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SURFACE DRESSING ON CONCRETE ROADS

by

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ABSTRACT

Re-texturing of worn concrete roads to maintain adequate resistance to skidding at high speeds is currently achieved by cutting grooves into the hardened concrete surface. Surface dressings are known to afford a cheap and rapid method of renewing texture on bituminous roads and this Report reviews five full-scale road experiments designed to test the effectiveness of the technique on heavily-trafficked concrete roads as an alternative to grooving.

The research has demonstrated the feasibility of applying single surface dressings to ungrooved roads carrying over 2000 commercial vehicles a day in one lane (cvd/lane). Surfaces which have been previously grooved require double dressings at this traffic level, but single dressings have proved satisfactory for such roads below 2000 cvd/lane.

Target rates of spread of binder recommended for use with 10 mm nominal sized chippings are:

(a)	Rubberised cut-back bitumen	1.1 l/m^2
(b)	Rubberised road tar	1.4 l/m^2
(c)	Tar/bitumen binder	1.3 l/m^2

It is shown that by using aggregate of high polished-stone value, considerable increases in resistance to skidding, averaging 0.20 and 0.27 units at 50 and 80 km/h respectively, have resulted from the application of surface dressings to worn concrete roads. At higher speeds, the effectiveness of the dressings is dependent upon depth of texture maintained and accordingly recommendations are made for the minimum abrasion values of the aggregates used, to limit wear under traffic.

1. INTRODUCTION

Work at the Laboratory[1] has demonstrated the importance of providing a coarse surface texture to maintain adequate resistance to skidding on all types of road carrying high-speed traffic. Accordingly a minimum texture-depth of 0.75 mm is currently specified[2] to ensure good resistance to skidding at high speeds on concrete carriageways. On new concrete roads this is normally achieved by brushing or by transverse grooving carried out whilst the concrete is still plastic, but sometimes the requirement is not fully met. On such roads together with older roads which have become worn under traffic it is necessary to restore texture by cutting grooves into the hardened concrete usually in a transverse manner. Special machinery to carry out these operations has been developed but the technique is fairly costly to implement.

The potential exists therefore for a rapid and effective method for retexturing concrete roads. Single surface dressings have for many years provided such a method for restoring surface texture on worn and polished bituminous roads, but the technique has rarely been applied to concrete roads as experience has shown that a two-stage (double) dressing is required using normal standards of workmanship and materials. However, the effectiveness of single dressings when extra care and supervision is employed was demonstrated in East Sussex in a programme of work surveyed by the Laboratory in 1969.

As a result of the encouraging results obtained in East Sussex a tentative specification for materials and work was prepared for use in the special conditions obtaining on high-speed heavily trafficked roads. Trials of single surface dressing were begun in 1970 on concrete roads carrying over 1000 commercial vehicles a day in one lane in one direction (currently lane traffic categories 1 and 2 of Road Note No. 39)[3].

This Report summarises the results obtained from a series of such road trials and experiments carried out between 1970 and 1975. Reference is also made to the use of more conventional double surface dressings on Motorway M4 in 1969 and later on grooved concrete.

2. THE FULL-SCALE ROAD EXPERIMENTS

Five full-scale experiments with surface dressings on concrete roads were carried out between 1969 and 1975 and these are summarised in the following sections. Where an experiment has not been previously fully reported details of the compositions of the experimental sections are given.

2.1 Trunk Road A20 Swanley, Kent

2.1.1 The 1970 experiment Three binders were used with two aggregates in this experiment[4] which comprises 13 sections each 150m long. A general view of the experimental site is given in Plate 1. All except two sections cover the full width of one of the three-lane dual carriageways thus permitting examination of the performance of the dressings under heavy traffic in the left-hand lane, under mixed traffic in the centre lane and under fast-moving light traffic in the right-hand lane. The carriageway carried 1950 commercial vehicles a day (April 1970), of which 1770 travelled in the nearside lane and 180 in the centre lane. These correspond to lane traffic categories 2 and 4 of Road Note No. 39.

The aggregates selected were gritstones representative of materials with high and medium resistance to crushing and abrasion – important properties in view of the hard, unyielding nature of the concrete substrate. In one section the aggregate used was calcined bauxite, an artificial aggregate which had given good performance on a motorway of flexible construction. An epoxy-resin/bitumen binder using 3 mm calcined-bauxite chippings was used on a further section.

The layout and compositions of the experimental sections is given in Fig. 1.

2.1.2 The 1973 experiment A second full-scale experiment[5] was begun in July 1973 with the object of determining whether higher levels of surface texture could be maintained when using truly single-sized chippings rather than chippings conforming to the current recommendations of BS:1971(Pt 2). Earlier experiments on bituminous substrates had shown the degree of embedment of chippings to have more effect on performance than variations in grading of the applied aggregate and a concrete road where no embedment would take place was therefore chosen to eliminate this variable.

Six experimental sections of single surface dressing, each 75 m long, were laid using three different gradings of each of two aggregate types (see Table 1). These aggregate types were the same as those selected for the 1970 experiment. A single binder which had given good performance in the 1970 experiment was used.

The layout and compositions of the experimental sections is shown in Fig. 2.

2.2 Trunk Road A2, Dartford, Kent 1972

The object of this trial[6] was to investigate the effectiveness of surface dressing in restoring the surface texture of previously grooved concrete. For various reasons the concrete surfacing had been subjected to a number of treatments in attempts to improve riding quality, to improve resistance to skidding at high speeds and to reduce noise generated by traffic passing over the grooved areas. The types of surface treatment are shown in Table 2 together with an estimate of the relative percentages of each on the 200 m length which was surface dressed. Texture depths of the various surface treatments varied widely and Table 2 also shows the mean texture depths obtained prior to surface dressing.

A traffic count in May 1972 showed that over 20,000 vehicles/day were using the east-bound carriageway; this is particularly heavy. Of the commercial vehicles, 3139 were carried in the left hand lane, 1279 in the centre lane and 82 in the right-hand lane. These correspond to lane traffic categories 1, 2 and 4 in Road Note No. 39.

This considerable difference in traffic intensity between the three lanes, together with the variable nature of the substrate, were major influences in the selection of the specification for this work. A revision of recommendations for road surface dressing with tar or cut-back bitumen was being undertaken at this time and a scheme was under consideration to ensure different specifications being prepared for each traffic lane according to traffic intensity. The scheme related the probability of loss of texture by embedment of chippings into the road surface to the number of commercial vehicles carried in each lane. Although particularly relevant to bituminous roads, the scheme was still considered applicable to concrete surfacings where the major factor was expected to be loss of texture due to wear of the aggregate.

Accordingly 10 mm chippings were selected for use in the left-hand lane, 6 mm being specified for the other two lanes. It was considered that a single surface dressing would not be appropriate in the left-hand lane because of the heavy traffic and the extremely rough and variable nature of the substrate. This traffic lane was therefore regulated by a first surface dressing using 6 mm blast-furnace-slag chippings. This dressing was applied and trafficked for a short period prior to applying the second dressing.

The separate specifications prepared for each lane are given in Table 3. The binder and aggregate type were chosen on the basis of having given good performance after two years of traffic on the experiment on A20 at Swanley. The site was too short to permit trials of other binders and aggregates.

