Review of protection provided by surface dressings and thin surfacings to structural pavements

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Executive Summary

Surface treatments, including surface dressings and thin surfacings, are used to improve the surface characteristics of a pavement and/or to seal, and hence protect, the underlying structure from environmental factors. The effectiveness of the surfacing can be, and has been, easily monitored but that of the structural layers is harder to demonstrate because they are, of necessity, hidden from view.

Surface treatments will initially cover or seal cracks and will thereby prevent the ingress of water. However, the effectiveness of this sealing will depend on the type of treatment, the condition of the existing surface (in particular the extent, class or type and severity of cracks), the cause of the distress and the operating conditions. The literature review identified very few papers that explicitly addressed this issue. One of the main problems is that of reflection cracking whereby existing cracks can cause stress concentrations in the new surface and ‘reflect’ through, or reappear, very quickly. Alternatively, surface treatments almost certainly have a significant beneficial effect on the type of deterioration that gives rise to cracking that begins at the top surface and propagates down. It is expected that, provided such a deteriorated surface is covered by a new surface in time, the treatment may be very effective. However, at this stage there is no research data to verify this hypothesis.

From requests to Maintaining Agents for the Highways Agency, sites were identified where surface dressings and thin surfacings have been used to protect the pavement structure, either intentionally or as a by-product. However, when trying to gain more detailed information about the past and present condition of the sites, there were problems of locating the data caused by changes in the organisation of Maintaining Agents and, when data were obtained, most of the information concerned the surface properties rather than the structural condition.

Nevertheless, from the information obtained, supported by a review of literature on the subject, an assessment was made. The conclusions drawn from the survey are:

1 Surface dressings and thin surfacings (particularly those less than about 30mm in thickness) have little or no direct strengthening effect on the structural performance of a highway pavement (i.e. they do not significantly increase the load-spreading ability).

2 Surface dressings and thin surfacings may, on suitably drained sites, have an indirect stiffening effect on the pavement structure by virtue of sealing the surface and, therefore, restricting the ingress of moisture to the foundation layers (i.e. they do restrict the loss of load-spreading ability that might otherwise occur).

3 Surface dressings and thin surfacings can provide a cost effective means of extending the serviceable life of a pavement beyond the critical condition by retarding and masking the effects of cracking and surface spalling.

4 Thin surfacings can provide a cost effective means of re-profiling and extending the life of a pavement that is rutted and/or subject to an uneven running surface profile.

5 On structurally sound pavements, thin surfacings can offer a cost effective means of providing serviceable standards of skid resistance and texture depth for periods comparable with the life of a hot rolled asphalt surface course. The equivalent period with surface dressings may be between 4 and 7 years for moderate to high stressed sites and, possibly, up to 12 years for low stressed sites.

These findings indicate that there are limited uses of these surface treatments in protecting a structure, but the surface treatments are very useful in restoring the surface characteristics.

The overall conclusion of the investigation is that surface treatments are able to protect a pavement structure from future deterioration, but only when the pavement is structurally sound and effectively impervious to moisture from below. However, because of these restrictions on when a surface treatment can protect the pavement and the limited availability of comparable sites with and without treatment for which the structural conditions have been monitored, the extent of the benefit is uncertain. Neither surface dressings nor thin surfacings can restore the structural properties of pavements that have severely deteriorated. As such, even thin surfacings are unsuitable as a treatment for pavements that are failing due to severe structural cracking and deterioration.

1 Introduction

1.1 General

There is limited information on the effectiveness of surface dressing and of thin surfacing treatments in protecting, preventing and/or controlling pavement structural deterioration and hence prolonging the service life of pavements. Therefore, the Highways Agency has commissioned TRL to investigate whether the presence of one of these treatments does have any measurable effect on the structural condition of a pavement. The research was focused on trunk roads in England, for which the Highways Agency is responsible, but the findings should also be applicable to other roads. A literature review was carried out and up to ten sites with each type of treatment were identified. The construction and performance of these sites and untreated control sections were reviewed in order to assess the influence of the treatments on the structural performance of the whole pavement and, in particular, its load-spreading ability.

As was anticipated at the start of the research, it was only possible to identify a limited number of sites that were constructed and subsequently treated by surface dressing or thin surfacing fulfilling the specific requirements of this research. Those specific requirements relate to the prevention of structural deterioration of the pavement rather than to the restoration of the desired surface characteristics. Furthermore, the ability to identify these sites was very dependent on the knowledge and co-operation of engineers responsible for the specific sites.

This report, which is primarily concerned with the identification of relevant sites and the attempt to collect the available data, describes the events leading to the current state of knowledge, presents the information assembled and, where possible, draws conclusions as to the relative performance of the various surfacing dressing and thin surfacing systems.

1.2 Surface dressings

Surface dressing is a maintenance treatment designed to provide a non-skid surface course[1] to seal the road surface against ingress of water and to arrest disintegration of the road surface. There are several surface dressing systems which vary according to the number of layers and sizes of chippings, the number of films of binder and the order of their application. The fundamental types dressing, fully described in Road Note 39 (Nicholls, 1996), are: single dressing, racked-in dressing, double dressing, inverted double dressing and sandwich.

1.3 Thin surfacings

Road pavements are constructed to provide a safe, durable and cost-effective structure. The pavements of trunk roads in the United Kingdom have traditionally been constructed using concrete, hot rolled asphalt or a dense macadam. However, as volumes of traffic increase, pavement design is required to take account of an ever-increasing number of factors including user comfort and environmental considerations to add to the requirements for safety, durability and cost-effectiveness. To this end, new materials are being developed (Nicholls *et al*., 1995; Nicholls, 1998a) to provide surfacings that can be applied with the minimum disruption to traffic (cost-effectiveness and environmental considerations) with:

- longer service lives (durability); and/or
- improved ride quality (user comfort); and/or
- low noise and spray characteristics (environmental considerations); and/or
- high resistance to skidding (safety).

In addition to the environmental and road safety aspects of pavement design, the cost of disruption to road users due to repairing worn-out roads is an important issue. Thin surfacings are a group of innovative treatments that seek to meet the challenge of producing a material that can be laid quickly, thereby causing less disruption to road users than conventional treatments. Some of the more well known surfacings include stone mastic asphalt, *Safepave* and *UL-M*, the last two being proprietary thin surfacings.

