfaces treated with de-icers, skid resistance decreases with speed, an effect typically observed on untreated wet surfaces. Similar effects were observed on both surface types.

2. The tests with the PFT have shown that de-icers reduce skid resistance at low sliding speeds (20 – 40 km/h) compared with an untreated wet road, but at higher speeds (60 km/h and above) skid resistance is greater than on a normal wet road.

3. At intermediate speeds the skid resistance with de-icers varies from slightly lower to slightly higher than background levels.

4. Within the limitations of the conditions tested, there were no clear differences in behaviour between the different de-icer types, including those treated with agricultural by-products.

5. The GripTester was also included in the test programme to assess its suitability for this type of assessment for potential use in reactive tests over a wider area. The device gave generally higher skid resistance on treated surfaces than on untreated surfaces. Analysis of the PFT records to estimate skid resistance under similar test conditions indicated a similar effect. It is concluded that, as a result of its operating principle, the GripTester is not suitable for general use in detecting any adverse effects due to de-icers.

6. The extent to which skid resistance on a damp or wet road is reduced at low speed tends to increase with greater levels of residual salt, whatever type of de-icer is used. For residual salt levels less than 80g/m², the percentage decrease in friction number at 20km/h relative to the background level was up to about 20%. In tests with very heavy levels of Eco-thaw treated salt (accumulations up to 200 g/m²) the relative decrease did not exceed 25%.

7. The changes of skid resistance observed in these tests suggest that on sites which already have skid resistance well above the investigatory level, de-icers are unlikely to increase the risk of skidding.

8. On roads that are closer to investigatory level, or when there is little or no seasonal increase, de-icers may reduce skid resistance below the investigatory level so there is a small theoretical increased risk of skidding in these specific circumstances.

9. In any event, skid resistance with de-icers present will always be much greater than would be the case if they were not used and frost or ice were to form.

Further work is recommended to address potential effects of de-icers that it was not possible to include in this project, particularly in relation to:

- The potential build-up of de-icer and associated detritus during prolonged cold spells with repeated application but little rainfall.

- The potential effects of previously treated areas remaining or becoming damp when roads are otherwise dry.

- The influence of the presence of undissolved de-icer, particularly in larger concentrations, and its potential influence on vulnerable users.
Acknowledgements

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References


**Crinson, L and J Martin (2008).** An assessment of the effect of de-icers on skidding accidents. TRL Published Project Report PPR220. TRL Limited, Crowthorne.


Appendix A. Further background on skid resistance and the measurement techniques used in this study

This Appendix provides some additional detail to the information provided in Section 2 of the main report in relation to the principles of tyre/road friction and skid resistance, and the measurement techniques used in this study.

A.1 The road surface and skid resistance

When a road surface is dry, the coefficient of friction is normally high and adequate for most vehicle manoeuvres. However when the road is wet, the tyre/road friction decreases significantly. It is also important to note that a road described as “damp” may also show a marked reduction in tyre/road friction even though it may no longer be raining.

The presence of water or other contaminants within the tyre-road interface prevents the intimate interaction between the tyre and road surfaces that is necessary for friction to be generated. It is the texture characteristics of the road surface, both micro and macrotexture (or texture depth) (Figure A1), that have a marked influence on the extent to which the water film can be dispersed or perforated and good contact established, and hence friction generated.

![Microtexture and texture depth](image)

Figure A1. Microtexture and texture depth

A.1.1 Microtexture

Microtexture is the name given to the fine asperities that occur on the surface of the road. This comes predominantly from the crystalline structure of the aggregate exposed at the road surface, but some contribution may also be provided by the areas of bituminous or cement mortar between the exposed aggregate.

At low speed, harsh texture on this scale is able to penetrate a water film, allowing friction to be generated in the areas where contact is made between the road surface and the tyre rubber. Surfaces with sharp microtexture therefore maintain relatively high levels of friction in wet conditions, although lower than the friction attained in dry conditions.

The microtexture of aggregates in road surfacings is polished by the action of traffic, particularly commercial vehicles, and friction is lost as a result. With time, the skid resistance of a road will fall to an equilibrium level which depends on the number of heavy vehicles using the road and the resistance to polishing of the aggregate used in the surfacing. In terms of skidding resistance, it is therefore important to select a suitable source of aggregate to ensure a reasonable interval between maintenance treatments.
A.1.2  Texture depth

Macrotexture is formed by the shape of, and the spaces around, the particles making up the road surface (or by brush marks or grooving on concrete pavements). Texture depth is a measure of this and can be measured using a volumetric technique to assess the average depth of the texture below the peaks of the surfacing or using laser sensors to measure average displacement from a nominal datum.

