SOME U.K. DEVELOPMENTS IN SKID-RESISTANT ROAD SURFACINGS

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Summary

The paper discusses various types of skid-resistant treatment appropriate for different categories of road. For particularly critical areas such as junctions in cities, treatments based on epoxy resin binders and calcined bauxite have proved highly effective in maintaining skid-resistance and reducing accidents. This combination was first proposed by the British Road Research Laboratory in 1959 and such treatments have been in commercial use in the U.K. and several other countries for up to 9 years. Methods of application and the performance of such systems are described. For heavily trafficked but less critical roads, improved methods of conventional bituminous surface dressing are discussed, the most promising systems being based on the use of high-viscosity cutback with pre-coated chippings and a polymer/bitumen emulsion with hot chippings. Methods of adapting open-textured asphalt carpets, or friction courses, already well-proven on airfield runways, to heavily trafficked roads and city streets with their more intense and channelised traffic, are also discussed. Finally the paper discusses possibilities of alternative treatments such as those based on improved slurry seal formulations.

Skidding is widely recognised as an important contributory cause of road accidents, particularly when road surfaces are wet. It may take the form of visible sliding of the vehicle but more commonly it is experienced as an increase in the stopping distance when braking. Skidding is often the result of a combination of factors but one of the most important is the slipperiness of the road surface. Heavily trafficked surfaces tend to become slippery because of the polishing effect of rubber tyres, and there is a clear relationship between the amount of traffic passing over a road and its average level of skid resistance, as shown by Szatkowski and Hosking (1). This effect, together with the relationship between skidding resistance and accident risk led to the recommendations first proposed by Giles (2) and subsequently embodied in the Marshall Report (3) in the U.K. for minimum standards of skidding resistance for different categories of road.

More recently, however, it has been increasingly recognised that the risk of accidents depends not only on the category of site and its traffic but also on other factors such as the precise layout of the particular site in question. For example, some very heavily trafficked roads such as straight lengths of motorways may develop low values of skidding resistance without showing high accident rates whereas road junctions where similar traffic volumes are combined with braking and turning manoeuvres often tend to become accident black spots, partly because of the potentially hazardous manoeuvres themselves and partly because the braking and turning actions cause extra polishing of the road surface at these places (4) (5). To take account of these effects new proposals have recently been published (6) in which recommended minimum values of sideway force co-efficient (SFC) would be based not only on the category of site but would additionally be dependent on a "Risk Rating" which would be determined by the accident potential of each site. Table 1 summarises the new suggested values.

Satisfactory skidding resistance depends on having an aggregate with an adequate resistance to polishing and a sufficient texture in the surface itself as measured by the sand-patch method (7) to ensure rapid contact between tyre and road in wet conditions, particularly at high speeds.

Depending on the severity of traffic conditions various methods are available for improving the texture and skid-resistance of road surfaces which have been worn smooth by traffic.

Resin/Bauxite Surfacings for Critical Sites

It has become clear from experience that on the most difficult sites (Type A1 in Table 1) it is hardly possible to obtain the required SFC levels for the high-risk sites with conventional road surfacing materials. However, in recent years a method of solving this problem has become established in which small chippings of calcined bauxite are bonded to the road surface by an extended epoxy resin binder. Refractory grade calcined bauxite has a higher resistance to polishing, as measured by the Polished Stone Value Test (8) than any natural roadstone, coupled with a high abrasion resistance. The epoxy resin binder, being thermo-setting, effectively prevents any embedment of the chippings with the result that in spite of the use of very small chippings (1 to 3 mm size) a remarkably high texture depth can be maintained even under heavy traffic.

The combination of refractory grade calcined bauxite and epoxy resin-based binder was first proposed by the British Transport and Road Research Laboratory (TRRL) and its effectiveness was demonstrated in road trials in 1959 which showed that the calcined bauxite gave a better skid-resistant surface than any other material (9) (10). Figure 1 shows the levels of skidding resistance obtained on three sections of surface dressing on the same road (i.e. having the same traffic) but with different types of aggregate. The calcined bauxite section shows a considerably better level of SFC than those with the natural stones which are typical of gritstones and granites respectively.