Thin surfacings, which are generally laid at a nominal thickness of between 15mm and 30mm (although they can be up to 40mm thick), are only appropriate for roads where the supporting pavement is structurally sound. Their main advantage is that they can be used to restore skidding resistance as well as having a limited ability to regulate uneven surfaces. They can be sub-divided into the following five generic types:

Thick slurry surfacing[2]

Cold-applied materials that use a positively charged (cationic) bitumen emulsion to bond to negatively charged mineral aggregate, up to 10mm nominal size.

Multiple surface dressing

A film of hot binder followed by several layers of chippings (which may also be heated), typically using nominal chipping sizes from 6mm to 14mm with the largest size at the bottom, with additional films of hot binder between some of the layers of chippings.

Paver-laid surface dressing (includes Safepave)

A hot bituminous mixture which is spread directly over a sprayed binder film. A purpose-built machine incorporates both the binder sprayer and the asphalt material distribution system. The binder is a modified emulsion containing approximately 70 per cent bitumen.

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[1] *The terms 'surface course' and 'binder course' are used in preference to 'wearing course' and 'basecourse' in this report (other than in quoted references) because they will be the ones used in the harmonised European Standards to replace the existing British Standards over the next few years.*

[2] *Thick slurry surfacings are also known as microsurfacings; slurry surfacings were previously known as slurry seals with the latter term still used in some countries.*

Thin asphalt concrete (includes UL-M)

A gap-graded mixture with a nominal size of 10mm coarse aggregate and generally using a modified binder. The material is bonded to the road surface by the prior application of a tack-coat. The material is laid using the same equipment as for hot rolled asphalt or macadam, usually to a nominal thickness of 20mm.

Thin stone mastic asphalt:

A gap-graded aggregate mixture with a relatively high binder content in which cellulose fibres or binder-modifiers are incorporated to prevent binder drainage during manufacture, transportation and laying.

Thin surfacings are all proprietary materials with the exception of stone mastic asphalt (Nunn, 1994: Nicholls, 1998a), although there are several proprietary thin surfacings based on stone mastic asphalt. Some examples of such materials are given in Table 1. Systems that have been assessed as being suitable for use on trunk roads by the Highways Agency have been highlighted.

Thin surfacings can be laid at a faster rate than conventional hot rolled asphalt and do not require the high degree of aftercare needed for conventional surface dressing. Use of thin surfacings, even when it takes longer to lay than surface dressing, is less disruptive to traffic because the new surface can be put into service soon after laying. Although the surfacings have not been in service for sufficient time to assess fully their durability, they provide an effective regulating layer, improving evenness, and give a good standard of surface finish with good skid resistance. Moreover, their spray and noise reducing properties are generally better than conventional hot rolled asphalt (Nicholls, 1998a).

Factors in the choice of which type of treatment to use include the anticipated traffic flow that the road will be required to carry and the condition of the existing pavement, particularly its hardness (Nicholls, 1998b). Thin surfacings are generally less expensive than conventional hot rolled asphalt but more expensive than surface dressings.

1.4 Potential benefits to the pavement of surface treatments

Surface treatments will initially cover or seal cracks and will thereby prevent the ingress of water. However, the effectiveness of this sealing will depend on the type of treatment, the condition of the existing surface (in particular the extent, class or type and severity of cracks), the cause of the distress and the operating conditions. The literature review identified very few papers that explicitly addressed this issue. One of the main problems is that of reflection cracking whereby existing cracks can cause stress concentrations in the new surface and 'reflect' through, or reappear, very quickly. Alternatively, surface treatments almost certainly have a significant beneficial effect on the type of deterioration that gives rise to cracking that begins at the top surface and propagates down. It is expected that, provided such a deteriorated surface is covered by a new surface in time, the treatment may be very effective. However, at this stage there is no research data to verify this hypothesis.

Table 1 Examples of proprietary thin surfacing types

Category	*Manufacturer*
Thick slurry surfacing (Microasphalt)	
Ralumac	Colas Ltd
Reditex	Associated Asphalt
Permatex	Syston Highway Services
Gripfibre	Jean Lefebvre (UK)
Multiple surface dressing	
Surphalt *	Lanfina Bitumen (now Totalfina)
Finatex *	Lanfina Bitumen (now Totalfina)
Paver-laid surface dressing	
Safepave *	Associated Asphalt
Thin asphalt concrete	
UL-M *	RMC, Tilcon, White Mountain & others
Hitex *	Aggregate Industries
Axoflex *	Lafarge Aggregates
Tuffgrip *	Hanson Quarry Products
Colrug *	Colas
Viapave *	RMC
Thinpave *	Aggregate Industries
Masterflex *	Tarmac
Triple-H	Pioneer (now Hanson QP)
Colsoft	Colas
Duratex P	Tilcon (now Tarmac)
Stratagem	Foster Yeoman
Brettpave	Brett Asphalt
Euro-Mac	McSweeney
Thin stone mastic asphalt	
Masterpave *	Tarmac
Axofibre *	Lafarge Aggregates
Viatex *	RMC
Steelpave *	Slag Reduction
Smatex *	Aggregate Industries
Premier Pave *	Foster Yeoman
Nashpave *	Nash Rocks (now Tarmac)
Masterphalt *	Tarmac for licensees
SMArtpave *	Pioneer (now Hanson QP)
Duratex F *	Tilcon (now Tarmac)
Brettmastic	Brett Asphalt
Megapave	Mid-Essex Gravel

** Type approved by Highway Agency (some with restrictions as to traffic), March 2001*

2 Literature review

2.1 Methodology

A literature search was carried out on the International Road Research Database (IRRD) at TRL. More than 130 papers were found and, from an initial review of their abstracts, 34 were selected for further assessment. The intention was to establish which surfacing treatments have been successfully used, preferably on trunk roads, to prevent the ingress of water and/or restore structural integrity to road pavements. Only a few of the papers contained relevant information that met the objectives of this investigation.

The limited extent of information directly relevant to this investigation arises because the majority of work has been aimed at demonstrating either the durability of the surfacing(s), rather than its effect on the durability of the whole pavement, or the suitability of a new variation of these surfacings. Furthermore, many of the trials that have been reported have not included controls or, if there were control sections, ones that are not suitable for assessing the influence of the surface treatment on the durability of the pavement. Nevertheless, some papers do provide interesting facts about the effect of surface treatments such as surface dressing and thin surfacing treatments on the pavement. These are listed in Table 2 with the type of surface treatment covered, the overall aim of the work behind it and the availability of control sections.