Texture is important because it provides drainage paths to allow any water to move rapidly from the tyre/road contact patch, a process assisted by the tyre tread. Also, more energy is needed to deform the tyre tread than is required for it to spring back to its normal shape; the excess energy initially being stored in the tyre, a process known as “hysteresis loss”. The amplitude and shape of the surface asperities determine the rate and degree of deformation of the tyre rubber and, hence, the magnitude of hysteresis loss generated. This process helps to slow down a skidding vehicle by converting kinetic energy into heat in the body of the tyre.

A.2  Skid resistance and speed

In wet conditions, as vehicle speeds increase, skid resistance decreases. The extent to which this occurs depends on the texture depth. Generally, the lower the texture depth, the greater will be the reduction in friction at higher speeds. Research conducted by TRL has shown that, in general, skid resistance reaches a minimum level at vehicle speeds of approximately 100 km/h. The research also showed that the rate of decrease in friction with speed was more rapid for surfaces with lower textures, particularly below 0.7mm SMTD (sensor-measured texture depth) (Roe et al, 1998).

The impact of low texture depth can first becomes apparent at about 50 km/h, i.e. at relatively low speed. This is demonstrated in Figure A2 where the two sites have different levels of skidding resistance at low speeds (given by the measurement with SCRIM, shown as SR on the graph legend) and different texture depths (SMTD). The rapid fall in friction with speed can be seen, and is particularly marked on the site with low texture depth (which is not, however, typical of UK roads).

![Figure A2. Typical friction/speed curves from two UK sites](image)

A.3  Seasonal variation

In climates such as that of the United Kingdom, the combined effect of climate and polishing under traffic leads to a seasonal fluctuation of skidding resistance (Hosking and Woodford, 1976). Fine particulates build up on the surface during the dry summer months, which act as a medium to
accelerate the polishing of the aggregate. Skid resistance therefore falls to an annual low during the summer and, for this reason, the summer average level is usually used when assessing the skid resistance condition of a road. During the winter, more frequent rain disperses the fines and the action of frost and grit results in a coarser deposit that tends to roughen the surface again, leading to an improvement in skidding resistance.

Variations in general weather conditions from one year to the next, for example, wet or dry summers, or warm and wet rather than cold, frosty winters, can result in different amounts of summer polishing and winter recovery. These components result in variation in skid resistance not only within individual years but also between successive years. However, under constant traffic levels, the summer skid resistance fluctuates about an equilibrium value for many years of service.

As a result of within-year and between-year variations in skid resistance, data from single measurements should be treated with caution as they may not represent the longer term equilibrium skid resistance of a site. It is therefore important when developing a skid resistance survey strategy to adopt a method that will characterise the long term performance of a surface by taking account of seasonal variations.

A.4 Measurement of skidding resistance

This section describes the principles of measuring skid resistance and provides details of some of the devices currently available for measuring skidding resistance, with the emphasis on those devices used in the British Isles. It is important when reviewing data relating to skid resistance to understand how the information was obtained in order for it to be interpreted sensibly.

A.4.1 Measurement principles

Many different devices have been developed to measure skid resistance, there are over 18 in Europe alone, but all use the same basic principles illustrated in Figure A3. A rubber slider or tyre is forced to slide across a wetted road surface at a standard speed, under a known load. The dimensions of the tyre or slider and the composition of the rubber are generally specified, as is the water depth or water flow rate. The conditions are standardised to remove, as far as possible, variability caused by factors other than the road surface. The horizontal force resisting the sliding of the tyre or slider is measured and the vertical load is either measured dynamically or assumed to be constant, allowing the friction coefficient to be calculated.

Figure A3. Principles of measuring road surface skidding resistance

The devices used to measure skid resistance employ one of four basic techniques:

- Rubber slider
- Side force (angled wheel)
- Braking-force (locked wheel)
- Braking-force (controlled slip)

The slider technique is a static method used for spot-checks and is unsuitable for dynamic measurements at traffic speeds. The devices referred to in this study, SCRM, Pavement Friction Tester and GripTester respectively use the latter three methods.