2.3 Motorway M4

2.3.1 Boston Manor (1969) In the summer of 1969 it was decided that a length of bituminous surfacing on the elevated section of Motorway M.4 should be re-textured by surface dressing to restore resistance to skidding. The opportunity was taken to include in the work two short trial lengths of surface dressing on the concrete length of M4 immediately adjacent to the proposed trial.

At this early stage of research it was considered that insufficient evidence was available about the performance of single dressings on concrete under very heavy traffic and accordingly the double-dressing technique then recommended in Road Notes Nos 1[7] and 38[8] for concrete roads was adopted.

Two sections, each about 85 m long, were laid. The first dressing consisted of an application of PVC/tar binder (46^{o} evt) at 1.0 $1/m^2$ covered immediately with 6.3 mm lightly tar-coated blast-furnace slag chippings. The dressing was immediately rolled using a pneumatic-tyred roller, swept, and then allowed to carry construction traffic engaged in surface dressing the adjacent bituminous surfacing. Approximately 33 h after applying the first dressing all loose chippings were removed by suction sweeper and a second application of the same binder made at 1.1 $1/m^2$, followed by an application of 14 mm blended bauxite/ gritstone chippings (1:2 mix) on one half of the section and 14 mm gritstone alone on the remainder. Both types of chipping were lightly coated with tar before use. As the 2-lane carriageway carries very heavy traffic (over 4000 cvd in 1969) the same specification was used in both lanes. After rolling and removal of loose chippings, the dressing remained untrafficked until motorway traffic travelling at unrestricted speeds was allowed on the following morning.

2.3.2 Osterley Park (1975) In 1975 a situation existed where successful experimental single surface dressings had been laid on roads carrying traffic in lane traffic category 2 (1000-2000 cv/d) but on lanes carrying category 1 traffic (over 2000 cv/d) only double dressing techniques had been used. For this reason, no positive recommendations for this traffic category had been included in Road Note No. 39. An opportunity to resolve this point arose from the need to obtain information on the economics of available methods for re-texturing concrete roads and a length of motorway M4 at Osterley Park was made available. Further sections of single surface dressing were laid in June 1975; details of the compositions laid are given in Fig. 3. A traffic count, made in 1969, showed the road to be carrying 2640 cv/d in the nearside lane and 1558 cv/d in the centre lane.

The experiment also comprised a number of surface grooving treatments, on which measurements of noise and resistance to skidding will be made. On one section grooves were cut using a concrete sawing technique. The pattern produced by the method was intended to simulate the texture obtained when concrete is grooved in the plastic state[9] and was included to ascertain whether such a surfacing could be covered effectively by surface dressing should the necessity arise. The grooves produced were much deeper than any previously dressed and the area received a double surface dressing. An interesting aspect of this surface-dressing experiment was that the work was carried out at night to reduce traffic delay costs. The length of motorway involved is fully illuminated.

The experimental sections of the experiment are not wholly satisfactory. During the work the spray tanker developed a pressure fault and rates of spread of binder on Section 8 (right-hand lane) were lighter than specified and on Section 6 (left-hand lane) were above specification. Accordingly considerable loss of chippings occurred in the right-hand wheel-track of Section 8 on opening the road to traffic. "Blacking-up" due to excess binder occurred on Section 6 later in the day when road temperatures and traffic intensity had risen considerably, and unfortunately sanding was not initiated in time to prevent significant damage. Vehicle tyres, contaminated with fluid binder, removed chippings from the adjacent Section 7. Inspection later in the day showed that repeated later sanding had prevented further damage and that the dressings had stabilised.

3. RESULTS FROM THE ROAD EXPERIMENTS

3.1 A20 Swanley (1970 and 1973)

3.1.1 Condition of the surfacings The condition of the surface dressings has been assessed annually by the Panel for the inspection of full-scale road experiments; results for the two Swanley experiments are given in Table 4. With the exception of Section 5 (calcined-bauxite aggregate) the 1970 dressings were in acceptable condition after five years of service. Loss of chippings occurred on Section 5 from the beginning of the experiment and it was apparent that the rate of spread of binder had been incorrectly selected. The bauxite contained a fairly high proportion of dense spherical particles whereas other particles were vesicular in nature. It seems clear that the variable nature of the aggregate when used in sizes up to 10 mm in surface dressings on concrete calls for rates of spread of binder some 10 per cent higher than recommended for crushed-rock aggregates.

Where Gilfach aggregate was used in the heavily-trafficked left-hand lane, the Panel assessed the sections as tending to be rich in binder after two years. It is considered that the fault is due to wear of the aggregate rather than the presence of excess binder and this aspect is discussed later. Section 11, where tar-bitumen binder with Haughmond aggregate was used, lacked durability and tended to lose chippings after one year. The rate of spread of binder was slightly lower than the target rate and it seems likely that the differential in rate of spread between cut-back bitumen and tar-bitumen blends may be greater for concrete roads than that recommended for bituminous roads in Road Note No. 39.

An epoxy-resin/bitumen binder with 3 mm calcined-bauxite chippings was laid in the left-hand lane only (Section 1). This type of treatment has given excellent resistance to skidding when applied to the surface of flexible roads at junctions and areas of high accident-risk where traffic speeds are relatively low. Difficulties arose when spraying the material and some variability in the condition of an otherwise good surfacing was noted soon after laying. The surface deteriorated with time, mainly by cumulative loss from damaged areas attributable to poor adhesion of the resin to the concrete. Further research is required into methods of preparing concrete road surfaces prior to spraying this type of binder before this material can be considered for use in re-texturing high-speed concrete roads.

Sections 1–4 were not assessed during 1975 as they had been severely damaged by construction plant during road works.

After two years of experiment the surfacings laid in 1973 were all in good condition and call for no detailed comment.

3.1.2 Texture measurements Measurements of texture depth were made on three occasions each year at seven defined points in the left-hand wheel-track. Average values for each year are given in Table 5. In view of loss of chippings from Section 5 (bauxite aggregate) no texture measurements are included.

An average texture depth of not less than 0.75 mm is currently set for the surface finish of new concrete carriageways[2]. These levels were achieved on the surface dressings after five years with both types of aggregate and all types of binder.

More recent proposals, based on TRRL Laboratory Report LR 510[11], suggest separate criteria for concrete roads (where the texturing is essentially transverse) and for flexible construction (random texture). Different levels are proposed for new construction and for levels below which maintenance may be required. The proposed requirements are:

	New construction	Maintenance intervention level
	(minimum texture depth (mm))	
Concrete construction (transverse texturing)	0.8	0.5
Flexible construction (random texturing)	2.0	1.0

As surface dressing provides a completely random pattern of chippings at the road surface, the appropriate criteria for surface dressing on concrete should be those for flexible construction. With both aggregates the initial requirement was readily achieved. The maintenance level was still exceeded after five years by the Haughmond aggregate, but the Gilfach aggregate fell below the suggested level after three years of trafficking.

In surface dressings on concrete roads there can be no loss of texture through embedment of chippings into the very hard substrate and changes in surface texture can be related to abrasion loss (wear) under traffic. The chippings selected were gritstones representative of materials of high and medium resistance to abrasion and this property is reflected in the changes observed in surface texture and illustrated in Plate 2.

