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SURFACE DRESSINGS FOR HEAVILY TRAFFICKED ROADS : RESULTS AFTER 10 YEARS OF THE FULL SCALE EXPERIMENT ON A30 BLACKBUSHE, HANTS

by

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Ownership of the Transport Research Laboratory was transferred from the Department of Transport to a subsidiary of the Transport Research Foundation on 1st April 1996.

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ABSTRACT

The embedment of surface dressing chippings under traffic can have a marked effect on the performance of the dressings, particularly with regard to maintenance of adequate texture depth. This Report describes the performance of surface dressings made with both tar and cut-back bitumen binders and a range of aggregates when laid on a hard substrate on a heavily trafficked road.

It is concluded that improved performance is obtained if precautions are taken adequately to render the macadam substrate uniform before surface dressing. Both tar and bitumen gave dressings of very good durability but, throughout the lives of the dressings, greater texture depths were maintained with tar binder rather than cut-back bitumen. At speeds below 80 km/h the resistance to polishing of the aggregates used was the main factor determining resistance to skidding which was independent of binder type.

Recommendations are made for limits for aggregate abrasion and crushing values to be set to avoid excessive wear of the applied chippings under heavy traffic.

1. INTRODUCTION

In the late summer of 1962 a full-scale experiment was begun on Trunk Road A30 at Blackbushe, Hampshire with the object of determining the relation between the polished stone value of a number of roadstones and the resistance to skidding of various types of surfacing made with these materials. Included in these surfacings were sections of surface dressing.

It has been shown by Miss Sabey[5] that on high speed roads (speeds in excess of 100 km/h) it is necessary to maintain a minimum texture depth of 0.65 mm (0.025 in) to ensure that the decrease in skidding resistance with speed is not unduly large.

This standard is readily achieved with new surface dressings but, under the action of traffic, the chippings tend to become embedded into the substrate to which the dressing is applied and in some instances the surface can become rich in binder. In these circumstances the nature of the binder can influence the resistance to skidding of the surfacing and therefore both tar and cut-back bitumen binders were used with the range of roadstones.

This report describes the performance of the sections of surface dressing over a period of almost 10 years and comments on the influence of the type of substrate on which they were laid.

2. SITE AND TRAFFIC

The experimental surfacings[1] were laid on the London–Penzance Trunk Road A30 at Blackbushe, Hampshire in the late summer of 1962. The two-lane carriageway is 7.3 m wide. The surface-dressing sections were laid at the eastern end of the experiment, those sections with tar binder being laid on the west-bound lane and those with cut-back bitumen binder on the east lane. Each section is 90 m long and occupies half the total width of the carriageway.

Up to 1971 traffic on the road was heavy and travelled in two clearly defined traffic lanes. Counts of the traffic were made during the period 1962–71; the figures given below are the sum of traffic in both directions:

Year	Total tonnes/day	Number of commercial vehicles/day
1962	30 000	2 500
1969	52 000	4 200
1971	14 000	1 200

The large drop in traffic volume in 1971 is a result of the opening of part of Motorway M3 in June 1971.

3. COMPOSITION OF THE SURFACINGS

3.1 The substrate

The substrate on which the surface dressings were laid was a close-textured ¾ in (19 mm) nominal-size bitumen-macadam in accordance with Road Note No 29, Appendix 4, Table 5 (1st Edition 1960) containing 200 pen bitumen. This corresponds to the specification given in the MOT Specification for Road and Bridge Works (1969) Clause 903, Table 25.

The surface texture of the newly laid basecourse was not as close as expected for the type of material used, probably because the long haul of the mixed material affected its temperature and consequently the degree of compaction obtained. An initial surface dressing of ⅛ inch (3 mm) uncoated basalt chippings and cut-back bitumen applied at 12 yd^2/gal (0.5 l/m^2) was therefore used as a seal to render the surface uniform. This dressing carried traffic for five weeks before the final dressing was applied. The texture of the substrate at this stage was close and very uniform and considered likely to resist the embedment of chippings under the action of traffic.

3.2 The surface dressings

3.2.1 Chippings The seven aggregates listed below were used in the surface dressings:

TABLE 1

Description of the aggregates

Source	Type of stone	Group classification (BS 812)
Corby	Blast-furnace slag	Artificial
Penmaenmawr	Granophyre	Porphyry
Groby	Diorite	Porphyry
Hartshill	Quartzite	Quartzite
Triscombe	Sandstone	Gritstone
Spring Grove	Dolerite	Basalt
Bauxite deposits	Calcined bauxite	Artificial

With the exception of the calcined bauxite which was of ⅜ in (9 mm) size (as larger chippings were not available), the chippings were all of nominal ½ in (12.7 mm) size. All were coated with 54° evt tar; slightly higher percentages of tar were used to coat the two artificial aggregates because of their greater porosity compared with the crushed-rock aggregates.

3.2.2 Binders The target rates of spread of the 45° evt tar binder were 5 yd^2/gal (1.1 l/m^2) where ½ in (12.7 m) chippings were used and 5.5 yd^2/gal (1.0 l/m^2) in the case of the ⅜ in (9 mm) calcined bauxite chippings. Similarly the cut-back bitumen (120 secs STV at 40°C) was applied at two rates, these being 5.5 yd^2/gal (1.0 l/m^2) for the larger chippings and 6.0 yd^2/gal (0.9 l/m^2) for the smaller bauxite. These specified rates of spread were accurately obtained.