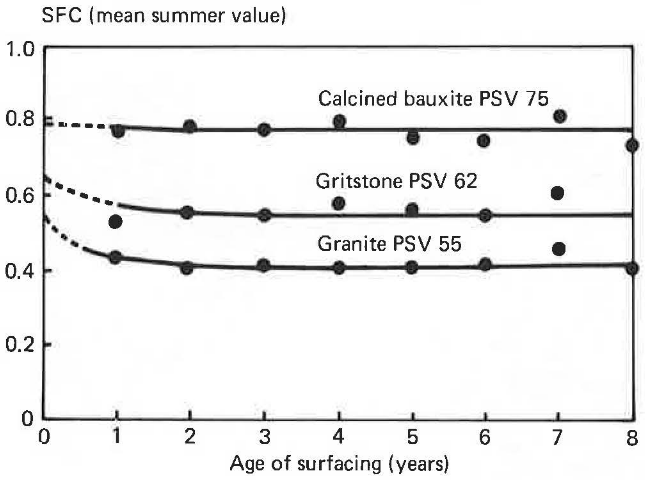
In 1966, as a result of growing concern over accident black spots in London, the Greater London Council (GLC) carried out some small-scale trials which showed that resin-based surfacings were feasible in heavily trafficked city streets. The following year, 1967, the GLC arranged to have the approaches to 7 major road junctions surfaced experimentally with a resin/bauxite system which had been developed by Shell Research Limited and is now

Table 1, Minimum* values of skidding resistance for different sites, proposed by TRRL

Site	Definition	SFC (at 50 km/h)									
		Risk Rating									
		1	2	3	4	5	6	7	8	9	10
A1 (very difficult)	(i) Approaches to traffic signals on roads with a speed limit greater than 40 mile/h (64 km/h) (ii) Approaches to traffic signals, pedestrian crossings and similar hazards on main urban roads						0.55	0.60	0.65	0.70	0.75
A2 (difficult)	(i) Approaches to major junctions on roads carrying more than 250 commercial vehicles per lane per day (ii) Roundabouts and their approaches (iii) Bends with radius less than 150 m on roads with a speed limit greater than 40 mile/h (64 km/h) (iv) Gradients of 5% or steeper, longer than 100 m				0.45	0.50	0.55	0.60	0.65		
B (average)	Generally straight sections of and large radius curves on: (i) Motorways (ii) Trunk and principal roads (iii) Other roads carrying more than 250 commercial vehicles per lane per day	0.30	0.35	0.40	0.45	0.50	0.55				
C (easy)	(i) Generally straight sections of lightly trafficked roads (ii) Other roads where wet accidents are unlikely to be a problem	0.30	0.35	0.40	0.45						

* 'Minimum' in this context does not refer to the lowest individual measurement taken but is defined in terms of the 'mean Summer SFC' (average of 3 readings taken during the months May—September) in a year of normal weather conditions. If the mean Summer SFC falls below the minimum value, the maintenance authority should initiate remedial action by including the length of road in question in the programme for future maintenance work, provided the accident record gives no grounds for re-coding with a lower risk number.

Figure 1 Levels of skidding resistance recorded on different sections of the same road (surface dressing using 13 mm chippings. Traffic in lane: 2100 commercial vehicles per day). (With acknowledgement to the Transport and Road Research Laboratory)



known as Shellgrip. The accident reduction which ensued was so striking that it was decided to proceed with further treatments on a full commercial scale and 19 more junctions were treated in 1968, a further 40 in 1969 and greater numbers since. In 1969 the treatment was also extended to 32 pedestrian crossing approaches with similarly beneficial results. Detailed accounts of this work and its results were published in 1969 (11) and 1970 (4). Figure 2 shows a typical site in London in which the rough texture of the calcined bauxite can be clearly seen.

Method of Application

The Shellgrip binder most commonly used in this type of work is a 2-component bitumen-extended epoxy resin compound. Equal parts of the two components are thoroughly mixed together and spread or sprayed on the road surface, preferably by machine, at a minimum rate of 1.35 kg per sq m. The binder is then covered with an excess of small calcined bauxite chippings, 1—3 mm in size, and the treatment is allowed to cure. After curing (1—5 hours depending on ambient temperature) excess aggregate is removed and the road opened to traffic. For the application of the 2-component binder special machines are necessary which will heat the components separately, proportion them accurately, mix them thoroughly and spray the mixture uniformly onto the road surface. Considerable improvement in the design and construction of such machines has taken place over the last few years. One of the most successful machines is manufactured in the U.K. by Thomas Coleman & Sons Ltd., of Derby, and is now being used by contractors in several countries (Figure 3). Heavily trafficked asphalt roads normally require no surface preparation before treatment and application of Shellgrip can be carried out at temperatures down to 5°C provided the surface is dry. The rate of application of the resin binder must be appropriate to the texture of the substrate, rough surfaces requiring a heavier application than smooth surfaces. Recent studies have determined the relationship between the texture depth of the surface and the required rate of spread of Shellgrip. This is shown in Table 2. With experience the required rate of spread can often be judged by visual inspection, but where any doubt exists the texture depth of the surface should be measured.

Performance

Resin/bauxite treatments have now been in extensive use in London for a period of 8 years. Most of the sites, including those treated in 1968, are still in good condition and continue to show high levels of skid resistance (SFC at 50 km per hour of more than 0.7). Figure 4 shows skid resistance measurements carried out by the Greater London Council on 127 Shellgrip treatments of various ages up to 6 years. No site has an SFC value at 50 km per hour lower than 0.74 and only two values are lower than 0.80.