In the heavily-trafficked left-hand lane of the 1970 experiment, the mean texture depths of the sections with Haughmond aggregate (AAV=5) were found to change by only 36 per cent, losing 1.01 mm of texture over five years, whereas 1.69 mm of texture (69 per cent) was lost by the Gilfach aggregate (AAV=12). A similar pattern is observable in the two years of the 1973 experiment; the changes are 30 per cent (0.80 mm) and 49 per cent (1.22 mm) respectively. After five years, textures of over 2 mm remained with both aggregates in the less heavily trafficked centre and right-hand lanes. Loss of texture amounted to only about 25 per cent of the original.

The primary object of the 1973 experiment was to determine whether higher levels of surface texture are maintained in surface dressings on high-speed concrete roads in lane traffic categories 1 and 2 when truly single-sized chippings are used rather than chippings conforming to the present grading of BS63:1971. The Haughmond aggregate (AAV=5) showed no significant differences between the three gradings used after two years, all having texture depths of around 1.85 mm. With the aggregate of medium resistance to abrasion (Gilfach, AAV=12) the best grading with 80 per cent of specified size retained a texture 0.2 mm greater than the other two although the percentage loss of texture over the period was the same for all three gradings.

Correlation between the aggregate abrasion value of chippings and the texture depth of surface dressings was found in an earlier experiment[10] on A40 at West Wycombe (1955) when a difference of one unit of AAV was found to be equivalent to a difference of about 0.05 mm of texture depth after nine years. The corresponding relation found at Swanley with two gritstones only is about 0.10 mm per unit of AAV over a period of five years. This increased rate of wear appears to be directly related to traffic flow; the number of commercial vehicles was about 1000 per lane in one direction at West Wycombe whereas at Swanley the figure is almost twice that. Road Note No. 39 recommends that the AAV of aggregates to be used for surface dressing on motorways and other heavily-trafficked high-speed roads should not exceed 10. Data from the Swanley experiments suggest that this criterion is applicable only to roads in lane traffic category 2 (1000 – 2000 cvd/lane) and that to maintain adequate surface texture in surface dressings on concrete roads in lane traffic category 1 (over 2000 cvd/lane) the aggregate abrasion value should not exceed 8.

3.1.3 Resistance to skidding The resistance to skidding of the experimental surfacings was determined, usually three times during the summer months of each year, by measuring the sideway force coefficients at 50 and 80 km/h and braking force coefficients at 50, 80 and 130 km/h. Measurements were made in the left-hand, centre and right-hand lanes; the average values for the years 1971–5 are given in Table 6.

The road at A20 Swanley may be considered as a Category B site (average – motorways and other high-speed roads) and target values of skidding resistance of 0.50 at 50 km/h (SFC 50) and 0.45 at 80 km/h (SFC 80) were proposed for such sites by the Marshall Committee in 1970. In 1973 a further scheme was proposed[11] which differed from the Marshall Committee's recommendations in that it did not define absolute levels of resistance to skidding which should be maintained but gave guiding values which required adjustment by individual engineers in the light of accident records for the particular site. (For the remainder of this report this scheme will be referred to as LR 510.) The highest target value for category B sites is raised in terms of SFC 50 to a maximum of 0.55 in LR 510.

These requirements were easily achieved with both aggregates and all three binders. Mean values of SFC 50 and SFC 80 measured in the left-hand lane were 0.66 and 0.60 respectively for Haughmond aggregate and 0.78 and 0.68 for Gilfach aggregate. Equivalent values for the less heavily trafficked centre and right-hand lanes were both about 0.04 units higher than the left-hand lane. The mean SFC 50 of the existing concrete surfacing was 0.52. Accordingly the superimposition of a surface dressing on this site has raised the SFC 50 by a minimum of 0.14 units and in the most favourable case by as much as 0.26 units.

Analysis of measurements made on roads over the last 10 years has shown a direct correlation[12] between traffic intensity and the skidding characteristics of the wet road surface, a correlation that varies consistently with the polishing characteristics of the aggregate. The values of SFC 50 measured at Swanley are in fact rather higher (by about 0.08 units) than the anticipated values derived from the above relationship. The polished stone values (PSV) of the aggregates were 62 for Haughmond and 71 for Gilfach. (The PSVs quoted are those obtained on the materials used for the experimental surfacings and are not necessarily typical of the production of these aggregates at other times.)

As skidding resistance is known to change with vehicle speed and the rate of change depends on texture depth, LR 510 also suggested that for high-speed roads the maximum drop in skidding resistance between braking force coefficients measured at 50 km/h (BFC 50) and at 130 km/h (BFC 130) should be 20 per cent. It was also implied that a minimum texture depth of 1.0 mm was required on flexible construction to achieve this. Surfacings which are relatively smooth continue to decrease in resistance to skidding with increasing speed of test whereas surfacings presenting a rough-textured surface will tend to show an improvement in skid resistance at high speeds.

This was found to be the case with the sections using Haughmond aggregate where the average texture depth over five years was about 2 mm. The BFC 130 results were invariably higher than those for BFC 50 although the BFC 80 values show a slight decrease from BFC 50. On the other hand, the Gilfach aggregate with an average texture depth of around 1.0 mm over five years, falling to about 0.8 mm in the last two years, shows an average drop of about 25 per cent between BFC 50 and BFC 130. The original concrete surfacing (texture depth around 0.5 mm) showed not only a much lower level of low-speed skid-resistance but also a 30 per cent drop in skidding resistance between BFC 50 and BFC 130.

These findings reinforce the earlier conclusion that minimum values of AAV should be specified for aggregates of high PSV intended for use in re-texturing concrete roads by surface dressing in order to maintain high texture depth with consequent good resistance to skidding at high speeds.

Over the shorter period of life of the 1973 experiment the same pattern of resistance to skidding occurs. There is no evidence that the use of more single-sized aggregate leads to an increase in resistance to skidding over the range of test speeds, from 50 km/h to 130 km/h.

3.1.4 Effect of type of binder A good surface dressing presents a close mosaic of stones to the tyres of vehicles; little or no binder should be visible. Where surface dressings on bituminous roads have become rich in binder this is generally due to the application of too much binder for the particular chipping size and/or to the rapid embedment of chippings into the substrate under traffic. Embedment is not a factor when surface dressing on concrete and as rates of spread of binder were closely controlled, no examples of excess binder occurred on either experiment.

No significant differences in texture depth or in resistance to skidding were found between sections in which different binders were used. In all cases the effect of aggregate type was of greater importance than that of type of binder. Subjective observations made during laying operations and immediately after opening to traffic gave the impression that the presence of rubber in the binder assisted in promoting rapid initial adhesion to the applied chippings, but it was not possible to quantify this factor.

It is concluded that, when used at the correct rates of spread, the three binder types used, rubberised cut-back bitumen, road tar containing added rubber and tar-bitumen blends, can all be expected to give satisfactory performance in surface dressings on heavily trafficked concrete roads. Lives in excess of five years can be expected on roads carrying traffic in lane traffic category 2 (up to 2000 cv/day per lane).

3.1.5 Treatment of concrete joints The opportunity was taken in the 1970 experiment to carry out a small trial to determine whether the presence of a superimposed surface dressing would cause increased spalling of the expansion and contraction joints in the concrete, caused by blockage of the joint by chippings penetrating into the joint sealer. The concrete road surface was in generally good condition, but some minor repairs to spalled joints were carried out a few weeks before laying the dressings. Two joints in each section were protected by masking prior to dressing; the masking, with the superimposed dressing, was removed before the road was opened to traffic. The remaining joints were given no protection.