2.2 Surface dressings

2.2.1 Performance in the United Kingdom

About 170 million square metres of road surface is surface dressed each year in the United Kingdom (Carswell, 1994). Its primary purposes are to restore both texture and skid resistance for major and minor roads:

- Major roads – restoration of both texture and skid resistance to the road surface.
- Minor roads – restoration of both texture and skid resistance to the road surface;
  - – extension of the serviceable life of the road;
  - – sealing the road surface from water ingress; and
  - – provision of a dust free riding surface to the road.

Whilst the application of a surface dressing to a weak pavement cannot strengthen it, sealing the road surface can prevent percolation of water from the road surface to the pavement foundation, thereby assisting in preserving the remaining structural strength of the pavement.

The main advantage of surface dressing is that it is a relatively cheap process that can be rapidly applied. With the Government's commitment to improve road safety, high levels of skid resistance will be needed and so surface dressing will continue to have a role to play in the United Kingdom as a maintenance treatment (Carswell, 1994).

There is a considerable variability in the ability of the surface dressing treatments to inhibit whole-carriageway deterioration (Lancaster and Potter, 1990; Robinson, 1994; Burtwell and Carswell, 1996). The time between application of a treatment and the need for re-treatment due to deterioration was found to vary from less than one year to more than eight years, with many instances of the time being less than two years. On sites where the total traffic flow was less than 500 vehicles per day, surface dressing treatments performed significantly better than on sites where the traffic flow was higher.

Whilst pre-treatment condition of a road and the level of traffic using the road have a significant influence on the effectiveness of the performance of the treatment, these factors did not account for all the variation observed. The cause(s) of the outstanding variation was probably related to factors not included in the analysis, which could include:

- shape of aggregate;
- size of aggregate;
- physical properties of the pre-treated road;
- binder application rates;
- pavement temperature at the time of treatment;
- speed of the traffic in the period immediately following the treatment; and
- level of supervision of the application of a treatment.

The reports recommended further research to establish which of these factors accounted for the variation in performance of the treated road surface and of the structure.

Research into the effect over time of a surface dressing treatment on a cracked or crazed pavement (Looker, 1991; Burtwell and Carswell, 1996) found that there were no significant differences in the mean deflection with time between the surface dressed and associated untreated control sections. Therefore, there was no significant improvement in the structural condition of the pavements arising from the surface dressing. Furthermore, the surface dressing did not:

Table 2 Available literature reviewed

	Treatment		*Objective*			
Reference	*Surface dressings*	*Thin surfacings*	*Surface properties*	*Alternative technique*	*Pavement durability*	*Control for pavement durability*
Carswell, 1994	✓		✓			
Burtwell & Carswell, 1996	✓		✓		✓	✓
Lancaster & Potter, 1990	✓		✓		✓	✓
Robinson, 1994	✓		✓		✓	✓
Looker, 1991	✓		✓		✓	✓
Woodside, 1995	✓		✓			
Sprague et al, 1993	✓			✓		
Hallett, 1994	✓			✓		
Marchand, 1993	✓			✓		
Curtis & Foster, 1997	✓			✓		
Anon, 1996		✓	✓			
Scott et al, 1990		✓	✓			✓
Nicholls, 1998a		✓	✓			✓
Jones et al, 1990		✓	✓		✓	✓
Morian et al, 1997	✓	✓	✓		✓	✓

- inhibit the propagation of reflective cracking in pavements constructed with lean concrete roadbase;
- prevent transverse cracking from re-appearing soon after application on pavements with non-lean concrete roadbases; or
- prevent wheel-path cracking from re-appearing.

However, surface dressing did inhibit the rate of propagation of new cracking for all types of cracking and, although from limited data, did restrict the development of crazing.

Innovative developments have been made to measure certain material characteristics not previously measured (Woodside, 1995). Three in-situ test methods relating to surface dressing treatments that can be used to assess the pavement condition are adhesive bond strength, chipping loss and efficiency of wetting surface agents. Four innovative techniques, developed to predict the performance of surface dressings, are the INAPOT test, interfacial stresses, the shape and permeability of aggregate particles, and ageing. The review by Woodside serves to illustrate the benefits of understanding the behaviour of surface dressing treatments and their performance.

2.2.2 Fabric-reinforced surface dressings

Fabric-reinforced surface dressing, under a variety of names, is a (re)surfacing technique that combines the use of geotextile and surface dressing. The geotextiles fabrics are intended to provide tensile strength to the surface layer rather than act as any form of moisture barrier.

Trials were carried out in North and South America, Europe and Australia. In each case (Sprague *et al.*, 1993), the fabric surface dressing successfully waterproofed the pavement structure, arrested disintegration and provided a durable skid-resistance surface. Short-term performance indicated that the treatment is promising. However, long-term performance and overall cost-effectiveness have yet to be reported.

A trial of six sections in New Zealand (Hallett, 1994) showed that the addition of rubber latex made no appreciable difference with regard to the crack attenuation properties of the surface dressing. However, the two sections with the polymer-modified binder provided the best performance in delaying the onset and severity of reflective cracking, indicating that sufficient polymer in the binder is necessary to provide significant crack attenuation properties. This modification produces good elastic recovery and limits the change in viscosity over the working temperature range for the binder. The results showed that the use of a polymer-modified binder with significant elastic properties, when used in conjunction with a double surface dressing, provides a practical and economic surface treatment for a cracked asphalt concrete pavement which is exhibiting little change in surface profile.

In France, trials have been monitored (Marchand, 1993) for the efficacy of the surface dressing to seal the underlying construction and the performance of the surface characteristics (texture, skid resistance, etc). The monitoring of the sites for up to five years showed that the technique was effective in that it delayed crack propagation and ensured imperviousness, although the lack of a control without geotextile reinforcement must limit the confidence that can be given to this conclusion.

In trials in the United Kingdom (Curtis and Foster, 1997), none of the sites showed any signs of cracking, indicating that the fabric was correctly installed. It was assumed that the combination of non-woven fabric and surface dressing acted as a moisture barrier (the binder) to reduce the oxidation of the underlying bitumen layers and a reflective crack retarder (the fabric) by reducing the strains at the interface in the bituminous paving system. The experience gained from these trials was claimed to support surface dressing with a paving fabric as a cost-effective solution for badly cracked pavements, but the lack of a control section with a surface dressing without fabric reduces the confidence of such a conclusion.

