TRANSPORT and ROAD
RESEARCH LABORATORY
Department of the Environment
SUPPLEMENTARY REPORT 213UC

INTERIM REPORT OF THE WORKING PARTY ON THE SLIPPAGE OF ROLLED ASPHALT WEARING COURSES

Any views expressed in this Report are not necessarily those of the Department of the Environment

Highways Department
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INTERIM REPORT OF THE WORKING PARTY ON THE SLIPPAGE OF ROLLED ASPHALT WEARING COURSES

ABSTRACT

A Working Party was set up under the auspices of the Department of the Environment, The County Surveyors' Society and the Asphalt and Coated Macadam Association to determine the causes of failure of a number of rolled asphalt wearing courses by sliding relative to the basecourse; failures normally occurred shortly after the completion of the construction of new roads. Most of these failures were reported in the eastern part of the country from Nottinghamshire northwards as far as Aberdeen in Scotland.

The Report gives an analysis of the factors stated to be present in the 56 failures discussed; most failures are associated with wet-mix or dry bound macadam bases laid in winter and early spring, but many counties using wet-mix bases have reported no failures. An appendix shows the extent to which wet-mix road bases were used during the period 1970-74.

Recommendations are made about the use of wet-mix and dry bound macadam bases, and the manufacture and laying of rolled asphalt wearing courses. Recommendations are made about further investigations needed, including the possible relevance to failure of the structural condition of the road when the surfacing is laid, of the properties of the binder in relation to the laying conditions and of the importance of adhesion between wearing courses and basecourses.

The County Surveyors' Society was not able to agree with the main conclusions of the Report, and a rider to this effect has been added.

1. INTRODUCTION

A number of failures of rolled asphalt wearing courses have occurred shortly after the completion of (mainly) newly constructed roads. The wearing course has slipped relative to the basecourse and "tearing" has resulted. On some sites only one such "tear" has occurred, but on many, long lengths of road have been affected. The incidence of such failures appears to be increasing and the Working Party has been set up by the Department of the Environment, the County Surveyors' Society and the Asphalt and Coated Macadam Association to determine if possible the reasons for the failures and to recommend methods of preventing them. The British Quarrying and Slag Federation has also been represented on the Working Party. The composition of the Working Party is as follows:-

Mr J H Nicholas (Chairman)	TRRL
Dr D Croney	TRRL
Mr G F Salt	TRRL
Mr J C Jacobs (Secretary)	TRRL
Mr R Lober	DOE
Mr J J Stansfield	CSS
Mr C E Hingley	ACMA & BQSF
Dr K R Peattie	ACMA
Mr A Windmill	ACMA
Professor P S Pell	University of Nottingham

Other members of TRRL, of the CSS and of ACMA attend by invitation as necessary.

The present report is intended only as an interim measure, with the aim of initiating some action that may lead to a reduction in the incidence of failures. The evidence so far available is voluminous, incomplete and inconsistent in parts, and it is very difficult to arrive at any unassailable conclusions that are not self-evident or trite. Much of what follows is necessarily broad-brush and based on global figures. It is hoped that after further research and analysis of data, it will be possible to produce a report containing more positive recommendations for measures to prevent failures occurring.

2. EXTENT OF THE PROBLEM

Individual failures can be serious and expensive, but the extent of the problem needs to be seen in perspective. Of the many jobs carried out over the past few years, 56 wearing course slippages have been reported up to the end of July 1974. Many of these involved only a small area of a given job, and even in Nottinghamshire, one of the Authorities most affected, the area of failure represents only about 10 per cent of the area of new road construction. On the other hand, the cost of remedial work can be considerable, and it is believed that the number of reported cases is probably increasing. Nevertheless, up to the present time, most counties report no failures of this type.

3. FACTORS AFFECTING FAILURE

Figs 1 to 6 give an analysis of the factors reported present in the 56 failures.

The factors that can be eliminated because they play only a minor part in the failures are:-

(a) type of basecourse material (whether coated macadam or rolled asphalt)

(b) use of tack coat.