With the 10 mm aggregates used in this experiment there was no indication of damage by spalling on either the protected or the unprotected joints after five years. Where the dressing was carried over the existing joint it appeared to reinforce the joint sealing compound and to increase adhesion to the concrete. This finding may not be valid for larger sizes of surface-dressing chippings, namely 14 or 20 mm nominal sizes.

3.2 A2 Dartford 1972

3.2.1 Condition of the surfacings The condition of the dressings was assessed on three occasions by TRRL staff only. The surface-dressed sections presented a good uniform colour and texture in direct contrast to the irregular, patchy appearance of the existing concrete. After three years' service, all three traffic lanes were in good or very good condition and it was not possible to distinguish by visual observation the position of even the most heavily textured concrete, that is the two patches where the road surface had been pre-treated by deep scabbling. It was just possible to discern the areas of deep grooving in the right-hand lane that had been treated with a single dressing with 6 mm chippings. No undue wear or polishing of the aggregate was observed, nor was there evidence of serious crushing under traffic.

3.2.2 Resistance to skidding and texture measurements Average values of resistance to skidding at speeds of 50 and 80 km/h for the years 1973–5 and of texture depth for 1972, 74 and 75 are given in Table 7. As the trial extended over only a relatively short length, resistance to skidding at high speeds was not measured.

In contrast to the Swanley experiment the results show little difference in resistance to skidding (at both 50 and 80 km/h) between the surface dressings and the existing concrete surface. This effect is maintained both on the most heavily trafficked left hand lane (3139 cv/d) and in the more lightly trafficked centre and right-hand lanes. At both speeds, the results of the concrete surfacings are significantly higher (by almost 0.10 units) than at Swanley; this is attributed to the maintenance of high average texture depth (0.75mm) due to the previous treatments carried out on the concrete. Measured texture depths on the concrete ranged from 0.45mm on untreated areas to 2.28 mm on areas treated by a deep scabbling process.

The encouraging results from this single test suggest that surface dressing offers a reliable alternative to further grooving in restoring the surface texture and resistance to skidding of worn concrete which has already been grooved or treated by other methods.

3.2.3 Rolling noise from tyre/road surface interaction When vehicles are driven at speed over some patterns of grooved concrete, noise tones are produced which are subjectively annoying. Harland[13] has deduced that interaction between the tyre and the road surface is the probable principal cause of rolling noise, with aerodynamic noise playing only a minor role. Rolling noise can be an important consideration in the choice of surface treatment on a concrete road and accordingly a subsidiary objective in the A2 Dartford experiment was to determine whether measurements of total noise would provide an effective comparison of the two types of surfacing, the previously treated concrete and the superimposed surface dressings.

For a number of reasons it was not found possible to carry out effective noise measurements on this site, but in order to resolve the problem a programme of measurements is planned to quantify the relationship between noise and skid-resistance obtained on different forms of surface texture. Some of this work will take place on the 1975 experiment on M4 at Osterley Park (see 2.3.2).

3.3 Motorway M4 (1969 and 1975)

This three-lane dual-carriageway motorway carries very heavy traffic which at the site of the trials is restricted to two lanes; accordingly traffic travels at low speeds in peak periods. This high level of traffic occupancy made it necessary to arrange closures of the carriageway to make measurements of resistance to skidding and of texture depth. As only a very limited number of right-hand-lane closures could be permitted only limited data are available for the 1969 trial. Both dressings, that with Gilfach gritstone and that with a mixture of Gilfach gritstone and calcined bauxite, have given good performance over a period of six years during which time the left-hand lane has carried over 6×10^6 commercial vehicles.

Less surface texture has been maintained with the single Gilfach aggregate than with the mixed Gilfach/bauxite aggregate; this effect was noticeable after the first year and is attributed to the differing abrasion characteristics of the aggregates. Texture-depth measurements ranged from over 2.5mm early in the life of the dressings to around 1.2 mm for the Gilfach/bauxite mixture and around 0.8 mm for the Gilfach aggregate alone when measured after six years' service.

The binder used in this trial was Type A road tar to BS76:1964 from a coke-oven crude source blended with 1.5 ± 0.25 per cent of dispersed polyvinyl chloride to give an evt after blending of $46 \pm 1.5^{\circ}C$.

This binder was selected for the major part of the work on the adjacent rolled-asphalt surfacing as embedment of chippings under traffic was expected and it was thought from previous experience that the tar binder would rapidly weather away in the event of excess binder appearing in the surface of the dressing. PVC-tar has proved satisfactory in this particular trial on concrete but it should be noted that prolonged storage at temperatures in excess of 100°C can lead to degradation of the added polymer[14] with consequent loss of the advantages of rapid initial adhesion of stone to binder.

At this stage little can be said about the long-term performance of the single dressings applied in 1975. Apart from some damage by traffic to Sections 6 and 7 due to lack of early sanding in very hot weather (see 2.3.2) the surfacings are all in Very Good or Good condition with surface texture depths in excess of 2.0 mm. No chippings were lost during cold weather early in the winter of 1975 and the dressings appear well bedded down and stabilised. The surfacings will be kept under observation, but it can be tentatively concluded that single dressings can be successful in retexturing concrete roads carrying traffic in lane category 1 (over 2000 cvd per lane/day/in one direction).

3.4 General

All the experimental work described in this Report was carried out in strict accordance with the recommendations of Road Note No 39 – Recommendations for Road Surface Dressings. This provides that surface dressings on high-speed heavily trafficked roads should be carried out only between mid-May and mid-July when reasonably settled weather may be expected and when road temperatures remain high. Under these conditions, with adequate supervision, and with plant and equipment in good condition, a high standard of surface dressing was achieved. Careful removal of surplus chippings prior to opening the roads to unrestricted traffic greatly reduced the risk of damage to windscreens by flying chippings and no instances of windscreen breakage were reported early in the lives of any of the dressings.

As a result of this work it is concluded that sufficient evidence now exists for the preparation of a specification for single surface dressings on heavily trafficked concrete roads carrying high-speed traffic in lane traffic category 1 (over 2000 commercial vehicles a day in one lane).

The general principles outlined in Clause 7 of Road Note No 39 are applicable, and recommendations for chipping size and rate of spread of binder are given in the conclusions to this Report.

4. CONCLUSIONS

The conclusions drawn from the full-scale road experiments on surface dressing on concrete roads surveyed in this Report are as follows:

(1) Good results have been obtained in single surface dressings on concrete roads carrying traffic in lane traffic category 1 (over 2000 commercial vehicles a day in one lane in one direction) with three binders, namely rubberised cut-back bitumen, rubberised road tar and tar/bitumen blends. Optimum rates of spread of binder for use with the preferred chipping size of 10 mm are tabulated below:

Type of surface	Lane traffic category (Table 1 RN 39)	Chipping size (mm)	Target rate of spread of binder (ℓ/m^2)		
			Rubberised cut-back bitumen	Rubberised road tar	Tar-bitumen binder
Very hard (concrete)	1	10	1.1	1.4	1.3

(2) The rate at which aggregates wear under the action of traffic has been shown to be an important factor in the retention of adequate surface texture depth in single surface dressings on concrete roads. It is recommended therefore that aggregates having an Aggregate Abrasion Value not exceeding 8 should be specified for use in single surface dressings on concrete roads carrying traffic in lane traffic category 1.