2.3 Thin surfacings

The use of *Safepave* (a thin surfacing system, see Table 1) was considered a cost-effective approach on the A31 in Dorset because condition surveys showed that no further remedial work was needed four years after the surfacing was applied (Anon, 1996). In TRL trials (Nicholls, 1998a), thin surfacing systems were monitored for up to six years with encouraging results, but the structural condition of the underlying pavement was not monitored.

A comparison of sections with and without slurry surfacings (Jones *et al.*, 1990), a specific type of thin surfacing, showed that the treatment acted as an extra thickness of bitumen-bound material with respect to binder hardening. As such, it could be used as a sacrificial layer if the treatment is replaced and should reduce the occurrence of top-down cracking, which is currently believed to be the predominant mode for ‘thick’ flexible pavements.

2.4 Comparative trials

Pavement maintenance operations can be grouped into two categories, ‘corrective’ and ‘preventive’. ‘Corrective’ pavement maintenance, including patching, is performed to restore distressed areas to an acceptable condition. ‘Preventive’ maintenance operations are applied to pavement surfaces to prevent the development of damage or to reduce the rate of development.

Scott *et al.* (1990) reported on a trial in Saskatchewan of 19 different overlay types and design thicknesses in the range 0 to 32mm. The treatments included heat scarified surfaces, Glasgrid in combination with an asphalt overlay, an asphalt overlay, a latex modified asphalt concrete, a porous asphalt overlay with 12.5mm maximum nominal aggregate size and 200/300 pen binder, a fibre reinforced asphalt concrete and a latex modified slurry surfacing. The results showed that the porous asphalt, the thickest latex treatment, the fibre-modified mixtures and the Glasgrid treatments were the most resistant to cracking. Slurry surfacings wore rapidly when they were not properly designed and were poor at resisting reflective cracking.

A major research project into the most effective timing for the application of various treatments and to evaluate the effectiveness of treatments in prolonging the life of the pavement (Morian *et al*., 1997) was undertaken in America. Four climate zones were identified in the SHRP-LTPP study named ‘wet/no-freeze’, ‘wet/freeze’, ‘dry/no-freeze’ and ‘dry/freeze’. The extent to which the performance of the four treatments were affected by the climate zones was examined.

Crack seal treatment

This treatment did not perform well in the dry regions of the country. It had a propensity towards adhesion failure after five years, although the sealant material remained functional. The expected life for crack sealing varied from six years to just over eight years for pavements in good condition. For those in fair condition, the variation was 1.5 years up to 7.5 years. The greatest variation existed for pavements in poor condition.

Slurry surfacing treatment

For pavements initially in good condition, the benefits of slurry surfacings were small when compared to control sections. For pavements initially in fair and poor conditions, improvements in pavement performance were noted primarily in those sections located in the south-east and west where conditions were generally drier. In general, the slurry surfacing treatment is expected to perform satisfactorily for six to eight years on pavements in fair condition.

Surface dressing treatment

In the wet/no-freeze climate zone, the surface dressing performed quite well. In the dry/no-freeze and dry/freeze zones, surface dressing consistently performed well. In the wet/freeze zone, the surface dressings performed well on good and fair pavements. The application of surface dressings resulted in average performance ratings across all pavement conditions that were better than the associated control sections. For pavements in fair condition, the performance expectations are eight to nine years. For pavements in poor condition, performance expectations are from six to eight years.

Thin surfacing overlay treatment

The thin surfacings were considered to perform well in all the regions. Although there were some sites that provided anomalies, the thin surfacings were reported to improve ride quality, to reduce rutting, and to reduce the severity of reflective cracking. In all cases, the average condition of the treated section was significantly better than that of the associated control section, indicating a benefit from the treatment. In the freeze zones, the treated section remained in fair condition for pavements in which the control section was in poor condition whilst it remained in good condition for pavements with control sections in fair condition. With respect to pavement condition level, thin surfacings produced a positive benefit. For pavement sections in good condition, the life performance estimates are eight to eleven years. For pavement sections in poor condition, the life performance estimates vary from six to nine years.

Other aspects covered in this study included the practicalities of handling and storage of emulsions, the shape of routing cracks for crack seal, moisture sensitivity, the limited success in preventing reflective cracking, and the season for carrying out the treatments.

Handling and storage

The lesson to be learnt was not to transport emulsions for excessive distances or to store them for long periods of time, although no values were put forward as maximum limits for either time or distance.

Crack routing reservoirs

The wide shallow crack seal reservoir outperformed the other crack sealing techniques.

Crack seal blotting

The method of blotting crack seal material was sufficiently effective to be adopted by Kansas DOT.

Aggregate characteristics

The inclusion of requirements for aggregate durability and quality control of construction operations (such as limits on the time between emulsion and aggregate applications and rolling) contributed to the success of the surface dressing treatments.

Moisture sensitivity

Problems of accelerated stripping were found when surface dressings and slurry surfacings were applied to pavements containing moisture-sensitive aggregates. The application of a slurry surfacing to the pavement surface can trap moisture in the asphalt and other layers. Higher temperatures and higher levels of traffic accelerate the effect of the moisture on the asphalt and can cause sudden pavement failures that are expensive to repair. A method to identify pavements that are susceptible to stripping is required. This could be achieved by performing strip tests on existing pavements prior to making a decision on the type of maintenance treatment to apply. Further tests could be made by assessing the likely impact of trafficking on pavements with materials that have a potential for the binder to strip from the aggregate.

Reflection cracking

The ability of a surface dressing, slurry surfacing or thin surfacing to maintain a well-sealed surface was found to be marginally effective in eliminating reflective cracking. For pavements in good, fair or poor initial condition, reflective cracking re-appeared within one year under most conditions. In the wet/no-freeze zone, a lower severity of reflection cracks was observed after five years on sections with thin surfacings and surface dressing treatments. Pavements that were crack-sealed prior to treatment also performed well.

Season for treatments

Climatic effects resulting from the season when the treatments are applied are important. It was found that surface dressing and slurry surfacings were the worst affected by the conditions in the wet/no-freeze zone and performed best in the dry/no-freeze zones.

After five years in service, the thin surfacing overlay treatment had provided benefits for pavements in all levels condition (poor, fair and good) at the time of their treatment. The treatment also performed best in no-freeze climates. Its full service life is not yet known because the treatment is still performing well.

3 Survey of existing sites

3.1 Methodology

3.1.1 Identification of sites

In addition to the contacts already established through other TRL research projects, telephone enquiries were made to the Materials Engineers of various Local Highway Authorities using the telephone directory issued by the Soils and Materials Engineers Group of the CSS (formerly known as the County Surveyors Society).