The factors that appear at first sight to play a significant role are:

(a) geographical location

(b) season of construction of the road pavement

(c) type of road base

(d) type of binder used in the wearing course

Slippage occurs when the shear stress at the interface of the basecourse and wearing course becomes to great for the adhesion and the shear resistance of the rolled asphalt. The stiffness of all the layers below the surfacing is of importance in determining the deflection of the pavement; that of the road base is particularly important in determining the shear stress at the interface between the wearing course and the basecourse. Many deflection measurements of the road surface have been made; but the evidence produced is confusing, and the experts disagree on the interpretation. The conflicting evidence may be due to the fact that the available data stem from measurements made after failure, when the pavement could well be in a state different from that when failure was initiated. Further studies are in progress to clarify the issue.

3.1 *Geographical location*

The map shown in Fig 7 gives the locations of failures to date; and it will be seen that the majority of these have occurred in the eastern part of the country from Nottingham northwards as far as Aberdeen in Scotland. It can also be seen from the map, Fig 8, that nearly all the failures occurred in areas where a large percentage of wet-mix bases has been used. There are a few counties which have had no failures, although they have used large amounts of wet-mix.

3.2 *Season of construction of the road pavement*

Most of the failures (80 per cent), occurred on new roads where the pavement was constructed between October and the beginning of May, ie the period when climatic conditions normally

(a) are conducive to high moisture contents

(b) give maximum stiffness to the bituminous layers.

The onset of failure is most frequently observed during warm weather in the spring and summer.

3.3 *Type of roadbase*

(a) Slippage failures have occurred on different types of base (including old roads) but all except two failures reported on new construction have involved the use of either wet-mix or dry-bound granular roadbase. This figure is so extraordinary, that it is impossible not to draw the conclusion that the use of the particular wet-mix or dry-bound macadam was the dominant factor in the failure. On the other hand, it should be noted that 10 counties using a substantial amount of wet-mix construction have reported no failures, so that susceptibility to failure is not necessarily an inherent property of this form of base. This is indicated in Table 1, which lists the use of wet-mix for road bases by Authority, during the period 1970-74.

(b) Little information is available for the composition of the wet-mix or the dry-bound macadam bases involved in slippage failures. In the few instances for which figures are available, there is reason to suspect that the fines content of the wet-mix was high - possibly outside the specification.

(c) Most of the failures involved limestone wet-mix, the most commonly used aggregate, although instances involving igneous rock and slag are known. In view of the high proportion of limestone used in wet-mix, the number of failures involving this aggregate does not seem to be unduly high.

(d) Changes in the specification for wet-mix materials might be related to slippage failures, but there is no evidence either to prove or disprove this. From 1957 to 1963 when very large quantities of wet-mix were laid, the specification permitted 3-7 per cent passing the No 200 (75μm) British Standard sieve. The plasticity properties of this fraction were not specified. A relatively few cases were reported where instability developed during the compaction of wet-mix bases to this specification; and these appeared to occur where the percentage passing the 75μm sieve was at, or a little above, the 7 per cent value. Full-scale experimental use of wet-mix on public roads, however, suggested that higher strengths could be obtained if the percentage passing the 75μm sieve was in the range 7-10. The explanation for this probably lies in the wide variety of aggregates used in wet-mix, and their varying natural moisture contents. Generally speaking, a high fines content in combination with a moisure content at the top of the permitted range gives low strength, but the same fines content with a lower moisture content gives a high strength. It was further suspected that some supplies of wet-mix contained a small amount of plastic overburden material.

In 1963 the then Ministry of Transport changed the specification for wet-mix to reduce the percentage passing the 75μm sieve to 0-2, with a proviso that if the material passing this sieve could be shown to be non-plastic, it could be increased to a maximum of 10 per cent.

This change which began to affect contracts in the early part of 1964, caused considerable unrest in the aggregate industry. In particular, limestone fines passing the 75μm sieve were found to be plastic by their nature, and the limitation of the fines content was said (by the industry), to place them in an impossible situation. The plasticity requirement was waived in a number of cases with which the TRRL was concerned, but the Laboratory is in no position to say how general this was over the period 1964-69.