For roads below this lane traffic category the recommended maximum AAV of 10 specified in Road Note No 39 for aggregates for use on heavily trafficked high-speed roads is still applicable for surface dressing concrete roads.

(3) The application of single surface dressings to ungrooved concrete roads has resulted in improved resistance to skidding compared with the existing concrete surface on all sites at speeds of 50 and 80 km/h where the polished stone value (PSV) of the aggregates used was not less than 60. The improvements amounted to between 0.14 and 0.26 units at 50 km/h and between 0.23 and 0.31 units at 80 km/h. At speeds up to 130 km/h the advantage of surface dressing was maintained, but the effectiveness of the dressings in this respect was found to be dependent upon depth of texture maintained.

(4) Previously grooved concrete surfaces which have been subjected to wear under heavy traffic may be effectively re-textured by surface dressing. Single dressings have been shown to be suitable for grooved traffic lanes carrying less than 2000 commercial vehicles a day, but double dressings are recommended for more heavily trafficked roads.

(5) No evidence was found to suggest that the use of more single-sized aggregate in single surface dressings on concrete roads leads to a better surface texture or to an increase in resistance to skidding over the range of speeds tested (50 to 130 km/h).

(6) During the experiments no spalling of joints in the existing concrete roads occurred due to penetration of applied surface dressings. It is concluded that provided the nominal size of the applied chippings does not exceed 10 mm no protection of joints is required.

5. ACKNOWLEDGEMENTS

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The Report was prepared in the Materials Division (Division Leader Mr. G.F. Salt) of the Highways Department of the Transport and Road Research Laboratory.

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TABLE 1

Gradings of aggregates used in surface dressings: A20 Swanley, Kent (1973)

B.S. SIEVE SIZE	Grading 1 Just within BS63: 1971 (Pt 2)		Grading 2 Well within BS63: 1971 (Pt 2)		Grading 3 Outside BS63: 1971 (Pt 2)	
	Target spec.	As laid	Target spec.	As laid	Target spec.	As laid
	(percent by weight passing)		(percent by weight passing)		(percent by weight passing)	
HAUGHMOND AGGREGATE						
14 mm	100	100	100	100	100	100
10 mm	90	94.0	95	97.6	85	90.8
6.3 mm	30	33.3	15	16.8	45	40.7
5.0 mm	10	12.6	5	5.5	15	19.3
2.36 mm	2	0.5	2	1.1	2	0.9
Flakiness Index (on 10 mm nominal size)	20-30	28	20-30	30	20-30	30
GILFACH AGGREGATE						
14 mm	100	100	100	100	100	100
10 mm	90	93.0	95	92.9	85	88.9
6.3 mm	30	29.6	15	15.9	45	44.8
5.0 mm	10	13.6	5	6.0	15	17.3
2.36 mm	2	0.2	2	1.0	2	0.6
Flakiness Index (on 10 mm nominal size)	20-30	25	20-30	28	20-30	23

TABLE 2

Types of surface treatment and texture-depth measurements prior to surface dressing A2. Dartford, Kent. (1972)

Type of treatment	Percentage of road surface	Mean texture depth (mm)	
		In wheel-track	In oil lane
1. Brushed concrete surface	54	0.53 (0.45–0.61)	0.55 (0.49–0.61)
2. Type B2 grooving* on surface-brushed areas NOT conforming to current texture requirements	5	0.62 (0.56–0.69)	0.67 (0.58–0.76)
3. Type B2 grooving* on areas previously planed to remove high spots	34	1.07 (0.82–1.39)	1.06 (0.84–1.38)
4. Type B2 grooving* with subsequent scabbling to remove sharp arrises	6	1.53 (1.32–1.63)	1.27 (1.06–1.54)
5. Deep scabbling over grooving (grooving completely removed)	1	2.07 (1.77–2.28)	1.67 (1.49–1.99)

* Type B2 grooving consists of a pattern of transverse cuts approximately 3 mm deep, each groove being 8 mm wide and located at 28 mm centres.

TABLE 3

Specification for surface dressing: A2 Dartford, Kent (1972)

		Left-hand lane	Centre lane	Right-hand lane
Traffic: commercial vehicles/day		3139	1279	82
Type of dressing		Double	Single	Single
Binder:	Type	Rubberised cut-back bitumen {120 ± 10 secs STV at 40°C}		
	Rate of spread (l/m²)			
	First dressing	0.9	1.0	1.1
	Second dressing	0.9		
Aggregate:	Type			
	First dressing	Blast-furnace slag	Haughmond (Gritstone group)	
	Second dressing	Haughmond		
	Nominal size (mm)			
	First dressing	6	6	6
	Second dressing	10		

TABLE 4

Surface dressing on concrete, A20 Swanley bypass, Kent

Key to inpsection results

VG = Very Good	F = Fair	Suffixes:–	
G = Good	P = Poor	+ = too rich	t = transverse variation due to traffic laning
FG = Fairly Good	B = Bad	- = disintegrating	
R = Written off for replacement		d = deformed	v = general variability

Sect. No.	1970
1975	1971
1974	1972
1973	

A. Laid June 1970

Results of inspection to May 1975

* Not inspected 1975. Severely damaged during road re-construction.

Type of binder	Size of applied chippings (mm)	Short name of aggregate: Haughmond, Left-hand lane	Haughmond, Right-hand & centre lanes	Gilfach, Left-hand lane	Gilfach, Right-hand & centre lanes	Calcined bauxite, Left-hand lane	Calcined bauxite, Right-hand & centre lanes
Rubberised cut-back bitumen	10	3 VG * G VG G G	3 VG * G VG G FG-	6 VG FG+ FG+ G G G	6 VG G G G G G	5 G FG-	5 FG- P-
		4 VG * G G G G	4 G G G G G FG	7 VG G FG+ G G G	7 VG G G VG G G	F- FG- F- FG-	P- P- P- P-
	6		2 VG * G VG VG VG				
Rubberised road-tar	10	9 VG G G VG G G	9 VG G G VG G G	8 FG+ FG+ FG+ G G G	8 VG G G VG VG G		
Tar-bitumen mixture	10	10 VG G G G G G	10 VG G G G VG G	12 VG FG+ F+v G FG+ FG+	12 VG G G FG- G FG-		
		11 VG F- FG- G FG-v FG-	11 VG F- FG- FG- FG- FG-	13 G FG+ FG+ G G G	13 VG G G G G G		
Epoxy – resin – bitumen binder	3					1 Gv * F-v FGv FG-v Gv	

Sect. No.	1974
	1975

B. Laid July 1973

Results of inspection to May 1975

Aggregate: Type	Aggregate: Grading	Type of binder	Size of applied chippings (mm)	Left-hand lane	Right-hand & centre lanes
Haughmond (Gritstone Group)	1	Rubberised cut-back bitumen	10	17 VG G	
	2		10	15 VG G/VG	
	3		10	19 VG G/VG	
Gilfach (Gritstone Group)	1		10	16 G G	
	2		10	14 G G	
	3		10	18 G G	
Haughmond	–		6		G/VG G/VG