### A.4.2 SCRM

SCRM (the Sideway force Coefficient Routine Investigation Machine), as its name implies, uses the side force technique to measure skid resistance (Figure A4). It was originally developed at TRL (then the Road Research Laboratory) and has been manufactured under license since the early 1970s. In this method, the vehicle is fitted with an additional test wheel aligned at an angle to the direction of travel. The test wheel is free to rotate, but the alignment means it is forced to slip continuously over the road surface at a rate determined by the vehicle speed and the angle of the test wheel relative to the direction of travel. The sideway force is measured along the direction of the test wheel axle.

The exact set up varies from vehicle to vehicle, but the test wheel is generally fitted to the nearside of the vehicle, such that the measuring line is in the nearside wheel track. A limited number of machines are fitted with a test wheel on both sides of the vehicle. The angle between the test wheel and the direction of travel is 20°. The test wheel is fitted with a smooth tyre fabricated from natural rubber within a specified resilience range. The vehicles are fitted with large water tanks, giving a range of 50km or more between tank fills and the robust construction plus the extended range makes these vehicles ideally suited to carrying out lengthy network surveys.

![Figure A4. SCRM (including detail of test wheel)](image)

SCRIM is used routinely to monitor the skid resistance on trunk roads in the UK and also on many local authority roads.

The device records a “SCRIM Reading” for each 5m or 10m length of road, which is the ratio between the measured average sideways force and the 200kg vertical load, multiplied by 100. Measurements are affected by speed and are therefore normally made at a standard test speed. In the UK this is 50 km/h. Tests can be undertaken at higher speeds, but the results are converted to the standard 50 km/h test speed for use in assessing the road. It is important to realise that because the test wheel is angled, the effective slip speed at which the tyre contact patch passes over the surface is only about 17 km/h at a test speed of 50 km/h.

### A.4.3 Pavement Friction Tester (PFT)

The PFT (Figure A5) is owned by the Highways Agency and operated on its behalf by TRL. It measures skid resistance using the locked wheel method. This enables the whole braking cycle to be
studied, by applying the brakes of the test wheel so that it is rapidly brought to a halt, or locked. The frictional forces are monitored during the lock-up stage and for a specified period afterwards, typically only a few seconds because of the high rate of tyre wear. The test wheel brakes are then released and the wheel spins up to the vehicle speed. This means that when the wheel is locked the tyre slips over the surface at the same speed as the test vehicle, so it can measure the skid resistance at any practical speed up to about 130 km/h. The nature of this test method means that tests are carried out at spot locations and not continuously.

The load and traction forces on the tyre are measured every 0.01s throughout the lock-up and release braking cycle. The average coefficient of friction is calculated over a period of one second after the wheel has locked and settled into the skid. Measurements are normally made on a wet road surface which is obtained by pumping water from a tank in the towing vehicle through a nozzle in front of the test wheel. The pumps are directly driven from the vehicle drive shaft, so the same nominal water depth (0.5 or 1mm) is achieved irrespective of the test speed.

A standard smooth tyre is normally used for measurements, but standard ribbed tyres or normal vehicle tyres can also be fitted.

**Figure A5. The Pavement Friction Tester**

**A.4.4 GripTester**

The GripTester, manufactured by Findlay Irvine Limited, is a three wheeled-trailer that can be towed behind a vehicle with a water delivery system (Figure A6) or pushed by the operator in more confined locations. The device is commonly used for friction measurements on airfield pavements and, in the UK, is used for road monitoring by some Local Authorities. In push mode the device is fitted with a small water tank and has been used in this manner to test the surfaces of aircraft carriers, helicopter landing pads and pedestrian footways.

**Figure A6. GripTester**

The GripTester uses the fixed slip technique to measure skid resistance. The test wheel is fitted with a smooth tyre, fabricated from rubber to an American Standard, ASTM E1844, and the device can be
operated up to a maximum speed of 130 km/h. The test wheel is geared to operate with a constant 14.5% slip ratio, so that it travels more slowly than the test vehicle, thus forcing the tyre to slip continuously over the road surface in the longitudinal direction. The horizontal and vertical components of the force acting on the test wheel are monitored continuously and from these a “GripNumber”, representing the skid resistance of the road is calculated.

As with SCRIM, the slip speed of the test tyre is much lower than the speed of the test vehicle and is only about 7 km/h at a test speed of 50 km/h.
Appendix B. De-icer applications and estimated residual salt levels for of skid resistance tests.

Although the de-icers in the trials were added at controlled target rates using calibrated spreaders, time had to be allowed for the salt to enter solution and the roads were open to traffic in the period between application and the skid resistance measurements. At the time of most treatments, there will have been some salt remaining from a previous application or series of applications. However, the effects of traffic and weather in the intervening periods will have influenced how much of the salt applied was present on the road surface by the time that the skid resistance measurements were made.