From these enquiries, various sites were identified as having the potential for further investigation to meet the requirements of the project. These sites, together with relevant trial sites set up for other TRL projects, are briefly described in Table 3 for the sites where surface dressing has been used and Table 4 for the sites where a thin surfacing has been applied.

3.1.2 Information requested

A written request for data was sent to each of the contact persons. The information requested was as follows:

a site location, the carriageways/lanes trialled and the start and finish points;

b details of the original condition of the pavement – including any Deflectograph and Falling Weight Deflectometer (FWD) data, visual condition and/or core information;

c records (or comment) on the maintenance of the site leading up to surfacing – including estimates of annual patching/pot-hole repair costs and expected life of the pavement without treatment;

d details of the surface dressing or thin surfacing applied – including the type, typical thickness, date of laying, weather conditions during laying and cost per unit area;

Table 3 Surface dressing sites

Road location	*Surfacing type*	*Description/comment*
Somerset A38 Tone Way, Taunton (all lanes)	Johnston Hot-Chip surface dressing over DBM patches and HRA.	Main access route into Taunton from M5. Construction and pavement assessment data available.
Somerset A38 Edithmeade to Cross (all lanes)	Racked-in surface dressing.	Surface dressing on cracked bituminous road. Pavement assessment data available.
Suffolk A140 Needham Market (2 sections southbound dual carriageway)	1984 surface dressing. 1988 Johnston Hot-Chip.	‘Before’ and ‘after’ data available for both sections.
Kent M2 east & west of A229 junction	Surface dressing over dry and ‘boney’ hot rolled asphalt with chipping loss.	Still in existence after several years wear, ‘before’ and ‘after’ data available.
Kent A2 Bridge by-pass	Surface dressing over reflective cracks.	No longer in existence, but data available.
Kent A21 Sevenoaks by-pass	Surface dressing over worn out and cracked hot rolled asphalt surface.	Parts still in existence on hill section at southern end.
Cambridge A47 Thorney Toll to Guyhirm	Surface dressing.	Comprehensive data available as reported in TRL Report TRL314 and TRL Project Report PR79.
Cambridge A14 Bar Hill	Johnston Hot-Chip.	Data available.
Warwickshire A5 Atherstone by-pass	14/6mm racked-in surface dressing.	1990 Deflectograph survey data and personal knowledge of C A Catt [Warwickshire Materials Engineer, 1967-94].
Buckinghamshire A413 Amersham by-pass	Trial site of various surface dressings.	Well documented trial site for various surface dressings with control sections, as reported in TRL Report TRL261.

Table 4 Thin surfacing sites

Road location	*Surfacing type*	*Description/comment*
Somerset A38 [Chart 230] East of Chelston	Safepave.	New surface course to reinstate running surface, regulate and seal existing pavement structure. 'Before' and 'after' data available.
Suffolk A14 Haughley(w)	Tarmac Masterpave (SMA).	'Before' and 'after' information available, material laid in 1994.
Cardiff A4232 (Ely Link)	Safepave.	Safepave placed over dry and cracked HRA during 1994.
Cardiff Eastern Ave, Cardiff	Hanson Tuffgrip.	Tuffgrip over cracked and crazed HRA during 1997.
Cambridge A10 Littleport	SMA with HRA control.	Comprehensive data available as reported in TRL Report TRL314.
Cambridge A47 Thorney to Thorney Toll	Safepave.	Comprehensive data available as reported in TRL Report TRL314 and TRL Project Report PR79.
Hampshire A34 [Chart 1/05 Ch. 1145 to Chart 1/34 Ch 270 m]	UL-M surfacing.	Pavement assessment and design information available.
Hampshire A31 Romsey	Safepave over cracked HRA with low texture.	Early trial of Safepave, used by Associated Asphalt as a sales demonstration and monitored as a long-term trial, reported in TRL Project Report PR79.
Berkshire M4 J5 to J6	Safepave over badly rutted HRA with longitudinal cracking (reprofiled by planing prior to application).	Used as short-term measure to remedy rutting problem prior to major maintenance in near future.

e condition of the road pavement and/or surfacing immediately after treatment, including any skidding resistance and texture depth measurements;

f longer-term condition of the road pavement, including Deflectograph and FWD data, expected life extension and subsequent annual maintenance costs; and

g historic and future traffic data in terms of million standard axles (msa) per annum.

3.1.3 Responses and information obtained

As a result of the recent changes in the arrangements for the maintenance of the Highway Agency trunk road network and the consequential movement/retirement of key staff, the response to the written enquiries made by TRL has, in most instances, been very disappointing. This poor response has reduced the number of sites for which contemporary records or first-hand information has been obtained. Nevertheless, all the information obtained, however subjective, has been included in the following reports for each of the listed sites.

For those sites monitored and reported by TRL as part of previous investigations into the performance of surface dressings and thin surface course materials, various data relevant to the present investigation have been extracted from TRL Report 261 (Nicholls and Frankland, 1997), TRL Report 314 (Nicholls, 1998a) and TRL Project Report 79 (Nicholls *et al.*, 1995), as referred to in Tables 3 and 4.

Where no detailed responses have been received, relevant comments have been reported from telephone conversations with the contact person, which were generally based on personal knowledge or perceived view of the particular sites. In cases where information has been quoted verbatim, the text is shown in *italics*.

3.1.4 Collation of data

As a result of the problems experienced in collecting data, every opportunity was taken to collect information by a variety of means, ranging from data extracted from previously published TRL reports to personal communication by telephone. In consequence, it was found impossible to collect the data in any standard format with the view of making direct comparisons between sites or for forming a consistent structural performance assessment. Also, because the maintenance information usually collected for surface dressing or thin surfacing concentrates on surface characteristics, it was often the case that the collected data only referred in passing to the effectiveness of the surfacing in terms of preventing and/or controlling pavement structural deterioration.

A resume of the findings for each site are given in Sections 3.2 for surface dressings and 3.3 for thin surfacings with a final summary of the relevant findings in Table 5 for surface dressing sites and Table 6 for thin surfacing sites.

3.2 Surface dressing sites

3.2.1 A38 Tone Way, Taunton

Johnston Hot-Chip system was applied in 1989 as a 'make do and mend' solution, with a life expectancy of about four years. However, no further maintenance was carried out until 1997, at which time the whole of the wet-mix roadbase and surfacing layers were replaced. During the life of the Hot-Chip surfacing, the routine Deflectograph surveys indicated no apparent structural deterioration of the deeper-seated pavement structure, despite the onset and development of severe wheel-track cracking.