TABLE 5

A20 Swanley, Kent: Average yearly texture-depth measurements

1970 Experiment

Aggregate * type	Traffic lane		Average yearly texture depth (mm) 1970	1971	1972	1973	1974	1975	Loss of texture over 5 years (mm)	Per cent change from original
HAUGHMOND (Gritstone Group) AAV = 5	Left-hand		2.79	2.76	2.33	2.17	1.84	1.78		
		Wear (mm/yr)	–	0.03	0.43	0.16	0.33	0.06	1.01	36
GILFACH (Gritstone Group) AAV = 12	Left-hand		2.45	2.00	1.38	1.06	0.81	0.76		
		Wear (mm/yr)	–	0.45	0.62	0.32	0.25	0.05	1.69	69
HAUGHMOND	Centre and right		3.29	2.45	2.65	2.74	2.55	2.55	0.74	22
GILFACH	Centre and right		2.90	2.29	2.41	2.37	2.18	2.12	0.78	26

1973 Experiment

Aggregate * type	Traffic lane	Grading	% specified size	1970	1971	1972	1973	1974	1975	Loss of texture over 2 years (mm)	Per cent change from original
HAUGHMOND	Left-hand	1	60				2.73	2.00	1.81	0.92	34
		2	80				2.65	2.05	1.85	0.80	30
		3	40				2.56	2.06	1.86	0.70	27
GILFACH		1	60				2.47	1.54	1.26	1.21	49
		2	80				2.85	1.75	1.43	1.42	50
		3	40				2.57	1.70	1.32	1.25	49
Original concrete surface				0.58	0.54	0.58	0.55	0.55	0.52		

* All chippings 10 mm nominal size.

TABLE 6

A20 Swanley, Kent: Average values of resistance to skidding

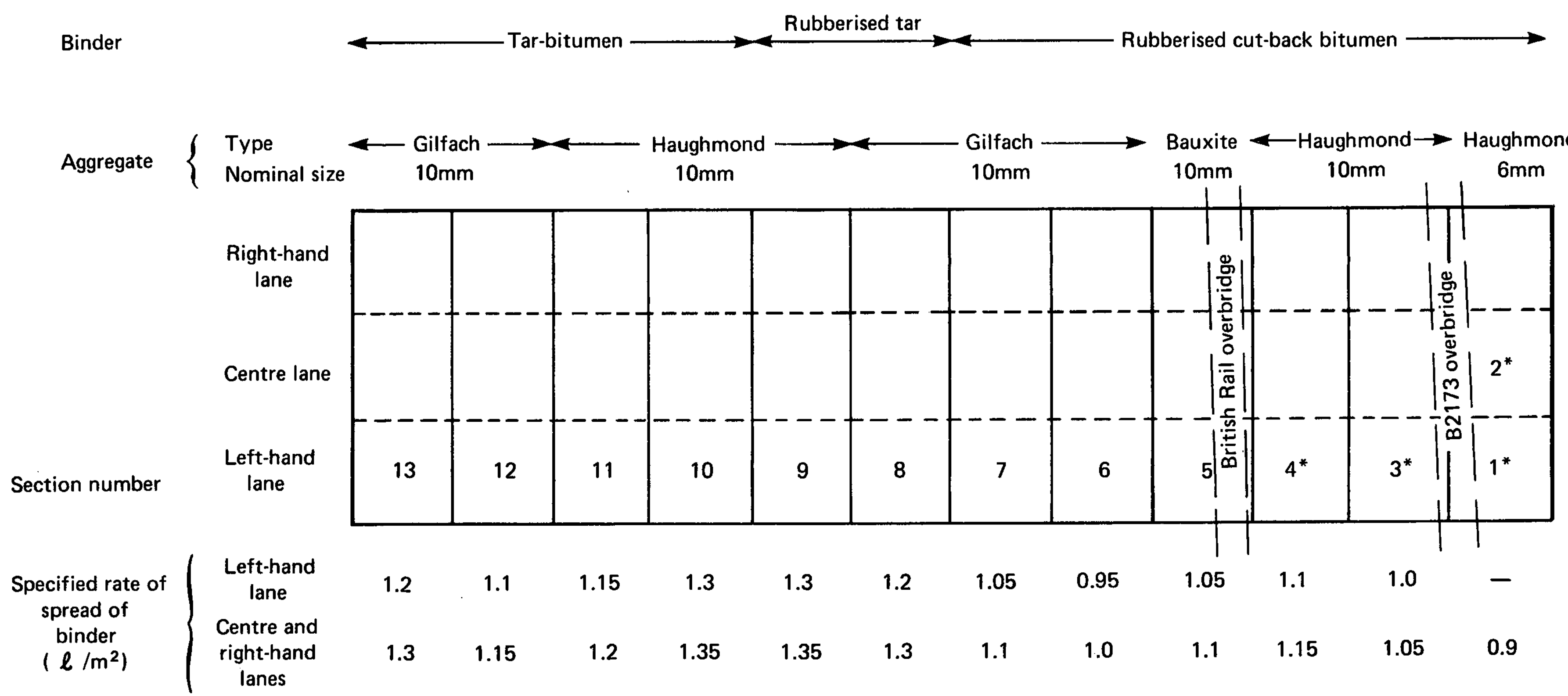
(a) 1970 Experiment

Section Number	Type of binder	Aggregate: Type	Aggregate: Nominal size (mm)			PSV	Left-hand lane (average): 1971–5 SFC 50 x100	1971–5 SFC 80 x100	1971–3–4 BFC 50 x100	1971–3–4 BFC 80 x100	1971–3–4 BFC 130 x100	Centre and right-hand lanes (average): 1971–5 SFC 50 x100	1971–5 SFC 80 x100	1971–3–4 BFC 50 x100	1971–3–4 BFC 80 x100	1971–3–4 BFC 130 x100
1	Epoxy-resin/ bitumen	Calcined bauxite	3			75	88	81	57	50	52	–	–	–	–	–
2			6.3				–	–	–	–	–	72	69	46	42	49
3		Haughmond gritstone	10			62	64	59	39	37	48	69	64	43	41	49
4	Rubberised cut-back bitumen		10				65	58	41	36	45	68	63	44	42	49
5		Calcined bauxite	10			75	92	86	56	52	53	92	88	58	55	63
6		Gilfach gritstone	10				77	67	51	42	36	83	80	51	48	51
7			10			71	80	71	51	46	39	84	80	51	48	50
8	Rubberised tar		10				78	68	49	45	37	82	78	48	46	49
9		Haughmond gritstone	10				67	60	39	37	43	68	65	42	40	46
10			10			62	66	60	39	36	42	67	63	42	39	45
11	Tar-bitumen blend		10				67	61	41	37	43	67	63	42	39	43
12		Gilfach gritstone	10			71	78	69	51	43	38	81	77	49	46	47
13			10				79	68	51	44	39	81	77	48	46	43
							(b) 1973 Experiment									
				Grading	% specified size		1973–5		1973–5							
14		Gilfach	10	2	80	71	83	74	48	45	41					
15		Haughmond	10	2	80	62	70	62	42	36	40					
16	Rubberised cut-back bitumen	Gilfach	10	1	60		81	70	52	44	42					
17		Haughmond	10	1	60		70	61	41	38	42					
18		Gilfach	10	3	40		81	70	50	44	42					
19		Haughmond	10	3	40		70	63	40	37	42					
Centre and right-hand lanes adjoining sections 14–19		Haughmond gritstone	6.3									78	76	48	43	43
Original concrete surface							52	37	34	20	24	60	54	40	30	27