Table 2 Rate of spread of Shellgrip for surfaces of different texture depths.

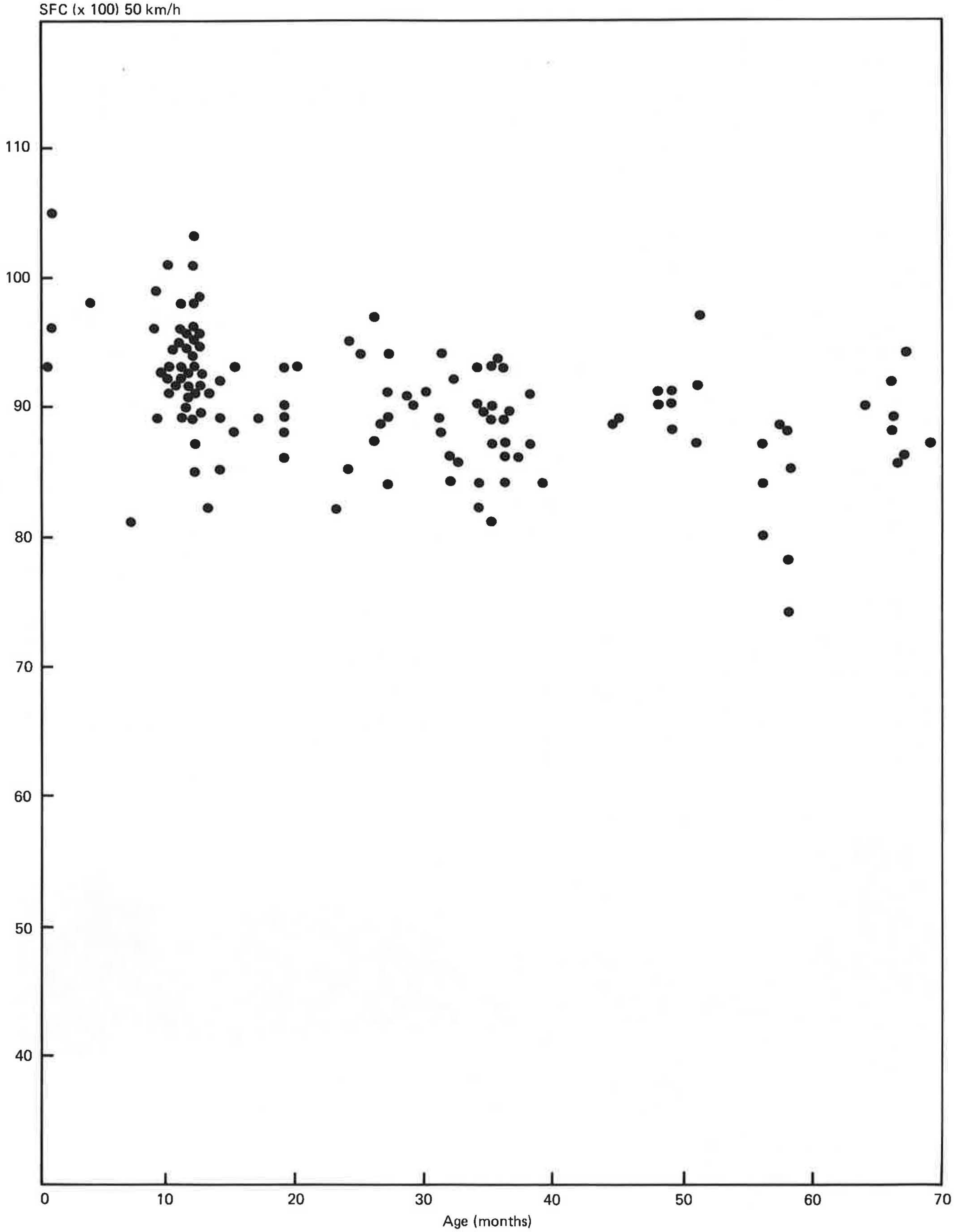
Texture Depth (mm)	Rate of Spread of Shellgrip (kg/m^2)
Up to 0.4	1.35
0.5	1.4
0.6	1.5
0.7	1.6
0.8	1.65
0.9	1.7
1.0	1.7
1.2	1.75
1.4	1.8
1.6	1.85
1.8	1.95*
2.0	2.05*

*For texture depths of more than about 1.75 mm application in two coats is recommended.

Figure 2 Shellgrip treatment at a typical busy road junction in London.

Figure 3 The Coleman machine laying two adjacent widths of Shellgrip binder.

Figure 4 Performance of Shellgrip at road junctions. Age v. SFC at 127 sites in London. Tests carried out in summer 1974. (With acknowledgement to the Greater London Council)



The Greater London Council carried out a survey of 120 Shellgrip sites selected at random from the sites of various ages so far treated. The overall proportion of failed or worn surface was very small (less than 1% area) and it is now forecast that the effective life of this type of surfacing in city conditions will be approximately 10 years.