4. PERFORMANCE OF THE DRESSINGS

4.1 Inspection

The road performance of the sections of surface dressing has been assessed at intervals by the Laboratory's Panel for the Inspection of Full-scale Road Experiments. The results of these inspections are given in Table 2; the assessment for 1972 was made independently by staff of the Transport and Road Research Laboratory.

After 10 years of service on the road there is little visible difference between the surfacings. All are in satisfactory condition although it will be noted that slightly inferior performance has been given by two of the aggregate types – a blast furnace slag and a dolerite.

Some loss of chippings has taken place from a narrow strip at the untrafficked edge of the road on those sections where tar binder was used; this is not apparent on the bitumen sections. This has been observed on other sites and current recommendations advise the application of slightly heavier rates of tar at road edges to avoid this imperfection. This can be achieved by substituting a slightly larger spray jet on the nearside of the spray bar.

TABLE 2

Results of inspections to February 1972 of surface-dressed sections

Key to inspection results

Sect	
No	1963
1972*	1965
1969	1967

VG = Very good
G = Good
FG = Fairly good

F = Fair
P = Poor
B = Bad

Suffixes:-
+ = too rich
- = disintegrating

t = transverse variation due to traffic laning
v = general variability
z = suspected of being slippery

Type of binder	Short name of aggregate													
	Corby		Penman		Groby		Hartshill		Triscombe		Spring Grove		Bauxite	
	12.7 mm		12.7 mm		12.7 mm		12.7 mm		12.7 mm		12.7 mm		9 mm	
Tar	6	G	4	G	2	G	12	G	10	G	8	FG-	14	G
45°	G*	G	G*	G	G*	G	G*	G	G*	G	FG-*	G	G*	G
evt	FG+v	FG+t	G	G	G	G	G	G	G	G	FGz	F+t	G	VG
Cut-back	5	G	3	G	1	G	11	G	9	G	7	FG+	13	G
bitumen	FGz*	G	G*	G	G*	G	G*	G	G*	G	FG+*	G	FG-*	G
120 sec at 40°C	FGz	FG	G	G	G	G	G	G	G	G	FGz	P+t	G	G

* 1972 results by TRRL observers only

4.2 Measurement of sideway force coefficient and texture depth

Measurements of sideway force coefficients at 50 km/h (SFC 50) and at 80 Km/h (SFC 80) have been made at intervals throughout the life of the dressings. Tests of SFC 50 are carried out at least three times during the summer of any one year and the average value has been used for comparison.

SFC 80 measurements were made less frequently and difficulty was experienced in obtaining readings on sections at the eastern end of the experiment as the test machine was not always able to attain the correct constant speed in the length available for acceleration.

Measurements of texture depth, made by a sand-patch method, have also been made on three occasions, in 1965, 1968 and 1971. The results of all these measurements are given in Tables 3 and 4.

5. DISCUSSION

Although the primary object of the full-scale experiment was to observe the behaviour of a range of roadstones in bituminous surfacings a number of results of value for the performance of surface dressings have emerged from the investigation.

TABLE 3

Surface dressing with 12.7 mm chippings : A30 Blackbushe
Sideway force coefficient at 50 km/h (SFC 50)

Section No	Binder	Roadstone in surface	Polished-* stone value (1965)	Sideway force coefficient at 50 km/h (SFC 50) Mean summer value								
				1963	1964	1965	1966	1967	1968	1969	1970	1971
5	Bitumen	Corby	49	.44	.46	.43	.45	.41	.41	.47	.46	.40
3	”	Penmaenmawr	52	.44	.47	.45	.47	.43	.38	.44	.44	.43
1	”	Groby	55	.42	.48	.44	.47	.44	.38	.49	.45	.43
11	”	Hartshill	55	.51	.51	.54	.58	.55	.52	.60	.56	.53
9	”	Triscombe	62	.52	.56	.57	.62	.58	.52	.59	.58	.57
7	”	Spring Grove	63	.30	.26	.30	.37	.37	.39	.47	.45	.37
13	”	Calcined bauxite (9 mm)	75	.73	.71	.70	.73	.70	.69	.76	.71	.61
6	Tar	Corby	49	.43	.42	.40	.42	.41	.44	.46	.40	.40
4	”	Penmaenmawr	52	.42	.40	.39	.41	.39	.39	.43	.39	.41
2	”	Groby	55	.44	.41	.41	.41	.41	.42	.47	.40	.45
12	”	Hartshill	55	.52	.54	.53	.56	.55	.54	.58	.52	.56
10	”	Triscombe	62	.54	.56	.55	.58	.56	.55	.62	.54	.57
8	”	Spring Grove	63	.47	.43	.40	.43	.43	.44	.49	.41	.38
14	”	Calcined bauxite (9 mm)	75	.78	.79	.78	.80	.77	.75	.82	.74	.81

* The values given apply to the actual chippings used and do not necessarily apply in general to aggregates from the same source.