In 1968, when the 1969 revision of the Ministry of Transport specification was under consideration, the Ministry, with the support of the Laboratory, decided to remove the plasticity requirement placed on the fraction passing the 75μm sieve; and to permit this fraction to rise to 8 per cent. At the same time, the moisture content requirements were linked to a compaction test to overcome instability due to high moisture contents. This change would have begun to influence contracts let in 1969.

The 1957 specification called for compaction to refusal by an 8-10 ton roller. The 1963 specification also permitted the use of a vibratory tandem roller in excess of 3 tons, compaction to 5 per cent air voids being required. This latter requirement was not possible with some gradings and moisture contents within the specification; and in 1969 a method specification was substituted which, in effect, required 8-16 passes of an 8-10 roller depending on layer thickness.

3.4 *Type of binder used in the wearing course*

There is no evidence to indicate that the proportioning of the constituents of the wearing course is at fault. Over 70 per cent of the failures involved wearing course containing pitch-bitumen. Nevertheless, a significant number (5) of failures occurred with lake-asphalt/bitumen blends and 4 involved refinery bitumen. As the binder market for rolled asphalt wearing course is currently dominated by pitch-bitumen, the proportion of failures involving this binder does not seem unduly high, and cannot therefore, be regarded as statistically significant; although it seems possible that it may be a contributory factor, as it is known

(a) that pitch-bitumen and TLA/bitumen blends tend to harden more readily than refinery bitumen, particularly in winter-working conditions and

(b) that changes in specification for pitch-bitumen referred to below have coincided with the sudden awareness of slippage failures.

Originally pitch-bitumens from vertical retort crude sources were used, but in 1971 the specification was changed to pitches based on the carbonisation of coal at or above a temperature of 600°C, or by blending pitches from such sources.

While therefore the type of binder may play a part in the failure, it is thought that it can be only a minor part.

4. CONCLUSION

In the present state of knowledge, it seems reasonable to conclude that most failures are caused by a reduced stiffness when wet-mix or dry-bound granular roadbases of possibly dubious composition and/or construction are laid in the winter and early spring. It then only needs one or two other factors to be slightly "off-centre", to a degree which would not normally give trouble, for failure to occur.

5. RECOMMENDATIONS

The interim recommendation is therefore, that where wet-mix macadam or dry-bound macadam is used, the composition should be thoroughly checked both for grading and for moisture content to ensure it is within specification. Adequate compaction of the wet-mix or dry-bound material should

be ensured, particularly in the wheelpaths and near the sides of the carriageway. Every precaution should be taken to prevent the roadbase wetting-up after laying, eg by quick overlaying with basecourse material, or when this is impossible, by surface dressing. Precautions should also be taken to minimize hardening of the binder in the wearing course during manufacture and laying; the maximum storage temperatures and times, and maximum mixing temperatures should be strictly observed.

Further study of jobs currently being constructed is recommended to see whether

(a) the precautions for wet-mix given above produce a significant improvement

(b) improved compaction of wet-mix produces an improvement

(c) early-life deflection, layer stiffness and surface curvature can be correlated with incidence of failure

(d) the role of the nature and handling of the binder, and the conditions of laying of the wearing course can be clarified.

(e) the degree of adhesion between the wearing course and basecourse can be related to subsequent failure and/or to any factors such as those in 5 above.

6. COUNTY SURVEYORS' SOCIETY RIDER TO THE REPORT

The County Surveyors' Society feels that in the present state of knowledge when so many other factors remain to be investigated, the conclusion in the Report places at this stage undue bias on the use of wet mix bases.

The Society appreciates that the Report is of an interim nature and based on limited research, but whilst there has been some investigation of the possible contribution of wet mix bases to slippage failures, other factors have not been investigated to the same depth, or to a stage where they can be considered to have no contributory effect.