3.2.2 A38 Edithmeade to Cross

Despite widespread cracking problems, the application of the racked-in surface dressings on this road has been governed mainly by financial restraint. Even so, these dressings have generally provided good value for money, particularly in terms of texture depth and skid-resistance retention. No measurement of any change in strength has been attempted although, by sealing the surface, the dressings may have restricted the ingress of moisture and retarded the development of further cracking. On adjacent sections of the same road, where only overbanding of cracks has been carried out (Figure 1), the Deflectograph deflection levels are of a similar order, but the texture and skid resistance values have not been maintained.

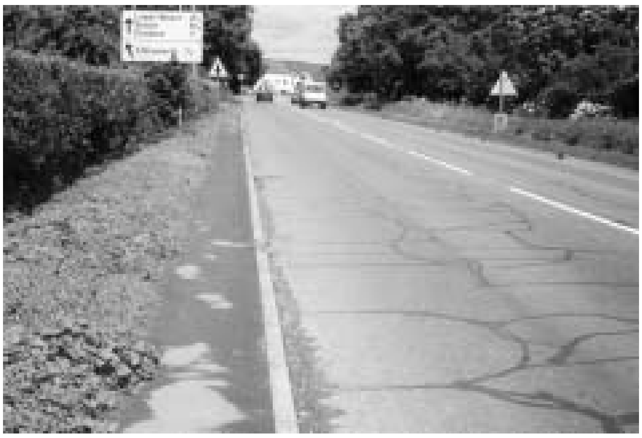

Figure 1 Overbanding on A38 Edithmeade to Cross (Chart 1140)

3.2.3 A140, Needham Market, Suffolk

The information received relating to the 1984 surface dressing and 1988 Johnston Hot-Chip sections of this site was primarily concerned with texture and skid resistance, which confirmed that the useful life of both the surface dressing and Johnston Hot-Chip was of the order of six to eight years. More recently, however, despite well developed wheel-track rutting with some cracking, the Deflectograph survey carried out in 1997 revealed a reasonably strong pavement and an inlaid surfacing was deemed to be the appropriate remedial measure.

3.2.4 M2 east and west of A229 junction

The surface dressing was applied in 1993 to an EVA modified hot rolled asphalt surfacing with the onset of chipping loss. As at 1998, it was performing satisfactorily with no evidence of any structural deterioration of the pavement.

3.2.5 A2 Bridge by-pass

The surface dressing was applied in 1986 as a 'holding measure' against reflective cracks in the surfacing of a flexible composite pavement. Cracking was re-established within 2 to 3 years and subsequently covered by a 200mm thick overlay during 1990. There is no evidence available to suggest any structural benefit provided by the surface dressing.

3.2.6 A21 Sevenoaks by-pass

The surface dressing was applied during 1991, primarily to re-establish texture, although reflective cracking was evident. The reflective cracking reappeared within 2 years and parts were overlaid during 1995 and 1996.

3.2.7 A47 Thorney, Cambridgeshire

During 1991, sections of racked-in surface dressing and *Safepave* surfacing were used in a road trial to cover an unstable jointed concrete pavement with flexible overlay that exhibited severe longitudinal cracks, edge deterioration, filled potholes and various poor reinstatements. A section of hot rolled asphalt surfacing was used as a control. Subsequent monitoring concentrated mainly on the surface characteristics and concluded that the useful life of the surface dressing was approximately 5 years, compared with the retained good condition of the *Safepave* and hot rolled asphalt. Survey records indicate that reflective cracking was soon re-established, but re-occurrence of the other defects was not reported.

3.2.8 A14 Bar Hill, Cambridgeshire

A Johnston Hot-Chip surface dressing was laid during 1987/8 over a pavement subject to significant rutting and some wheel-track cracking. The initial 'coarse and boney' condition of the dressing tended to disguise the rutting but with subsequent chipping embedment the rutting was re-established within two years. No mention was made of further cracking. The Hot-Chip dressing was replaced in piece meal fashion between 1996/8 and was generally perceived to have extended the life of road by approximately 6 to 8 years.

3.2.9 A5 Atherstone by-pass, Warwickshire

By the mid 1980s, the 25 year old overlaid structure of the Atherstone by-pass was heavily overbanded and large areas were reported to be in a 'past critical' condition, badly cracked but not rutted, with particular problems associated with water ingress. As a means of maximising the life of this pavement, a racked-in surface dressing was applied to seal the cracks and allow the pavement to progress to failure condition. A subsequent Deflectograph survey indicated a short-term ‘stiffening up’ of the pavement and the pavement survived without further maintenance until major reconstruction during 1997/98.

3.2.10 A413 Amersham by-pass, Buckinghamshire

The 1988 test site for various surface dressing systems was placed over a 24-year-old flexible composite pavement structure exhibiting early signs of non-structural rutting. As at 1998, the various surface dressings are still functioning as the surfacing, with some chipping loss, fatting-up and wheel-path fretting. Also, the wheel-track rutting of up to 10mm is more pronounced and a few isolated reflective cracks are reported as causing an uneven ride. In comparison, an adjacent control section of the original hot rolled asphalt containing a bitumen/TLA blended binder is described as looking in poor condition such that it was only just serviceable.

3.3 Thin surfacing sites

3.3.1 A38 Chelston to Piccadilly

A *Safepave* surface was used in 1993 to seal and regulate the flexible pavement that was heavily patched and uneven as the result of various utility reinstatements, with significant spalling at joints. Also, for reasons that are unclear, a significant proportion was overlaid by a further *Safepave* surfacing during 1995. Routine Deflectograph surveys, before and after the *Safepave* surfacing, revealed that neither the material laid in 1993 nor that laid in 1995 resulted in any structural enhancement; nevertheless, it did help seal the surface and restrict moisture ingress to the pavement foundation. As at 1998, the *Safepave* remained in a serviceable condition, but it was showing signs of cracks which reflect the underlying joints and edges of utility reinstatements.

3.3.2 A14 Haughley, Suffolk

The Tarmac *Masterpave* surfacing laid in 1994 was placed over a structurally sound pavement, but with early signs of surface course rutting and low texture. It was laid primarily to re-establish profile and surface characteristics and has performed satisfactorily to date.

3.3.3 A4232 (Ely link), Cardiff

The *Safepave* surfacing was laid during 1994 over a pavement exhibiting a variety of major and minor defects, including wheel-track cracking, spalling and surface irregularity. A recent drive-over visual inspection during April 1998 revealed no signs of deterioration.