TABLE 4

Surface dressing with 12.7 mm chippings : A30 Blackbushe
Sideway force coefficient at 80 km/h (SFC 80) and mean texture depth (sand-patch method)

Section No	Binder	Roadstone in surface	Polished-* stone value (1965)	Sideway force coefficient at 80 km/h (SFC 50) Single measurements					Mean texture depth (Sand-patch method) mm		
				1964	1968	1969	1970	1971	1965	1968	1971
5	Bitumen	Corby	49	.43	–	.44	.39	.35	0.48	0.33	0.27
3	”	Penmaenmawr	52	.44	–	–	.41	.40	0.69	0.48	0.52
1	”	Groby	55	.43	–	–	.43	.37	0.61	0.48	0.45
11	”	Hartshill	55	.50	.53	.51	.52	.48	0.56	0.41	0.49
9	”	Triscombe	62	.52	.54	.57	.55	.51	0.81	0.64	0.58
7	”	Spring Grove	63	.26	.34	.43	.37	.27	0.25	0.20	0.21
13	”	Calcined bauxite (9 mm)	75	.72	.62	.71	.66	.48	0.41	0.30	0.26
6	Tar	Corby	49	.42	–	.44	.32	.42	0.53	0.48	0.56
4	”	Penmaenmawr	52	.45	–	–	–	.42	0.86	0.79	0.80
2	”	Groby	55	.47	–	–	–	–	0.86	0.69	0.83
12	”	Hartshill	55	.49	.54	.54	.49	.55	0.81	0.69	0.70
10	”	Triscombe	62	.51	.55	.56	.46	.61	1.14	0.91	0.86
8	”	Spring Grove	63	.45	.40	.41	.30	.33	0.41	0.33	0.44
14	”	Calcined bauxite (9 mm)	75	.70	.74	.78	.72	.74	0.58	0.48	0.69

* The values given apply to the actual chippings used and do not necessarily apply in general to aggregates from the same source

5.1 The influence of substrate treatment on the life of the dressings

After 10 years of wear all the sections were on visual inspection in satisfactory condition, although polishing and wear of the chippings in the sections containing Corby and Spring Grove aggregate were reported as giving the impression that these surfacings might be slippery when wet. This aspect will be discussed later.

Early in the life of the dressings, extremely low values of SFC 50 were obtained on the section containing Spring Grove aggregate with cut-back bitumen binder. This was due to abnormally rapid wear and breakdown of the aggregate and in normal practice a long length of a dressing in this condition would have been replaced.

For economic reasons close-textured bitumen macadam basecourse material is frequently laid as a strengthening course on existing roads and is often required to carry traffic for long periods before receiving further treatment. This practice has the drawback that the basecourse material tends to become slippery under the action of heavy traffic and in some circumstances the Engineer may wish to apply a surface dressing to provide a more satisfactory texture.

In many cases the surface requiring treatment will be porous and some of the surface dressing binder will penetrate into the substrate leaving insufficient on the surface to hold the larger sizes of chipping. Surface dressings of good durability are unlikely to result under these conditions. An earlier surface dressing experiment on Trunk Road A40 at West Wycombe, Bucks[2] in 1955 showed that uniformity of the substrate to which the dressings were applied was an extremely important factor in achieving good durability. Dressings lasting up to 11 years under heavy traffic were obtained on this site.

The lessons learned from this work were applied in the present case and the coated macadam substrate was rendered extremely uniform by the application of a first dressing using 3 mm uncoated chippings. This provided a very good surface on which to apply the standard dressing using 12.7 mm chippings, and again long lives (10 years in this case) have been obtained.

It is concluded, therefore, that very durable surface dressings may be obtained when laid on coated macadam substrates of uniform texture according to the recommendations given in Road Notes Nos 1 and 38[3, 4]. The application of a first surface dressing using a small-sized (3 mm) chipping provides a cheap and useful method of regulating the texture of the surface. This technique is of particular value in regulating macadam surfacings where there is a risk of loss of surface-dressing binder into interstices in the surfacing. It would be expected to be more controllable than the practice of applying coated grit to the road surface and obtaining compaction by passing traffic.

5.2 The effect of type of binder on the maintenance of texture depth

To maintain good resistance to skidding at medium and high speeds on heavily trafficked roads it has been recommended[5] that a minimum texture depth of 0.65 mm should be maintained. The texture depth of surface dressings with 12.7 mm chippings immediately after laying is of the order of 3–4 mm, but this is soon reduced by re-orientation of chippings and their partial embedment into the substrate under the action of traffic. Wear and crushing under traffic will then act to reduce the texture depth still further.

Measurements of texture depth on the experimental surface dressings were made in 1965, three years after laying, and again in 1968 and 1971. The yearly average texture depths for all aggregate types with tar and cut-back bitumens are shown in Fig 1. These show that in the sections in which tar binder was used the average texture depth of the dressings was either very close to, or exceeded the recommended minimum texture depth of 0.65 m. Comparable sections in which the binder was cut-back bitumen were invariably appreciably below this standard.

However, despite the greater texture depths given by the tar sections, there was in general no significant difference in the resistance to skidding as measured. At speeds below 80 km/h the resistance to polishing of the stone used in the road surface was the main factor determining resistance to skidding which in this experiment was found to be independent of binder type.

It should be noted that the difference between the rates of spread of the two binders used in the experiment was less than currently recommended in Road Note No 39 – Recommendations for road surface dressing. The use of either more tar or less bitumen on this very uniform substrate may well have narrowed the gap between texture depths although the effect on durability cannot be estimated.

5.3 The effect of the physical properties of the aggregates on texture depth

Particularly low texture depths have developed with three of the aggregates used in the experiment and which were found in laboratory tests to have relatively poor resistance to either abrasion or crushing. This is shown in Table 5.