This type of treatment has also been found to be particularly effective at critical areas on high-speed roads such as motorway turnoffs, roundabouts and junctions on trunk roads, and exposed sites such as high-level bridges. Accidents occurring at these sites are often individually more disastrous than urban accidents because of the higher speeds involved. Figure 5 shows a typical site on a high-speed road which has been treated with Shellgrip. In providing a skid-resistant surface for such sites it is important to ensure that the surface maintains a good texture depth in order to minimise the fall-off in skidding resistance with increasing speed. Since the resin/bauxite surfacings use calcined bauxite of only 1–3 mm in size there were some doubts originally as to whether such a fine-textured surface would be suitable for high-speed traffic. However, experience on many sites including a runway at Belfast Airport, Northern Ireland, has shown that initial values of texture depth are as high as 1.5 mm. This falls off fairly rapidly under traffic to a value of about 1.0 mm but thereafter the decline in texture is very slow. This level of texture depth is certainly adequate for high-speed traffic.

A trial length of Shellgrip was laid on the trunk road A1 at Sandy in England in 1968 and its skid-resistance has been measured at regular invervals by the Transport and Road Research Laboratory (12). Average sideway force co-efficient measurements at 50 and 80 kilometres per hour are shown in Figure 6 for the first 6 years of the trial. The fall-off from SFC at 50 kilometres per hour to SFC at 80 kilometres per hour is generally less than 10%, and the SFC figures at the higher speed are generally between 0.75 and 0.80. A few Braking Force Coefficient (BFC) measurements have also been carried out at higher speeds and in 1972 it was found that the fall-off from BFC at 50 km/h to BFC at 130 km/h was 14 per cent.

Accident Studies in London

Since the early years of these surfacings, considerable refinement in the analysis of accident statistics and methods of selection of sites for treatment has been achieved by the Greater London Council who have set up a central computerised accident statistics system for this purpose. Continuing studies of the effect of Shellgrip treatment on accidents have essentially confirmed Hatherly's 1970 cost/benefit calculations (4). A typical series of results is given in Table 3 relating to 37 sites which had been selected for treatment mainly on the basis of the previous year's high accident figures. It could be expected of course that some

Figure 6 Skidding resistance at 50 and 80 km/h of epoxy resin/calcined bauxite surface dressing on trunk road A1 at Sandy, England. Surfacing laid October 1968. (With acknowledgement to the Transport and Road Research Laboratory)

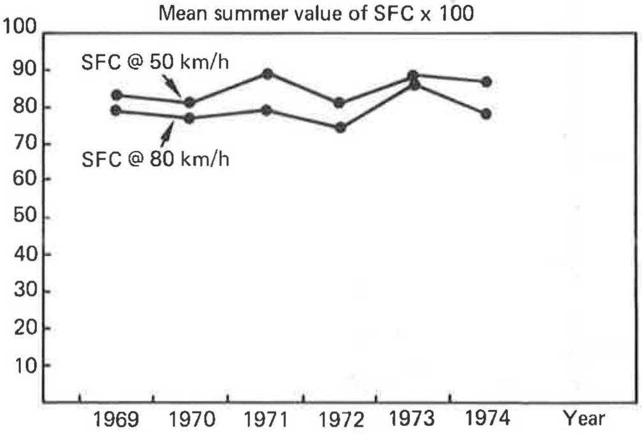


Table 3 Effect of resin/bauxite treatment at intersections in London

Accident Type	Change in Accident Numbers (%)		
	Treated Sites	Untreated Sites	Net Change due to treatment
Total	−44	−18	−31
Wet road	−76	−42	−47
Dry road	−26	− 1	−25
Skidding	−87	−60	−67
Loss of control	−54	+32	−66
Vehicle collision	−39	−29	−14
Pedestrian	−47	− 6	−44
Other (13% of total)	−36	−52	+33

23 treated sites
14 control sites
747 accidents in study period (one year before treatment, one year after treatment).

(With acknowledgement to the Greater London Council, Department of Planning and Transportation.)

Figure 5 Shellgrip treatment on the approach to a roundabout on a high-speed road in England.

reduction from the previous year's peak may well occur by chance alone. For this reason only 23 of the sites were treated with Shellgrip and 14 were left untreated as controls. In the following year the treated sites showed a 44% reduction in accidents but the untreated control sites showed an 18% reduction, the nett reduction to be ascribed to the Shellgrip treatment being 31%, corresponding to a saving of about 3 accidents per site per year attributable to the Shellgrip treatment. Thus although such treatments are expensive, the economic benefits far outweigh the initial cost, which for a major road junction is approximately equivalent to the cost of 2 personal injury road accidents.