While the evidence to date shows that asphalt slippages can occur over a suspect wet mix base, the significant number of failures on other types of base and overlay, together with the growth in the number of failures over recent years, suggests that other factors play a significant role.

It is therefore with regret that the Society is unable to endorse the Report as presented.

7. ACKNOWLEDGEMENT

This Report was prepared by the Highways Department of the Transport and Road Research Laboratory.

TABLE 1

The use of wet-mix road bases during 1970-74

Authority	Area of wet-mix laid 1970-74 (m^2)	Percentage of wet-mix of total road base laid	Main type of aggregate used in wet-mix	Number of contracts with reported slippage failures
ENGLAND				
Metropolitan Counties				
Greater Manchester	No information			0
Merseyside	No information			0
South Yorkshire	229,000	9	Limestone	1
Tyne and Wear	385,000	70 approx	Limestone	0
West Midlands	10,000	4	Limestone	0
West Yorkshire	54,000	14 (Trunk Roads)	Limestone	4
	12,000	0.3 (Motorway slip roads)		
Non-Metropolitan Counties				
Avon	161,000	15 approx	Limestone	0
Bedfordshire	8,300	5 approx	Slag	0
Berkshire	0	0		0
Buckinghamshire	7,000	<5	Limestone	0
Cambridgeshire	0	0		0
Cheshire	0	0		0
Cleveland	221,000	99	Limestone	6
Cornwall	0	0		0
Cumbria	50,000	10 approx	Limestone	0
Derbyshire	0	0		1
Devon	872,000	75		2
Dorset	136,000	98	Limestone	0
Durham	194,000	80	Limestone	10
East Sussex	0	0		0
Essex	0	0		0
Gloucestershire	0	0		0
Hampshire	50,000	<5	Limestone	0
Hereford & Worcester	360,000	95	Limestone	1
Hertfordshire	0	0		0
Humberside	265,500	50 approx	Limestone	1
Isle of Wight	No return			0
Kent	0	0		0
Lancashire	32,000 (county)	4	Limestone	0
	207,000 (NWRCU)	5	Limestone	0
Leicestershire	190,000	90	Limestone	0
Lincolnshire	No information			3?
Norfolk	0	0		0
North Yorkshire	328,000	75	Limestone	0
Northamptonshire	135,000	65	Granite	0
Northumberland	No return			6
Nottinghamshire	410,500	77	Limestone	5
Oxfordshire	No information			0
Salop	0	0		0
Somerset	63,000	5 approx	Limestone	0
Staffordshire	0	0		1
Suffolk	0	0		0
Surrey	0	0		0
Warwickshire	0	0		0
West Sussex	0	0		0
Wiltshire	No return			
WALES				
Clwyd	0	0		0
Dyfed	133,500	21	Limestone	0
Gwent	73,000	5 approx	-	0
Mid-Glamorgan	No information			0
South Glamorgan	0	0		0
West Glamorgan	0	0		0

TABLE 1 (Continued)

The use of wet-mix road bases during 1970-74

Authority	Area of wet-mix laid 1970-74 (m^2)	Percentage of wet-mix of total road base laid	Main type of aggregate used in wet-mix	Number of contracts with reported slippage failures
SCOTLAND				
Aberdeen	0	0		0
Angus	0	0		0
Argyll	0	0		0
Ayr	0	0		1
Banff	0	0		0
Berwickshire	0	0		0
Buteshire	No return			0
Caithness	32,500	41	Gritstone	0
Clackmannan	0	0		0
Dumfries	0	0		0
Dumbarton	0	0		0
East Lothian	0	0		0
Fife	106,500	77	Basalt	0
Inverness	0	0		0
Kincardine	0	0		0
Kirkcudbright	No return			0
Lanark	0	0		0
Midlothian	0	0		0
Moray and Nairn	0	0		0
Orkney	0	0		0
Peeblesshire	0	0		0
Perth and Kinross	116,000	25	Basalt	1
Renfrew	0	0		1
Ross and Cromarty	0	0		0
Roxburgh	0	0		0
Selkirk	0	0		0
Stirling	44,000	15	Basalt	0
Sutherland	0	0		0
West Lothian	0	0		0
Zetland	No return			0
NEW TOWNS, BOROUGHS AND PRIVATE ROADS				
Cumbernauld	No return			1
Glenrothes	No return			1
Livingston	No return			5
Aberdeen City	No return			3
Falkirk	No return			1
Cambridge private road	-			1
Total	4,885,000			