TABLE 5

Comparison of aggregate properties with texture depth

Type of aggregate	Aggregate crushing value	Aggregate abrasion value	Texture depth (mm) 1971		SFC 80 1971	
			Bitumen	Tar	Bitumen	Tar
Spring Grove (dolerite)	15	13	0.21	0.44	0.27	0.33
Corby (slag)	24	9	0.27	0.56	0.35	0.42
Calcined bauxite	33	3	0.26	0.69	0.48	0.74

An explanation for the rapid wear of Spring Grove aggregate has been put forward by Hosking[6] who suggests that weathering plays a part in the degradation of this aggregate. He also suggests that crushing under the steel-tyred rollers used during construction has had a deleterious effect on the performance of Corby slag and the essentially undersized calcined bauxite aggregate. The hard substrate on which the experiment was laid may also have contributed towards the crushing under the rollers and the traffic. The current use of pneumatic-tyred rollers will tend to reduce this hazard.

Throughout the lives of the dressings consistently lower levels of texture depth have been shown by the calcined bauxite aggregate when the binder has been cut-back bitumen rather than tar. The reasons for this are not clear although it must be remembered that in this experiment the bauxite aggregate used was one size smaller than the remainder of the aggregates, that is, 9 mm instead of 12.7 mm. However, highly successful work has been carried out elsewhere with this artificial aggregate with tar binders and its relatively poor performance with cut-back bitumen suggests that the qualities of durability found in cut-back bitumen make it less suitable binder for use with this expensive aggregate.

The part played by the aggregate must be considered of equal importance to that played by the binder in maintaining non-skid textures in surface dressings. It is not within the scope of this Report to discuss in detail the reasons why certain properties of aggregates render them unsuitable for surface dressing work on heavily trafficked roads, but it is clear that where possible the hardest, toughest examples of stone should be used. It has previously been suggested[7] that limits should be imposed for aggregate crushing values and aggregate abrasion values for chippings for use in surface dressing on concrete – the hardest of all substrates. The limits proposed were an aggregate crushing value of not more than 20 and an aggregate abrasion value not greater than 12; a recent revision of Road Notes Nos 1 and 38 reduces this latter value even further to 10.

It is suggested that similar limits should now be considered for aggregates used in surface dressings on heavily trafficked roads on hard substrates other than concrete, particularly where long lives are envisaged for the dressings.

6. CONCLUSIONS

The main findings after 10 years of experiment are as follows:

1. Very good durability has been obtained from surface dressings using ½ in (12.7 mm) chippings with both tar and cut-back bitumen binder on close-textured macadam surfacings of uniform texture. The application of a first surface dressing using a small (3 mm) chipping provides a cheap and reliable method of making the substrate of uniform texture.

2. Throughout the life of the experimental dressings those made with tar binder have consistently maintained greater texture depths than those made with cut-back bitumen binder.

   At speeds below 80 km/h resistance to polishing of the stone used in the road surface was the main factor determining resistance to skidding which in this experiment was found to be independent of binder type.

3. The degree of wear experienced by some aggregates used in the dressings has led to the conclusion that limits should be set for aggregate crushing values and aggregate abrasion value for chippings used for surface dressings on hard or very hard substrates on heavily trafficked roads. Aggregate crushing values of not more than 20 and aggregate abrasion values not greater than 10 are proposed.

7. ACKNOWLEDGEMENTS

The work described in this Report forms part of the research programme of the Materials Division (Leader Mr G F Salt) of the Highways Department. The co-operation of the County Surveyor of Hampshire in making the site available for experiment is gratefully acknowledged.