Surface Dressing

Surface dressing has long been one of the cheapest and most effective means of restoring a high skid resistance to a road surface and it is used on a very large scale for the maintenance of asphalt roads. It is particularly suitable for high-speed roads because of the coarse surface texture formed by the angular chippings. In fact surface dressing provides a much better skid-resistant surface texture than conventional asphaltic concrete and, because of the orientation of the chippings, gives a better texture than hot rolled asphalt (Figure 7.) In the U.K. tar, tar/bitumen mixtures, cutback bitumen and bitumen emulsion are all widely used as binders for surface dressing, the most striking changes in the last few years being the greatly increased use of high-bitumen-content hot-applied cationic emulsions and of tar/bitumen mixtures at the expense of tar and cutback bitumen. At the present time the proportions of different binder types used in the U.K. are roughly as follows:

Tar	8%
Tar/Bitumen mixtures	25%
Bitumen Cutbacks	36%
Cationic Emulsions	31%

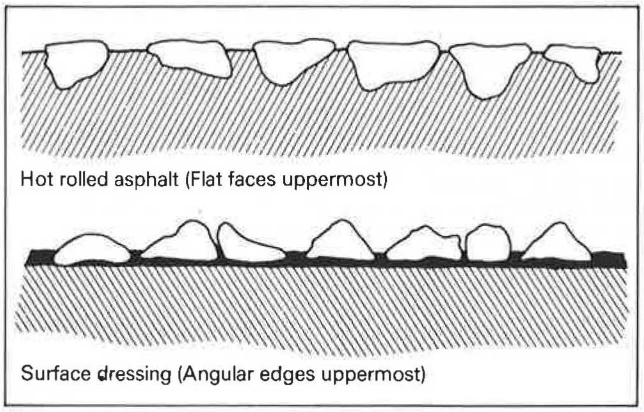
A typical cationic emulsion contains about 70% bitumen and is sprayed at 85°C. It has the advantages of negligible fire risk, no solvent fumes around the spray bar (only water vapour), less heat required than with cutbacks or tars, and ability to cope with damp road surfaces and chippings.

Until recently surface dressing was largely restricted to the less heavily trafficked roads or less critically stressed sites, and the treatment of heavily trafficked roads was not often undertaken because of the difficulties involved. These include the vulnerability of the new dressings to damage by heavy traffic, particularly at highly stressed points such as bends or braking areas, and the danger of loose surplus chippings in the first few days or weeks of the new dressing which can result in broken windscreens. Many authorities have attempted to overcome these difficulties by more elaborate specifications for main road work, including better control of application and equipment, restriction of the working season and more careful control of traffic on the newly laid dressings. Recommendations based on full-scale experiments by the TRRL have recently been published in the U.K. (13) relating the size of stone and the rate of application of binder to the hardness of the substrate, the volume of traffic and the season of the year.

In recent years efforts have been made to extend the use of surface dressings to major roads, including motorways, and to the more difficult sites such as junctions, roundabouts and other highly stressed areas. The main problem arises in the early stages when the binder has to be fluid enough to wet the chippings and yet stiff enough to hold them against traffic forces before any embedment into the old road surface has taken place.

Probably the most useful development in recent years has been the widespread introduction of coated chippings (i.e. coated with about 0.5 to 1.0% of bitumen or tar). This serves two purposes; surface dust is eliminated and rapid adhesion to the binder film is achieved. Thus low viscosity binders are no longer necessary to ensure good wetting of the chippings and much higher viscosity binders can now be used successfully with the result that

Figure 7 Surface textures of hot rolled asphalt and surface dressing.


Hot rolled asphalt (Flat faces uppermost)

Surface dressing (Angular edges uppermost)


Figure 8 Example of surface dressing with high-viscosity cutback after 2 years. A41 road, Bushey, England.

as soon as the binder has cooled it is stiff enough to hold chippings against normal traffic forces and moreover enables a much more vigorous sweeping procedure to be adopted. Thus loose chippings can be more effectively removed without damaging the surface dressing.

An example of this technique is the use of bitumen cutbacks of viscosity 400 seconds STV at 40°C (about 1600 poises) which have been used on a full scale-trial basis in the U.K. since 1971. This is a much higher viscosity binder than is normally used for surface dressings in the U.K. but by using coated chippings, applying them quickly, and generally giving close control to all aspects of the operation it has been remarkably successful. Figure 8 shows an example of this type of surface dressing after two years on a road carrying Category 2 traffic (1000-2000 commercial vehicles per day per lane). The chippings are Gilfach Gritstone which has a Polished Stone Value of about 71 and thus provides a satisfactory skid resistance for this class of road.

An alternative approach is to incorporate a polymer into the binder in order to increase its stiffness at high road temperatures without causing it to become too brittle at low temperatures. A particularly promising development of this type is a hot-applied cationic emlusion containing a thermoplastic rubber. The application of the bitumen/polymer binder in emulsion form avoids the danger of degradation of the polymer which is such a common problem when incorporating polymers in cutbacks or tars. With this binder hot chippings are used to ensure rapid breaking of the emulsion and a high level of adhesion. Surface dressings with this system have been shown to be resistant to heavy rain falling shortly after laying and to severe traffic forces on roundabouts and junctions.