3.3.4 Eastern Avenue, Cardiff

The Hanson *Tuffgrip* surfacing was laid during 1997 over a pavement exhibiting a variety of major and minor defects, including a cracked and partly crazed hot rolled asphalt surface course. A recent drive-over visual inspection during April 1998 revealed no signs of deterioration.

3.3.5 A10 Littleport, Cambridgeshire

The stone mastic asphalt surfacing trial was constructed during 1993 using sections of hot rolled asphalt surfacing as a control. The previous condition of the road is not known and no structural defects have been noted to date. It is reported that the stone mastic asphalt has an excellent deformation resistance (as measured by the wheel-tracking test) and a durability comparable to other types of surfacing.

3.3.6 A47 Thorney, Cambridgeshire

During 1991, sections of *Safepave* and racked-in surface dressing were used in a road trial to cover an unstable jointed concrete pavement with flexible overlay that exhibited severe longitudinal cracks, edge deterioration, filled potholes and various poor reinstatements. A section of hot rolled asphalt surfacing was used as a control. Within 3 years of construction, parts of the *Safepave* trial were subjected to severe differential settlement that caused surface cracking, resulting in replacement by an inlaid hot rolled asphalt. Elsewhere, as at 1998, the *Safepave* was performing as well as the hot rolled asphalt control and there had been no report of a re-occurrence of the original pavement defects.

3.3.7 A34 Whitway to county boundary

The *UL-M* surfacing on this site was used specifically in 1995 as a holding measure to extend the serviceable life of the failing pavement beyond the time required to complete the Newbury by-pass. To date, the *UL-M* has performed well under very heavy trafficking and the life of over 95 per cent of the surfaced area has been extended beyond the opening of the new by-pass. Routine Deflectograph surveys have indicated a general structural improvement of the *UL-M* surfaced pavement, although this improvement is attributed mainly to the effects of sealing the surface and restricting the ingress of moisture into the pavement foundation.

3.3.8 A31 Romsey, Hampshire

The *Safepave* was laid during 1991 on the heavily trafficked pavement that was exhibiting significant longitudinal and transverse cracking, loss of texture and general deterioration. Subsequent monitoring of the pavement showed that the surface profile was improved by the *Safepave* and maintained at a good standard for at least 3 years. Rutting was only marginally reduced in the short-term and cracking was re-established within 2 years. As at 1998, the *Safepave* was performing in a satisfactory manner, although showing increasing signs of wear and distress.

3.3.9 M4 Junction 5 to 6, Berkshire

The *Safepave* surfacing was carried out during 1996 with the aim of providing a temporary surface course whilst awaiting major reconstruction in 1998. The original pavement was badly worn, cracked and severely rutted. Partial removal of the ruts was achieved by planing, the remainder by using the regulating properties of the *Safepave*. After approximately 1 year, the condition of the *Safepave* surfacing reflected most of the underlying cracking and the rutting in some areas had returned although it was less severe. As at early 2001, the *Safepave* remained in a serviceable condition and had achieved more than the planned 2 years extension of life.

Table 5 Summary of findings for surface dressing sites

Road location	*Surfacing type*	*Structural benefits*	*Other benefits*
Somerset A38 Tone Way, Taunton	Johnston Hot-Chip surface dressing.	None, except to keep the road serviceable from critical to failure condition.	Surface characteristics were maintained at an acceptable level.
Somerset A38 Edithmeade to Cross	Racked-in surface dressings.	No direct effect, although possible extension of life gained from sealing the surface.	Surface characteristics maintained at an acceptable level, in comparison with adjacent overbanded sections.
Suffolk A140 Needham Market (2 sections southbound dual)	1984 surface dressing. 1988 Johnston Hot-Chip.	None evident, although the pavement has remained in a reasonably strong condition.	Surface characteristics acceptable for 6 to 8 years.
Kent M2 east and west of A229 junction	Surface dressing.	None, but has stopped chipping loss from an underlying 'dry and boney' HRA w/c.	Satisfactory surface characteristics maintained after 5 years wear.
Kent A2 Bridge by-pass	Surface dressing.	None, reflective cracks reappeared within 2 to 3 years.	Surface characteristics were enhanced, but overlaid after 4 years.
Kent A21 Sevenoaks by-pass	Surface dressing.	None, reflective cracking reappeared within 2 years.	Surface characteristics were enhanced, but parts were overlaid after 4 to 5 years.
Cambridge A47 Thorney Toll to Guyhirn	Surface dressing.	Reflective cracking soon reappeared but edge deterioration and potholes were sealed.	Sections of 'fatting' and 'fretting' of the dressing were a problem within 1 year.
Cambridge A14 Bar Hill	Johnston Hot-Chip.	No direct strengthening but extended life of the pavement by 6 to 8 years to failure.	Enhanced surface characteristics.
Warwickshire A5 Atherstone by-pass	Racked-in surface dressing.	Deflectograph survey indicated 'stiffer' pavement and extended serviceable life of pavement to failure.	Enhanced surface characteristics for 10 to 12 years.
Buckinghamshire A413 Amersham by-pass	Trial of various surface dressings.	None reported.	For most dressings the surface characteristics have been maintained at satisfactory level for over 10 years.

Table 6 Summary of findings for thin surfacing sites

Road location	*Surfacing type*	*Structural benefits*	*Other benefits*
Somerset A38 [Chart 230] East of Chelston	Safepave.	None indicated by the Deflectograph surveys, although the deterioration of the surfacing has been retarded.	Surface characteristics so far maintained at a serviceable level for 4 to 5 years.
Suffolk A14 Haughley(w)	Tarmac Masterpave (SMA).	None, but rutting was removed and has not reappeared after 4 years.	Enhanced surface characteristics.
Cardiff A4232 (Ely Link)	Safepave.	None, but cracked and spalled HRA was covered and the condition did not deteriorate for over 4 years.	Enhanced surface characteristics.
Cardiff Eastern Ave, Cardiff	Hanson Tuffgrip.	None, but cracked and crazed HRA was covered and the condition did not deteriorate for over 1 year.	Enhanced surface characteristics.
Cambridge A10 Littleport	SMA with HRA control.	None reported, except excellent wheel-track rate.	Durable surface.
Cambridge A47 Thorney-Thorney Toll	Safepave.	None, with parts adversely affected by differential settlement. Elsewhere the original surface defects have not reappeared after 7 years.	Has performed as well as HRA control.
Hampshire A34 [Chart 1/05 Ch 1145 to Chart 1/34 Ch 270 m]	UL-M surfacing.	Deflectograph surveys indicate general structural improvement, but mainly attributed to control of moisture ingress.	Good surface characteristics retained.
Hampshire A31 Romsey	Safepave over cracked HRA with low texture.	None reported, but original cracked surface has not extended for more than 7 years.	Enhanced surface characteristics.
Berkshire M4 J5 to J6	Safepave over badly rutted HRA with longitudinal cracking (reprofiled by planing prior to application).	None reported, but the life of the cracked and severely rutted pavement has been extended for over 4 years.	Short-term enhancement of surface characteristics.