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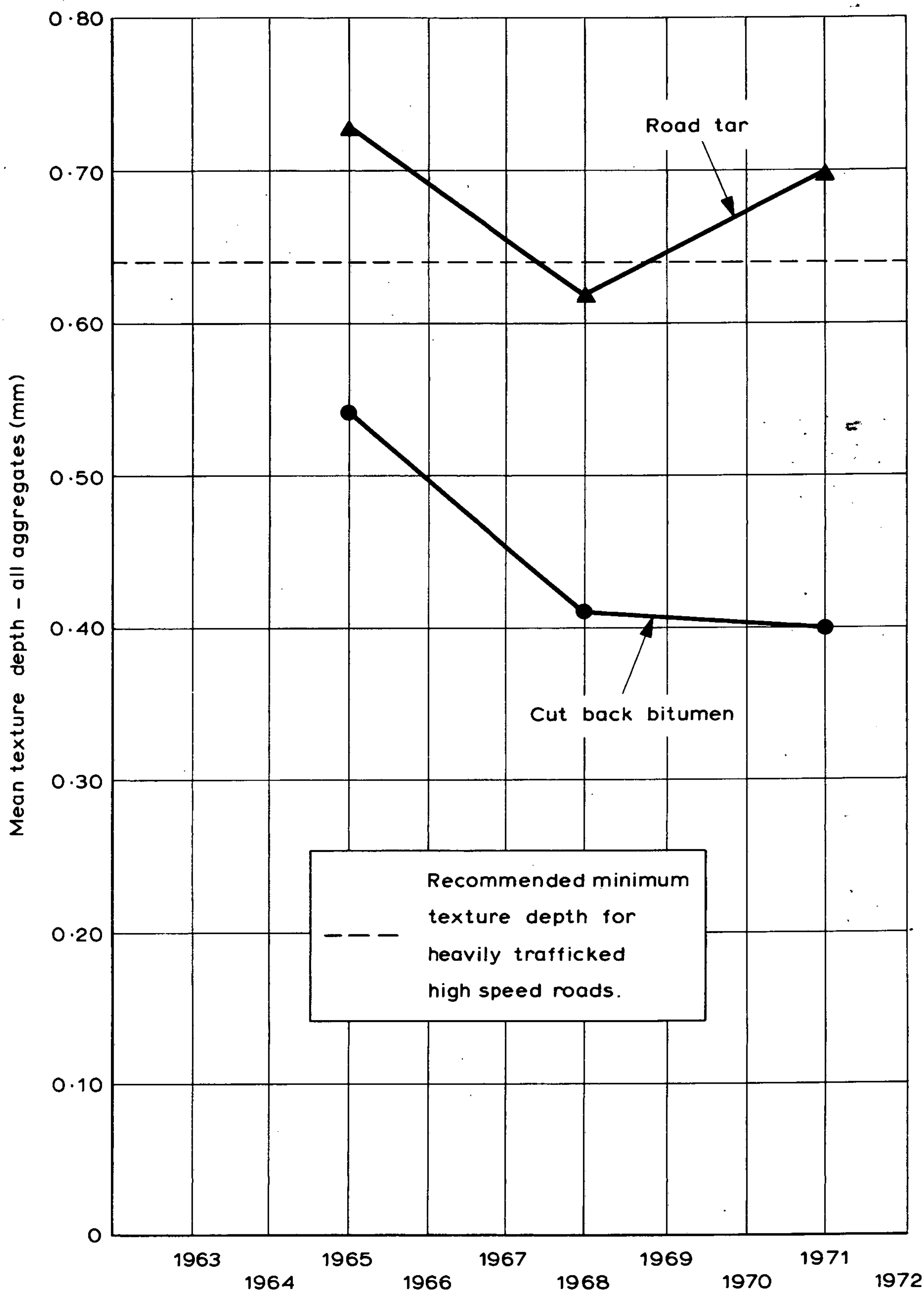


Fig. 1. YEARLY AVERAGE TEXTURE DEPTHS OF SURFACE DRESSINGS USING ROAD TAR AND CUT-BACK BITUMEN BINDERS - A30 BLACKBUSHE HANTS