Good quality surface dressings made with 10-12 mm chippings would show initial values of texture depth of about 2.5 mm and although this declines under heavy traffic it would still be expected to show values of about 1.0 mm after four years which would ensure only a slight fall-off in skid resistance with increasing speed. The use of tar/bitumen blends in the U.K. is a further development which by aiming at an optimum rate of weathering of the binder, helps to maintain an adequate skid resistance and texture depth without leading to premature disintegration of the dressing.

Porous Friction Courses

An additional road hazard which has become increasingly recognised in recent years is that of splash and spray in wet weather. This can cause danger and discomfort on all classes of road having impervious surfaces such as dense asphalt or surface dressing. Even in city streets splash can cause discomfort to pedestrians and damage to road furniture and structures, particularly in winter when de-icing salts are used. But on high-speed roads the spray can be particularly dangerous in seriously reducing visibility.

A possible solution to the problem which is already widely used on airfield runways and is being increasingly applied to road surfaces is the porous friction course. This is a type of open-graded bitumen macadam which can absorb a considerable quantity of water before becoming saturated and also allows water to flow through the material towards the drainage channel at the side of the road. (The underlying surface needs to be impervious and of adequate crossfall in order to facilitate drainage.) There is then very little free water on the surface to be thrown up as spray. A specification for this type of surface was drawn up by the British Air Ministry in about 1959 and is given in Table 4.

This material has been shown to be extremely effective on both military and civil airfield runways and in the last few years the major U.K. airports of Prestwick, Gatwick and Heathrow have had their runways surfaced with friction course (14). Similar treatments have been carried out in a number of other countries, notably U.S.A. and Denmark.

The application of porous friction courses to roads seemed a logical development since in addition to reduction of splash and spray and almost complete freedom from the risk of aquaplaning, friction course shows a high skid resistance, a lower level of noise than either surface dressing or chipped rolled asphalt and minimum reflection of light in wet conditions. It is also relatively cheap and easy to lay. In the U.K. its use on roads has been pioneered by Warwickshire County Council using a mix of the "Air Ministry" type (Figures 9 & 10). Simultaneously the TRRL has carried out several series of trials with mixes of different composition in an effort to obtain improved performance since it was considered that under the intense and channelised traffic on a major road the friction course would tend to lose its drainage properties fairly rapidly as a result of a combination of compaction by traffic and silting-up (15). Similar trials have also been carried out in London by the GLC, in Holland by the Rijkswaterstaat and elsewhere. In most cases, although there has been considerable reduction in voids and permeability as a result of compaction in the wheel tracks and clogging by dirt and oil, the surfaces have remained effective in reducing splash and spray for several years.

Table 4 – Specification for Open-Graded Friction Course

Aggregate:	Crushed rock Crushing Value, less than 16% (BS 812) Flakiness Index, less than 25% (BS 812) Polished Stone Value, greater than 62%	
Binder:	Petroleum bitumen 190/210	
Filler:	Portland cement to BS 12 or limestone with minimum 85% passing No. 200 sieve. At least 1% up to a maximum of 2% is to be hydrated lime.	
Aggregate grading (including filler):	BS Sieve	% wt. passing
	½ inch (14 mm)	100
	⅜ inch (10 mm)	90-100
	¼ inch (6.3 mm)	40-55
	⅛ inch (3.35 mm)	22-28
	No. 200 (75 μm)	3-5
Binder content:	Percentage by wt. of total mixed material 4.75 to 5.25	
Mixing temperatures:	Aggregate 80-120°C (175-250°F) Binder 95-135°C (200-275°F)	
Rolling temperature:	Not less than 70°C (160°F)	
Compacted thickness:	¾ inch	

Figure 9 Lorry on typical impervious surface in rain. (With acknowledgement to Mr. I. A. Cram, Warwickshire)

Figure 10 Same lorry on friction course with junction between the two surfaces clearly visible. (With acknowledgement to Mr. I.A. Cram, Warwickshire)

Nevertheless the need is still felt for a more effective mix for the most severe traffic conditions. The trials referred to above indicated that modifications to the binder either by using harder grades or by the addition of rubber or other polymers are unlikely to result in any significant improvement. On the other hand the TRRL trials showed that the use of larger aggregates (maximum size 19 mm instead of 10 mm) produced a more effective material with longer-lasting drainage properties, but this of course would require the application of a thicker layer of material which not only increases the cost but is not actually possible on many roads such as city streets where surface levels cannot be raised by more than a few millimetres.