TABLE 7

A2 Dartford,Kent: Average values of resistance to skidding and of texture depth

Type of surfacing	Traffic lane	Nominal size of chippings (mm)	Average values of resistance to skidding						Average texture depth (mm)		
			1973		1974		1975				
			SFC 50 x 100	SFC 80 x 100	SFC 50 x 100	SFC 80 x 100	SFC 50 x 100	SFC 80 x 100	1972	1974	1975
Surface dressing	Left-hand	10	60	55	55	56	65	57	1.96	1.65	1.42
	Centre & right	6	69	64	65	63	78	75	1.46	–	1.28
Original concrete	Left-hand	–	62	59	53	54	64	57	Average value for all concrete textures = 0.75 (range 0.45–2.28)		
	Centre & right	–	73	64	61	63	74	75			



*Damaged by construction plant during road re-construction 1974/5

Fig. 1 LAYOUT AND COMPOSITION OF EXPERIMENTAL SECTIONS (LONDON-BOUND CARRIAGEWAY) SINGLE SURFACE DRESSINGS ON CONCRETE: A20 SWANLEY, KENT 1970

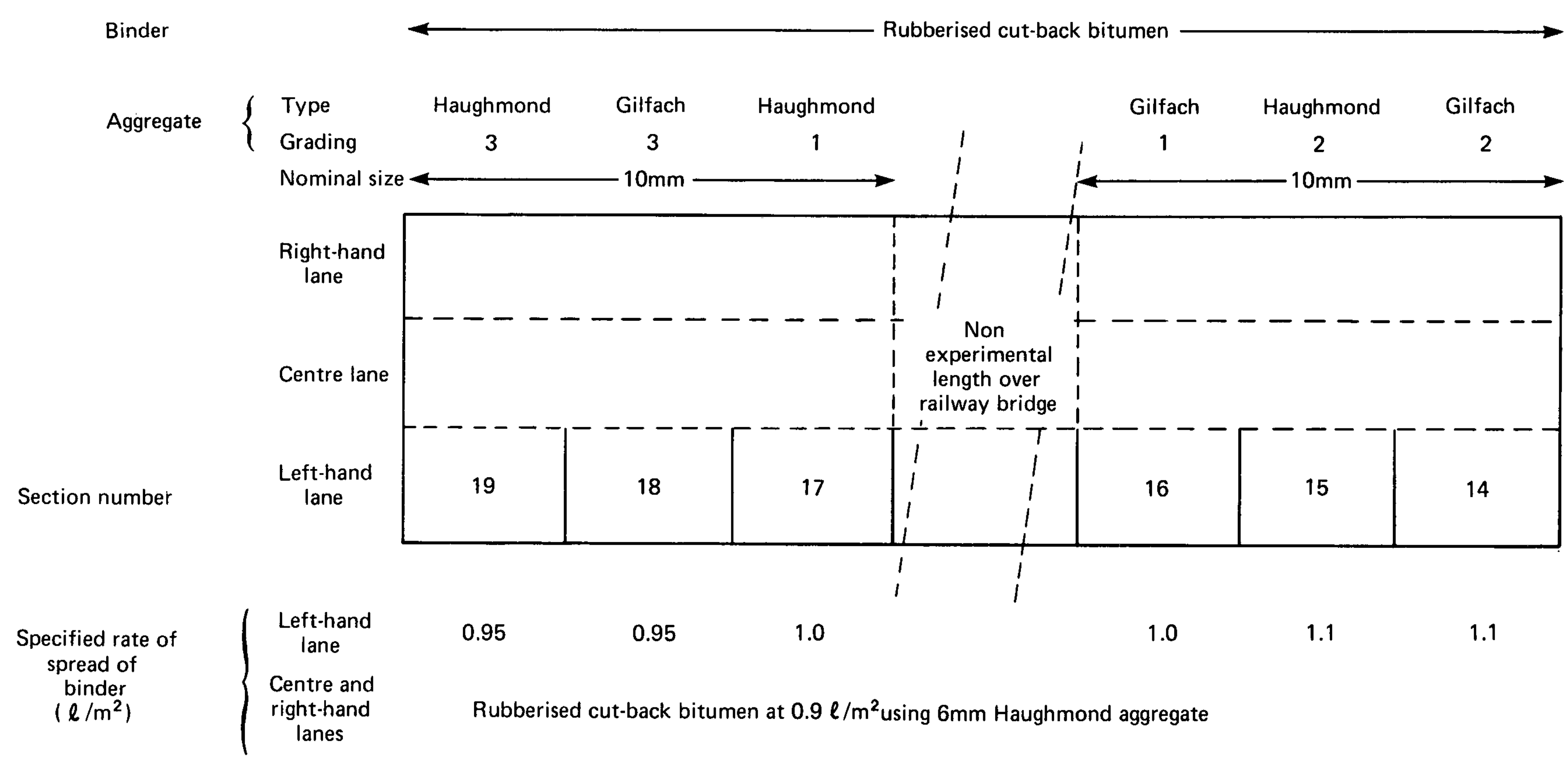


Fig. 2 LAYOUT AND COMPOSITION OF EXPERIMENTAL SECTIONS (LONDON-BOUND CARRIAGEWAY) SURFACE DRESSINGS WITH DIFFERENT AGGREGATE GRADINGS: A20 SWANLEY, KENT. 1973