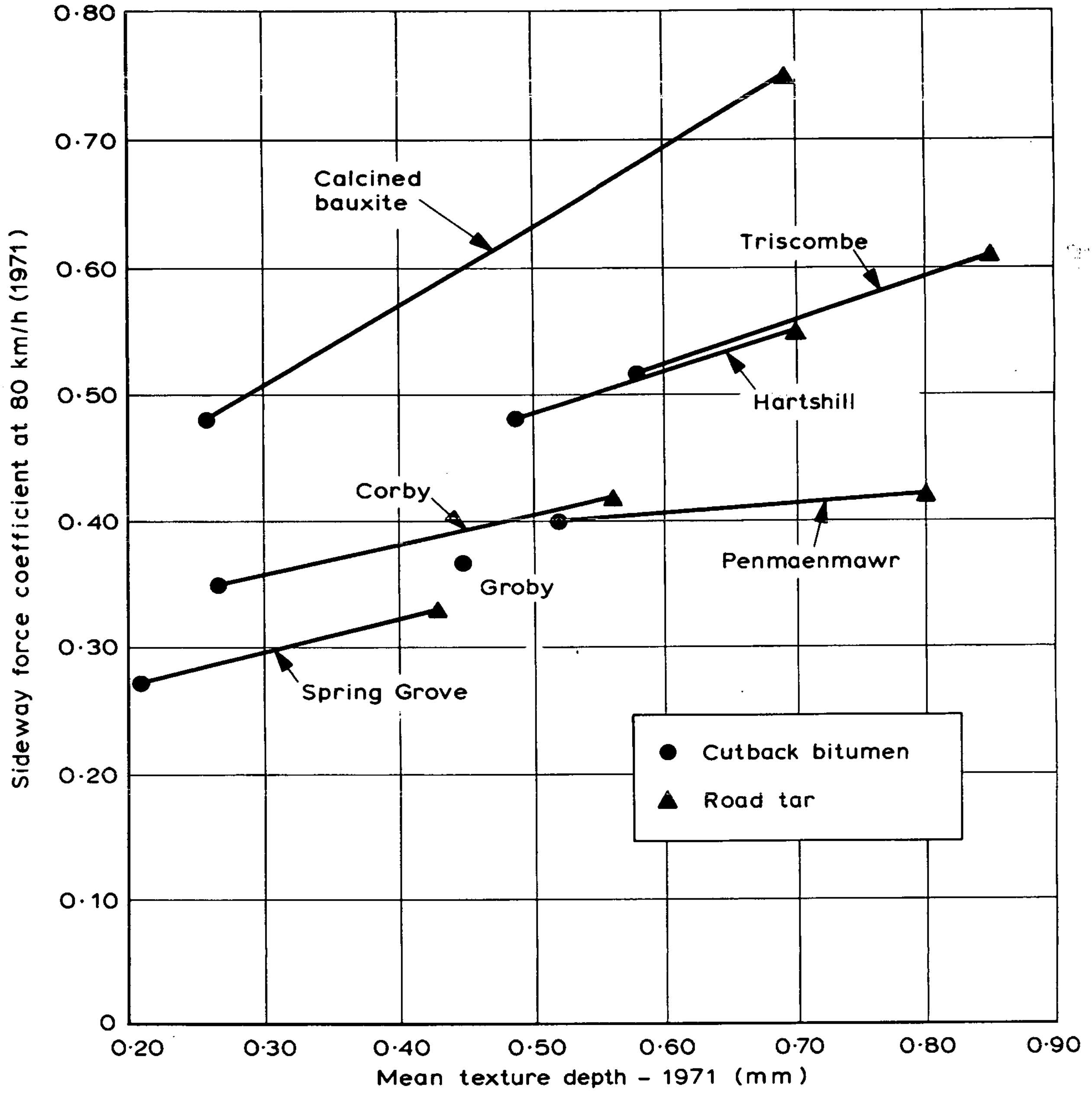
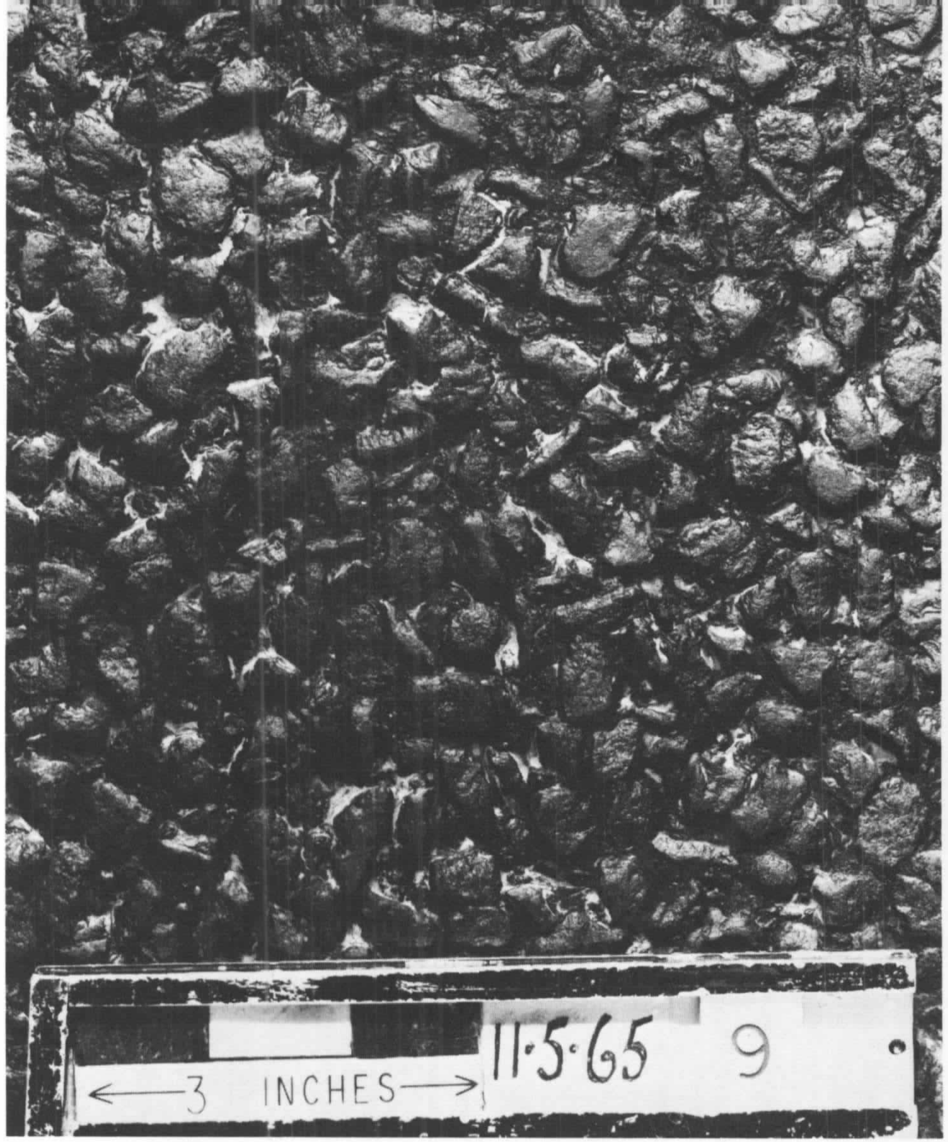