4 Conclusions

4.1 Literature review

The literature review found no evidence about the effects of thin surface treatments, including surface dressings, slurry surfacings and thin surfacing overlays, on the long-term structural performance of pavements. The lack of positive evidence is because the structural performance has not been monitored with respect to surface treatments. Many of these surfacings have been in service for a short while (particularly the thin surfacing overlays) and, therefore, performance data about their contribution to pavement performance is limited. Nevertheless, a number of trials have been carried out in the UK and elsewhere to establish the long-term performance of a range of thin surfacing treatments. However, much of this work has concentrated on the performance of the surfacing material and surface characteristics rather than the long-term performance of the pavement structure.

Both surface dressings and thin overlays are generally reported to seal the surface and ‘mask’ cracking, but there is limited information to substantiate that this ‘sealing’ actually results in the pavement being stronger than if it had not been treated. Additional evidence needs to be gathered together in order to determine the effectiveness of the range of treatments and their ability to protect the road from ingress of water, reflective cracking and to determine the optimum timing of treatments during the life of a pavement.

4.2 Survey of sites

The conclusions of the survey are listed below. Wherever possible, these conclusions are based on the results of the reported pavement assessment surveys. However, owing to the subjective nature of much of the information collected, they are significantly biased towards the practical experiences of the contributors and those who provided details of the sites.

In these conclusions, a distinction is drawn in the effect of a surfacing on the structural performance of a pavement in terms of whether it is a direct or an indirect effect. A direct effect is where the surfacing significantly increases the load-spreading ability of the pavement by its presence whilst an indirect effect is where the loss of load-spreading ability of the pavement with time is significantly reduced because of the presence of the surfacing.

4.2.1 Surface dressings

1 Surface dressings have no direct strengthening effect on the structural performance of a highway pavement.

2 Surface dressings may, on suitably drained sites, have an indirect stiffening effect on the pavement structure by virtue of sealing the surface and, therefore, restricting the ingress of moisture to the foundation layers. The effectiveness of surface dressing in doing this must depend on the nature of the existing cracks.

3 Surface dressings can provide a cost effective means of extending the serviceable life of a pavement beyond the critical condition, until complete failure, by retarding and masking the effects of cracking and surface spalling.

4 On structurally sound pavements, surface dressings offer a relatively low-cost means of providing serviceable standards of skid resistance and texture depth for periods of between 4 and 7 years for moderate to high stressed sites and up to 12 years for low stressed sites.

4.2.2 Thin surfacings

1 Because of the limited thickness at which they are laid, thin surfacings have little direct strengthening effect on the structural performance of a highway pavement; the limitations on strengthening ability tend to be exacerbated for those with more open aggregate structures.

2 Thin surfacings may, on suitably drained sites, have an indirect stiffening effect on the pavement structure by virtue of sealing the surface and therefore, restricting the ingress of moisture to the foundation layers. The effectiveness of thin surfacing in doing this must depend on the nature of the existing cracks.

3 Thin surfacings can provide a cost-effective means of extending the serviceable life of a pavement beyond the critical condition, until complete failure, by retarding and masking the effects of cracking and surface spalling.

4 Thin surfacings can provide a cost effective means of re-profiling and extending the life of a pavement that is rutted and/or subject to an uneven running surface profile.

5 On structurally sound pavements, thin surfacings can offer a relatively low-cost means of providing serviceable standards of skid resistance and texture depth for periods comparable with the life of a hot rolled asphalt surface course but for only about three quarters the cost per unit area.

4.3 Overall

Surface treatments when applied to damaged surfacings do appear to be able to protect a pavement structure from future deterioration, but only when the pavement is structurally sound and effectively impervious to moisture from below. However, because of these restrictions on when a surface treatment can protect the pavement and the limited availability of comparable sites with and without treatment for which the structural conditions have been monitored, the extent of the benefit is uncertain. Neither surface dressings nor thin surfacings can restore the structural properties of pavements that have severely deteriorated. As such, even thin surfacings are unsuitable as a treatment for pavements that are failing due to severe structural cracking and deterioration.

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Abstract

Surface dressings and thin surfacings are used to improve the surface characteristics of a pavement and/or to seal and, hence, protect the underlying structure from environmental factors. However, the full effectiveness of these maintenance treatments is, as yet, unsubstantiated. A literature review and an investigation into a number of existing sites where these surface treatments have been used were carried out. The aim was to establish the effectiveness of both surface dressing and thin surfacing treatments in protecting, preventing and/or controlling pavement deterioration and hence prolonging the service life of pavements. The investigation found that surface dressings and thin surfacings have little or no direct strengthening effect on the structural performance of a highway pavement. However, on suitably drained sites, these treatments may have an indirect stiffening effect on the pavement structure by virtue of sealing the surface and, therefore, restricting the ingress of moisture to the foundation layers. On poorly drained sites or sites were water can enter the pavement from below, the application of a surface layer has little effect on structural performance. Nevertheless, these treatments are very useful in restoring the surface characteristics.

Related publications

TRL314 *Road trials of stone mastic asphalt and other thin surfacings* by J C Nicholls. 1998 (price £35, code H)

TRL261 *The long-term performance of a surface dressing trial on A413, Amersham* by J C Nicholls and D P Frankland. 1997 (price £25,code E)

PR79 *Road trials of thin wearing course materials* by J C Nicholls, J F Potter, J Carswell and P Langdale. 1995 (price £35, code H)

PR65 *Evaluation of stone mastic asphalt (SMA): a high stability wearing course material* by M E Nunn. 1994 (price £25, code E)

PR12 *The testing and performance of surface dressing binders for heavily trafficked roads* by J Carswell. 1994 (price £25, code E)

RN35 *Design guide for surface dressing (4th edition, revised)* by J C Nicholls. 1998 (price £35, code J)

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