In order to compare the influence of the different levels of salt present it was necessary to estimate the amount of residual salt on the surface at the time of each skid resistance test pass. In making these estimates, it was assumed that:

- Heavy rainfall over several hours reduced the residual salt level to zero.
- The amount of salt spread to the wheel paths corresponded to the target spread rate.
- The decrease in the residual salt level was linear with the level of trafficking and did not vary with the de-icer type or state, i.e. it was the same before and after the de-icer had gone into solution.
- The residual salt level decreased by 20% during each rush hour without rainfall.
- The residual salt level decreased by 80% over 24 hours without rainfall.
- The residual salt level decreased more rapidly than indicated above when there was light rain but not significant runoff.

Tables B1 and B2 give (for the A69 and A421 respectively) the chronology of the de-icer applications in the planned trials, the estimated residual salt levels at the time of each skid resistance test pass and the assumptions made regarding reductions in the salt level with time in each case.

Table B3 gives the estimated residual salt levels for the reactive tests that the GripTester carried out separately on A69 Sites E and F with Safecote de-icer.

### Table B1. Chronology of salting and testing on A69 sites with estimated residual de-icer levels

<table>
<thead>
<tr>
<th>Date</th>
<th>Test no.</th>
<th>Approx. time of spreading</th>
<th>Approx. time of skid resistance test run</th>
<th>Spread rate (g/m²)</th>
<th>Surface condition at test</th>
<th>Estimated residual salt before spreading (g/m²)</th>
<th>Estimated residual salt at test or after spreading (g/m²)</th>
<th>Assumed salt loss before next test or spreading (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16/01/07</td>
<td>1</td>
<td>17:30</td>
<td>20:00</td>
<td>Damp</td>
<td></td>
<td>12</td>
<td>100</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>12</td>
<td>100</td>
<td>0</td>
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<tr>
<td>Rain overnight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17/01/07</td>
<td>1</td>
<td>11:00</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>100</td>
<td></td>
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<tr>
<td>Heavy downpours - washed all salt off surface before it could be tested</td>
<td></td>
<td></td>
<td>30 (C and D)</td>
<td>0</td>
<td>24 (A and B)</td>
<td>20</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Date</td>
<td>Test no.</td>
<td>Approx. time of spreading</td>
<td>Approx. time of skid resistance test run</td>
<td>Spread rate (g/m²)</td>
<td>Surface condition at test</td>
<td>Estimated residual salt before spreading (g/m²)</td>
<td>Estimated residual salt at test or after spreading (g/m²)</td>
<td>Assumed salt loss before next test or spreading (%)</td>
</tr>
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<td>----------------------------------------------------------</td>
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</tr>
<tr>
<td></td>
<td>2</td>
<td>20:00</td>
<td>Damp</td>
<td></td>
<td></td>
<td>24 (A and B) 54 (C and D)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>22:00</td>
<td>30 (A and B)</td>
<td></td>
<td></td>
<td>22 (A and B) 49 (C and F)</td>
<td>5</td>
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</tr>
<tr>
<td></td>
<td>3</td>
<td>23:00</td>
<td>Damp</td>
<td></td>
<td></td>
<td>49 (A and B) 47 (C and D)</td>
<td>100</td>
<td></td>
</tr>
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<td></td>
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<td><strong>No salting between 19/01/07 and 22/01/07</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>22/01/07</td>
<td>4</td>
<td>19:00</td>
<td>Damp</td>
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<td>24</td>
<td>40</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Light snow showers overnight / frost</strong></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23/01/07</td>
<td>5†</td>
<td>19:00</td>
<td>Damp (E and F wetter)</td>
<td></td>
<td></td>
<td>60</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Snow showers overnight</strong></td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>24/01/07</td>
<td>6†</td>
<td>05:00</td>
<td>30</td>
<td>24</td>
<td></td>
<td>54</td>
<td>0</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>06:00</td>
<td>Damp (A and B)</td>
<td></td>
<td></td>
<td>54</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>09:00</td>
<td>Damp (F wetter)</td>
<td></td>
<td></td>
<td>43</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14:30</td>
<td>30 (C and D)</td>
<td>26</td>
<td></td>
<td>56</td>
<td>0</td>
<td></td>
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<tr>
<td></td>
<td>7</td>
<td>15:00</td>
<td>Wet</td>
<td></td>
<td></td>
<td>56</td>
<td>10</td>
<td></td>
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<tr>
<td></td>
<td>8</td>
<td>18:45</td>
<td>Wet</td>
<td></td>
<td></td>
<td>72</td>
<td>0</td>
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<tr>
<td></td>
<td>9</td>
<td>19:15</td>
<td>Wet</td>
<td></td>
<td></td>
<td>102</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>20:00</td>
<td>Wet</td>
<td></td>
<td></td>
<td>102</td>
<td>0</td>
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</table>
## Table B2. Chronology of salting and testing on A421 sites with estimated residual de-icer levels