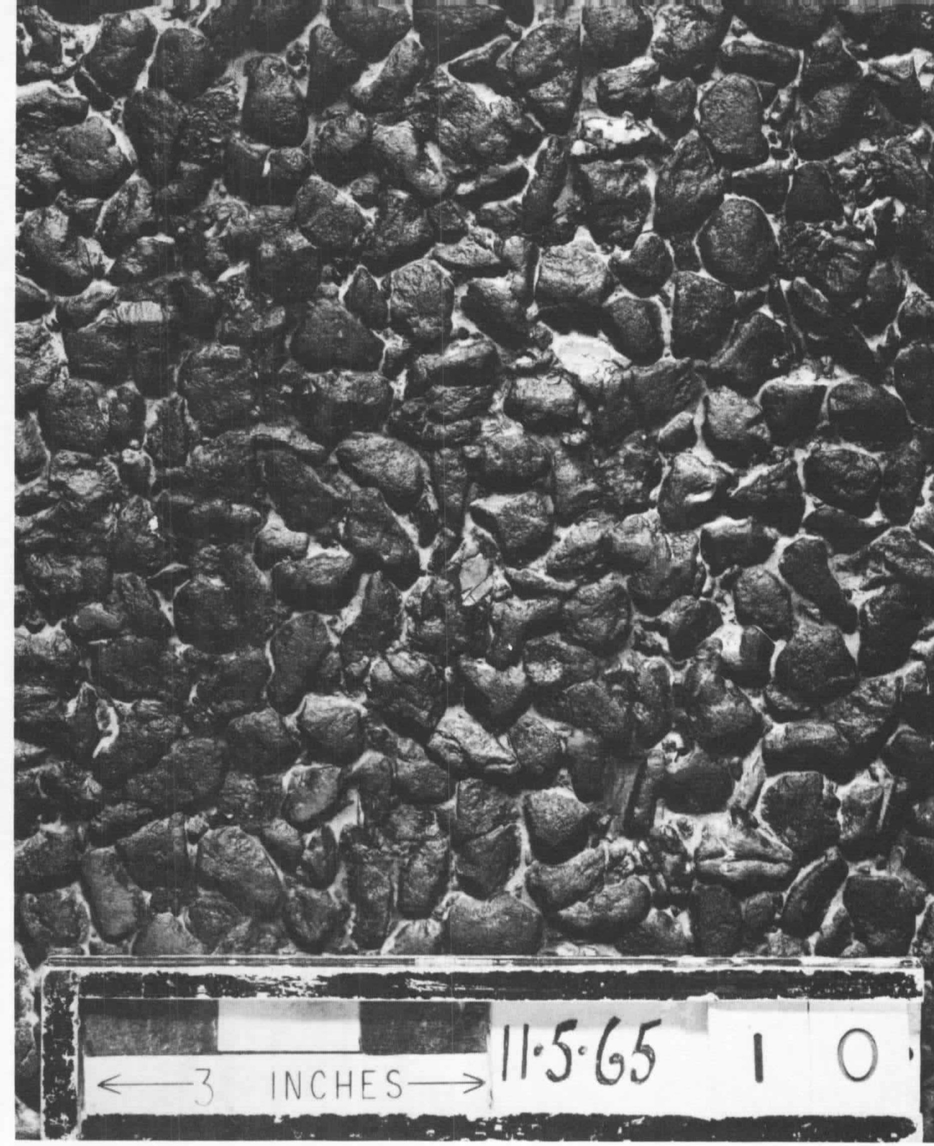