It is believed that only a radically different type of binder would enable the required improvements to be achieved. Trials have therefore been made of a friction course using an epoxy/bitumen binder which is thermo-setting and produces a mix of great strength. With such a binder a mix of more open grading can be used without risk of fretting or disintegration and a number of trials of such a material have already been made in the U.K. Figure 11 shows part of one such trial in London on the A4 road which carries about a quarter of a million vehicles per week. Figure 12 shows the texture after two years traffic of a section of the trial in which a more open-graded mix was used, the grading of which is given in Table 5. This has been found to be considerably more effective in draining water rapidly than the adjacent mix made to the normal grading which is also shown in Table 5.

Table 5 – Mix compositions used in epoxy/bitumen friction course trials on A4 road, London.

	Normal grading ("Air Ministry")	Open grading
B.S. sieve (% w passing)		
14 mm	100	100
10 mm	98	77
6.3 mm	55	32
3.35 mm	24	17
75 µm	5	2.3
Binder content, % w.	4.9	4.0

Figure 11 Epoxy friction course on A4 road, Hammersmith, after 2 years.

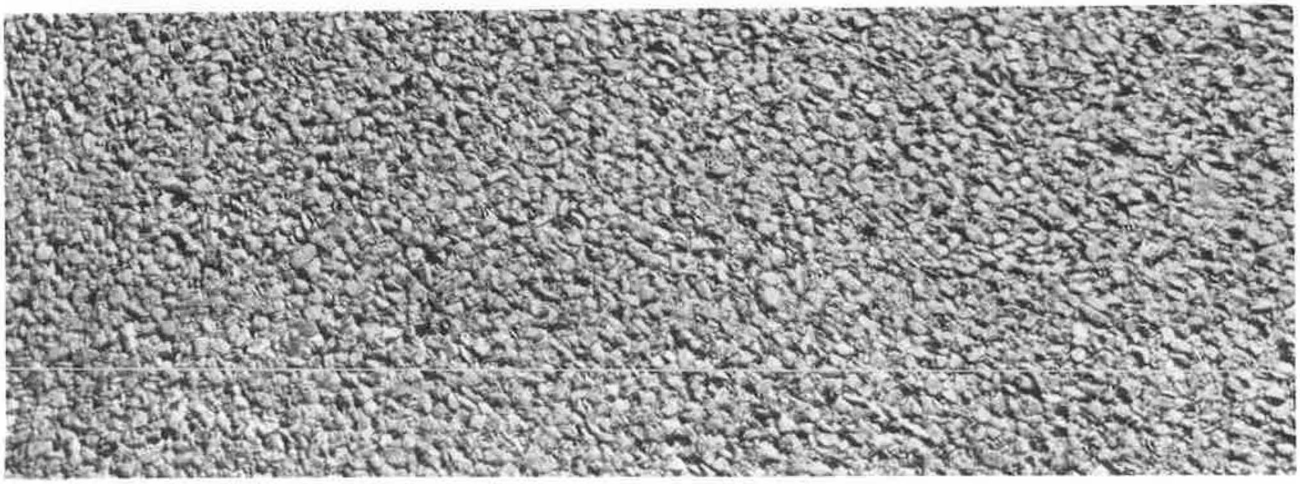


Figure 12 Texture of epoxy friction course after 2 years.

As can be seen from Figure 12 the epoxy/bitumen friction course has retained its very open texture even after two years of extremely heavy traffic. It is considered that such an open-graded mix would be unlikely to survive under very heavy traffic if made with a normal binder and is only feasible with a binder such as epoxy/bitumen.

Bauxite Slurry Seals

The success of the epoxy resin/calcined bauxite type of surface treatment has led to increasing interest in the possibility of using the remarkable properties of calcined bauxite in other forms of surfacing. Since the calcined bauxite is only readily available in small sizes, the possibility of using it in a slurry seal was investigated by the TRRL (16).

Slurry seals are mixtures of fine aggregate, filler, bitumen emulsion and water and are widely used for sealing airfield runways, motorway hard shoulders and lightly trafficked roads (Figure 13). They have not hitherto been considered to be sufficiently durable for use on heavily trafficked roads, but it was thought that the replacement of a proportion of the normal crushed-rock aggregate by calcined bauxite would improve the resistance to skidding and the durability. A trial was carried out at the approaches to a roundabout on the A1 road near Grantham, England, where the surface is subject to braking and turning traffic. A proprietary rapid-setting anionic slurry seal (Bitupave) was used in which half the normal crushed-rock was replaced by calcined bauxite.

The trial showed that in the fast lanes carrying about 3500 vehicles per day, mainly passenger cars, the calcined bauxite slurry seal remained in good condition for over three years and showed a satisfactorily high resistance to skidding. However, in the slow lanes, carrying nearly 6000 vehicles per day, nearly half of which were heavy goods vehicles, the slurry seal required replacing after 2 years. It also appeared that thicker layers of slurry were required than are normally laid on lightly trafficked pavements.