<table>
<thead>
<tr>
<th>Date</th>
<th>Test no.</th>
<th>Approx. time of spreading</th>
<th>Approx. time of skid resistance test run</th>
<th>Spread rate (g/m²)</th>
<th>Surface condition at test</th>
<th>Estimated residual salt before spreading (g/m²)</th>
<th>Estimated residual salt at test or after spreading (g/m²)</th>
<th>Assumed salt loss before next test or spreading (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30/01/07</td>
<td>14</td>
<td>22:30</td>
<td>40 (C and D)</td>
<td>0</td>
<td>Damp</td>
<td>30</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>00:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31/01/07</td>
<td>15</td>
<td>20:00</td>
<td>40 (C and D)</td>
<td>6</td>
<td>Damp</td>
<td>36</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>22:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>22:30</td>
<td>20 (C and D)</td>
<td>36</td>
<td>Damp</td>
<td>51</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>00:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01/02/07</td>
<td>17</td>
<td>21:00</td>
<td>20 (C and D)</td>
<td>10</td>
<td>Damp</td>
<td>25</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>22:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>23:00</td>
<td>20 (C and D)</td>
<td>25</td>
<td>Damp</td>
<td>40</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>00:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: for these sites using pre-wetted salt, the estimated residual salt levels exclude the water content of the brine.
On the A421, additional 20 km/h skid resistance measurements were made after salt had been spread at a very high spread rate at the start of each site. Measurements were also made on a section in advance of the specially treated area. The extra tests were made immediately after the additional salt had been spread (at about 21:00 on 1 February). The heavily salted sections were also included in the test passes for Tests 17 and 18. The residual salt levels on the heavily treated length for these measurements were estimated to be 215, 215 and 230g/m², respectively. The residual salt on the area in advance of the heavily salted section was estimated to be 25g/m².

Table B3. Estimated residual de-icer levels during reactive measurements with GripTester alone on the A69

<table>
<thead>
<tr>
<th>Date</th>
<th>Test no.</th>
<th>Approx. time of spreading</th>
<th>Approx. time of skid resistance test run</th>
<th>Spread rate (g/m²)</th>
<th>Surface condition at test</th>
<th>Estimated residual salt before spreading (g/m²)</th>
<th>Estimated residual salt at test or after spreading (g/m²)</th>
<th>Assumed salt loss before next test or spreading (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/03/07</td>
<td>17:30</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>02/03/07</td>
<td>19</td>
<td>15:15</td>
<td>16:20</td>
<td>30</td>
<td>Dry</td>
<td>2</td>
<td>32</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td></td>
<td>17:30</td>
<td></td>
<td>Dry</td>
<td></td>
<td>27</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td></td>
<td>18:30</td>
<td></td>
<td>Dry</td>
<td></td>
<td>24</td>
<td>60</td>
</tr>
<tr>
<td>03/03/07</td>
<td>22</td>
<td>07:10</td>
<td>30</td>
<td></td>
<td>Damp</td>
<td>10</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td></td>
<td>08:05</td>
<td></td>
<td>Damp</td>
<td></td>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td></td>
<td>09:15</td>
<td></td>
<td>Damp</td>
<td></td>
<td>38</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10:30</td>
<td></td>
<td>Damp (Site E mostly dry)</td>
<td></td>
<td>36</td>
<td>20</td>
</tr>
<tr>
<td>14:00</td>
<td></td>
<td></td>
<td>30</td>
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<td></td>
<td></td>
<td>29</td>
<td>59</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>15:05</td>
<td></td>
<td></td>
<td>Dry</td>
<td></td>
<td>56</td>
<td>5</td>
</tr>
<tr>
<td>26</td>
<td></td>
<td>16:10</td>
<td></td>
<td></td>
<td>Dry</td>
<td></td>
<td>53</td>
<td>5</td>
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<tr>
<td>27</td>
<td></td>
<td>17:15</td>
<td></td>
<td></td>
<td>Dry</td>
<td></td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C. Friction/speed curves including GripNumber and peak friction