Fig. 2. EFFECT OF BINDER TYPE ON TEXTURE DEPTH AND RESISTANCE TO SKIDDING AT 80 km/h



Neg No H2509/65

Cut-back bitumen binder
Texture depth: 0.81 mm

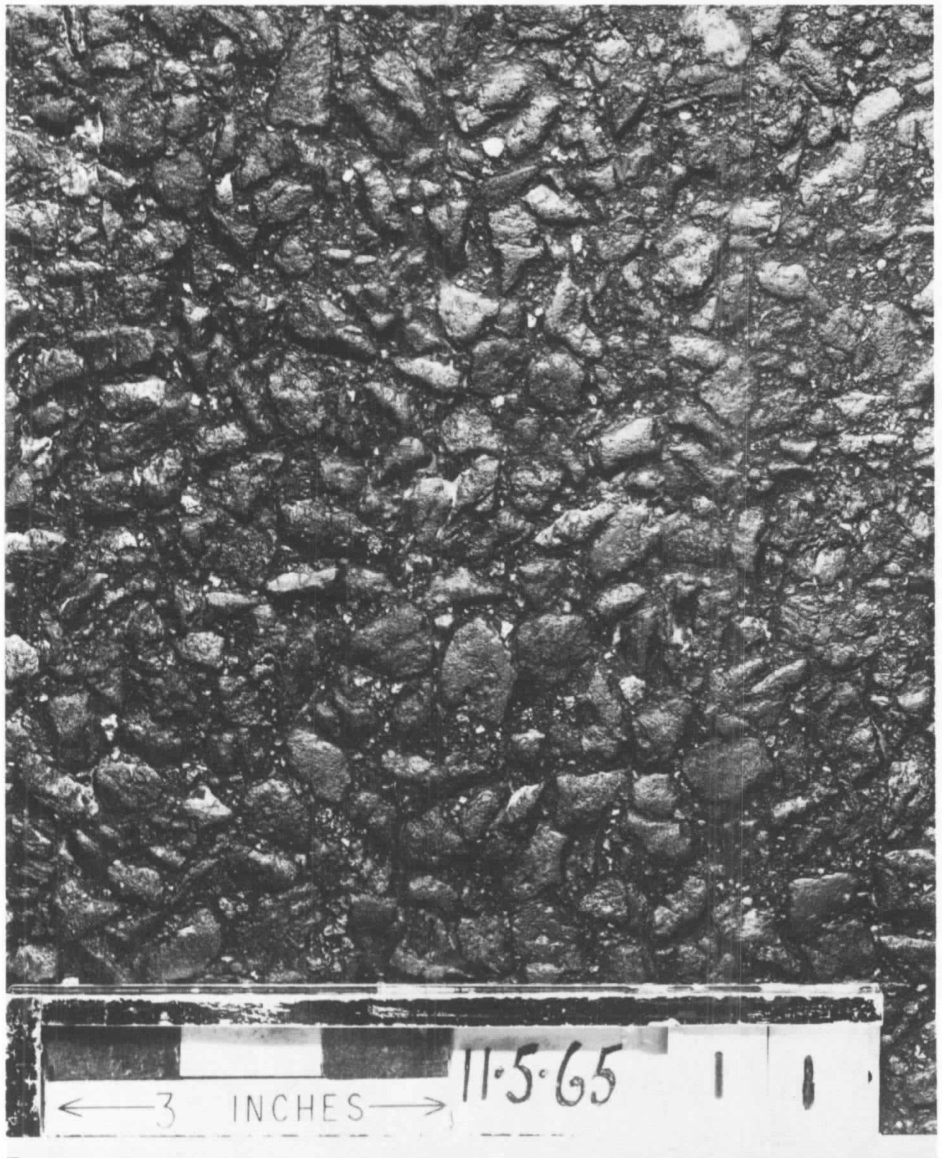


Neg No H2511/65

Tar binder
Texture depth: 1.14 mm

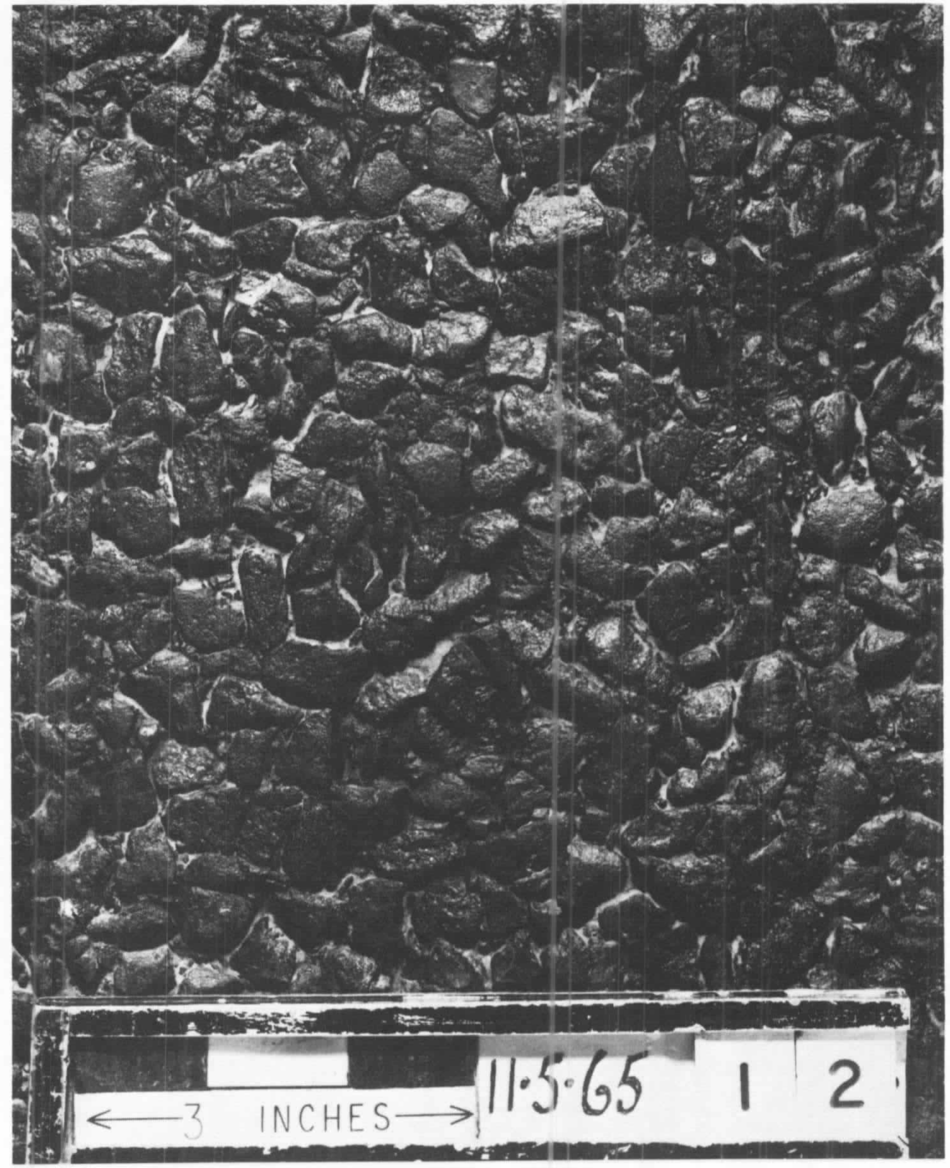
PLATE 1

Differences after 3 yrs in surface texture of surface dressings made with Triscombe sandstone aggregate
A30 Blackbushe, Hants



Neg No H2507/65

Cut-back bitumen binder
Texture depth: 0.56 mm



Neg No H2512/65

Tar binder
Texture depth: 0.81 mm

PLATE 2

Differences after 3 yrs in surface texture of surface dressings made with Hartshill quartzite aggregate
A30 Blackbushe, Hants

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ABSTRACT

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It is concluded that improved performance is obtained if precautions are taken adequately to render the macadam substrate uniform before surface dressing. Throughout the lives of the dressings consistently greater texture depths have been maintained with tar binder than with cut-back bitumen. The tar sections also show higher resistance to skidding at 80 km/h than equivalent sections with cut-back bitumen; both binders have given dressings of good durability.

Recommendations are made for limits for aggregate abrasion and crushing values to be set to avoid excessive wear of the applied chippings under heavy traffic.

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