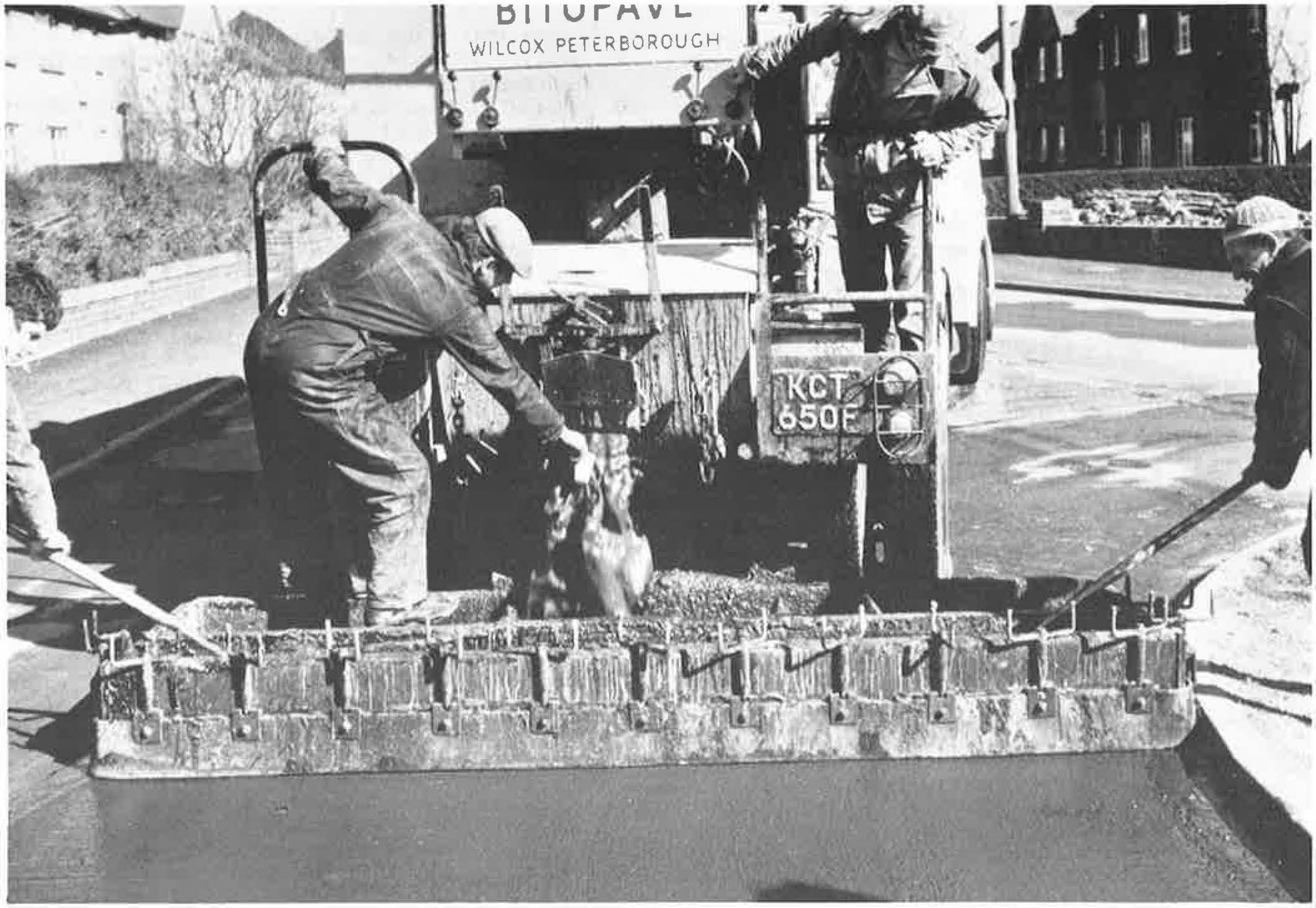


Figure 13 Slurry seal being laid on residential street.

It is concluded that the calcined bauxite slurry seal process is promising but requires further development to establish the most suitable specifications for different traffic patterns. Moreover, for heavily trafficked areas it may require the development of a binder of improved properties, and this possibility is now under consideration.

General Conclusions

Increasing experience of epoxy resin/calcined bauxite surface treatments has shown them to be very effective in providing a high level of skid resistance at the most heavily trafficked sites for a period of at least 8 years. Their widespread use in urban situations has resulted in a significant fall in the number of accidents.

The same type of surface is also highly effective when used on high speed roads at particularly demanding locations such as junction approaches. In spite of the small size of aggregate used the texture depth is sufficient to ensure little fall-off in skid resistance with increasing speed.

For less critical sites a number of other treatments are available including surface dressing, porous friction course and slurry seal. Further development of all these processes is continuing and it is expected that each will establish an important place in the range of skid-resistant surfacings.

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