Key: Solid symbols (▼) = Friction number    Empty symbols (□) = GripNumber

Figure C1. Untreated salt on damp thin surfacing (A69 Site A Tests 1 to 6)

Figure C2. Untreated salt on damp HRA surfacing (A69 Site B Tests 1 to 6)
Figure C3. Eco-Thaw treated salt on damp HRA surfacing (A69 Site C Tests 1 to 6)

Figure C4. Eco-Thaw treated salt on damp thin surfacing (A69 Site D Tests 1 to 6)
Figure C5. Safecote treated salt on damp HRA (A69 Site E Tests 1, 4, 5 and 6)

Figure C6. Safecote treated salt on damp thin surfacing (A69 Site F Tests 1, 4, 5 and 6)
Figure C7. Untreated salt on damp HRA surfacing (A69 high and low friction sections at end and start of Site B Tests 5 and 6)

Figure C8. Eco-Thaw treated salt on wet HRA surfacing (A69 Site C Tests 7 to 13)
Figure C9. Eco-Thaw treated salt on wet thin surfacing (A69 Site D Tests 7 to 13)

Figure C10. Pre-wetted salt on damp thin surfacing (A421 Site G Tests 14 to 18)
Figure C11. Pre-wetted salt on damp HRA (A421 Site H Tests 14 to 18)
Abstract

Highway authorities have a duty to keep highways free of ice and snow and endeavour to meet this duty by treating roads with de-icers. It is unlikely that de-icers will reduce grip to levels that would occur with ice or frost on the road, but concerns have been expressed by some road users that de-icers, particularly repeated applications that cause them to build up on the road surface, can adversely affect the skid resistance and increase the risk of skidding accidents compared with that in normal conditions. This report describes a study in which a test methodology was established to investigate the effect of de-icers on skid resistance. The study included measurements of skid resistance on sites with hot rolled asphalt and proprietary thin surfacings that had been treated with de-icers. Four de-icers were included in the investigation, namely dry untreated rock salt, rock salts treated with Eco-Thaw and Safecote, and pre-wetted salt (rock salt pre-wetted with brine). The measurements were made with Highway Agency’s Pavement Friction Tester (PFT) and a GripTester. The tests with the PFT showed that de-icers reduce skid resistance at low sliding speeds (20 – 40 km/h) compared with a wet road with no de-icer present, but at higher speeds (60 km/h and above) skid resistance with de-icer present is greater than on a normal wet road. The significance of these changes was assessed with reference to the seasonal increase in skid resistance from summer to winter and the investigatory level. The GripTester was found not to be suitable for general use in detecting any adverse effects due to de-icers. Since it was not possible to determine the effect of all the potential effects of de-icers on skid resistance, including a build up of de-icer and associated detritus during prolonged cold spells with repeated applications but little rain, further tests with the PTF are recommended.
Road trials to determine the effect of de-icers on skid resistance

Highway authorities have a duty to keep highways free of ice and snow and endeavour to meet this duty by treating roads with de-icers. It is unlikely that de-icers will reduce grip to levels that would occur with ice or frost on the road, but concerns have been expressed by some road users that de-icers, particularly repeated applications that cause them to build up on the road surface, can adversely affect the skid resistance and increase the risk of skidding accidents compared with that in normal conditions. This report describes a study in which a test methodology was established to investigate the effect of de-icers on skid resistance. The study included measurements of skid resistance on sites with hot rolled asphalt and proprietary thin surfacings that had been treated with de-icers. Four de-icers were included in the investigation, namely dry untreated rock salt, rock salts treated with Eco-Thaw and Safecote, and pre-wetted salt (rock salt pre-wetted with brine). The measurements were made with Highway Agency’s Pavement Friction Tester (PFT) and a GripTester. The tests with the PFT showed that de-icers reduce skid resistance at low sliding speeds (20 – 40 km/h) compared with a wet road with no de-icer present, but at higher speeds (60 km/h and above) skid resistance with de-icer present is greater than on a normal wet road. The significance of these changes was assessed with reference to the seasonal increase in skid resistance from summer to winter and the investigatory level. The GripTester was found not to be suitable for general use in detecting any adverse effects due to de-icers. Since it was not possible to determine the effect of all the potential effects of de-icers on skid resistance, including a build up of de-icer and associated detritus during prolonged cold spells with repeated applications but little rain, further tests with the PTF are recommended.

Other recent titles from this subject area

- **PPR315** Measuring skid resistance without contact. A Dunford. 2008