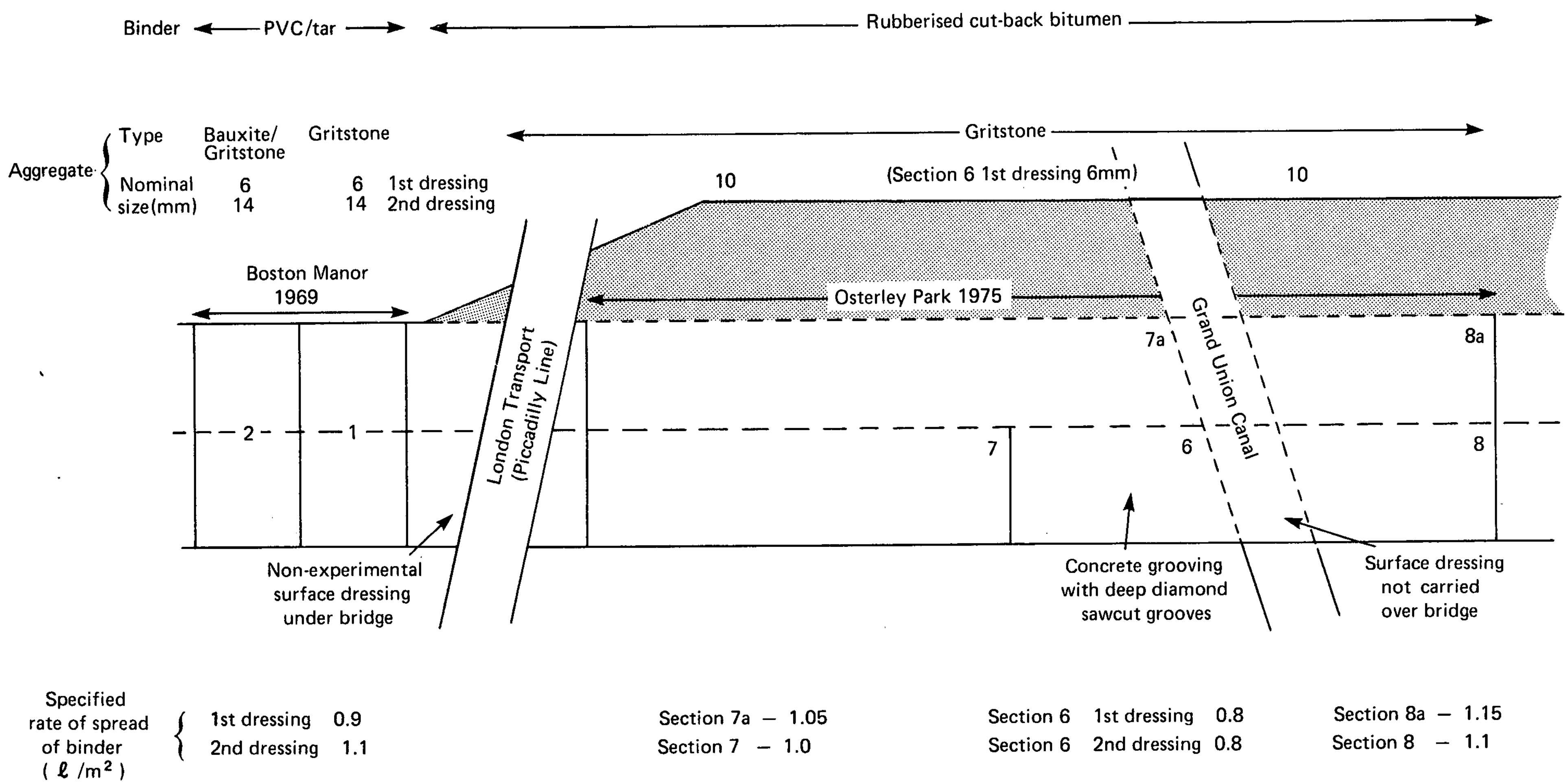


Fig. 3 LAYOUT AND COMPOSITIONS OF EXPERIMENTAL SECTIONS (LONDON–BOUND CARRIAGEWAY) MOTORWAY M4 BOSTON MANOR (1969) AND OSTERLEY PARK (1975)

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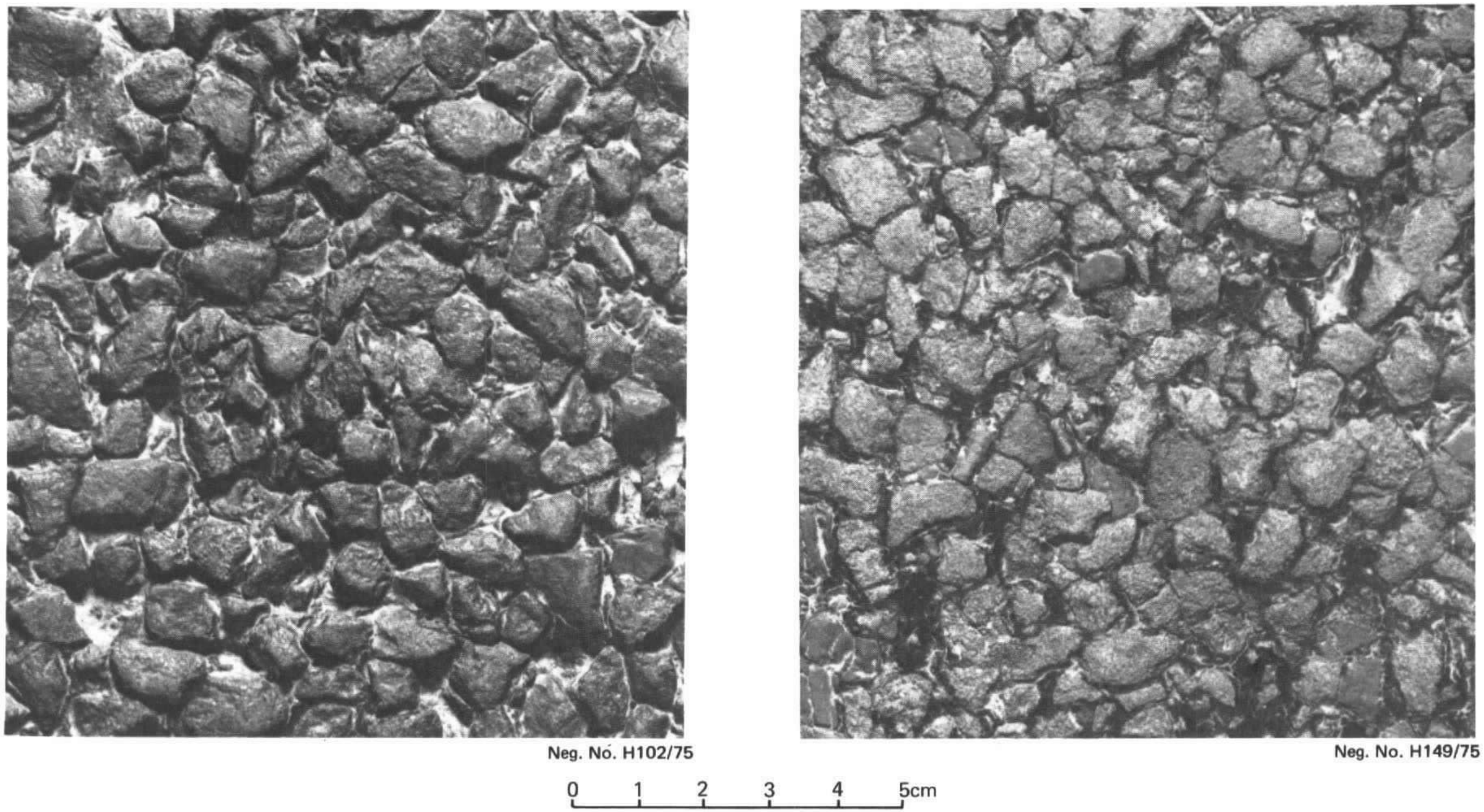
PLATE 1. General view of experimental sections: A20 Swanley, Kent, 1970



(a) Haughmond aggregate (AAV = 5)
Texture depth 1.70mm

(b) Gilfach aggregate (AAV = 12)
Texture depth 0.89mm

Plate 2 APPEARANCE OF SURFACE DRESSINGS ON CONCRETE AFTER 5 YEARS SERVICE IN LEFT HAND LANE – A20 SWANLEY, KENT. TOTAL VEHICLES (1970–5): 11.2 x 10^6 INCLUDING 3.4 x 10^6 COMMERCIAL VEHICLES

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ABSTRACT

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The research has demonstrated the feasibility of applying single surface dressings to ungrooved concrete roads carrying over 2000 commercial vehicles a day in one lane (cvd/lane). Surfaces which have been previously grooved require double dressings at this traffic level, but single dressings have proved satisfactory for such roads below 2000 cvd/lane.

Target rates of spread of binder recommended for use with 10 mm nominal sized chippings are:

(a)	Rubberised cut-back bitumen	1.1 l/m^2
(b)	Rubberised road tar	1.4 l/m^2
(c)	Tar/bitumen binder	1.3 l/m^2

It is shown that, by using aggregate of high polished-stone value, considerable increases in resistance to skidding, averaging 0.20 and 0.27 units at 50 and 80 km/h respectively, have resulted from the application of surface dressings to worn concrete roads. At higher speeds, the effectiveness of the dressings is dependent upon depth of texture maintained and accordingly recommendations are made for the minimum abrasion values of the aggregates used, to limit wear under traffic.

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