8. APPENDIX

Notes on the use of wet-mix roadbases during 1970-74 (Table 1)

Of the 68 counties who replied and were able to give information, 24 stated that they used wet-mix roadbases. As the total area of road construction is not known, it is not possible to calculate the proportion of wet-mix used nationally. If, however, it were to be assumed that equal areas are constructed by each county, then the average area of road constructed using wet-mix roadbase is nationally of the order of 12 per cent (say 10 per cent), of the total.

As a very rough estimate, some 5 to 6 million sq metres of wet-mix have been laid during 1970-74; of this area, the area of failure is approximately 100,000 sq metres ie about 2 per cent.

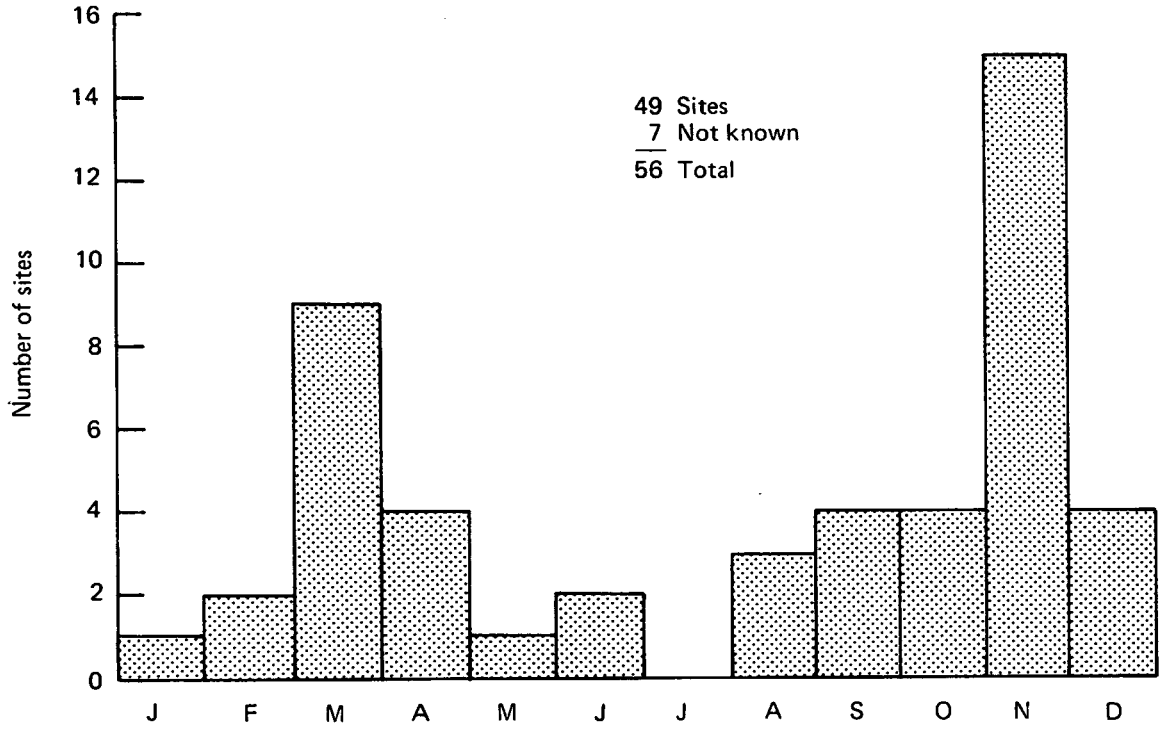

Fig. 1 MONTH WHEN WEARING COURSE WAS LAID

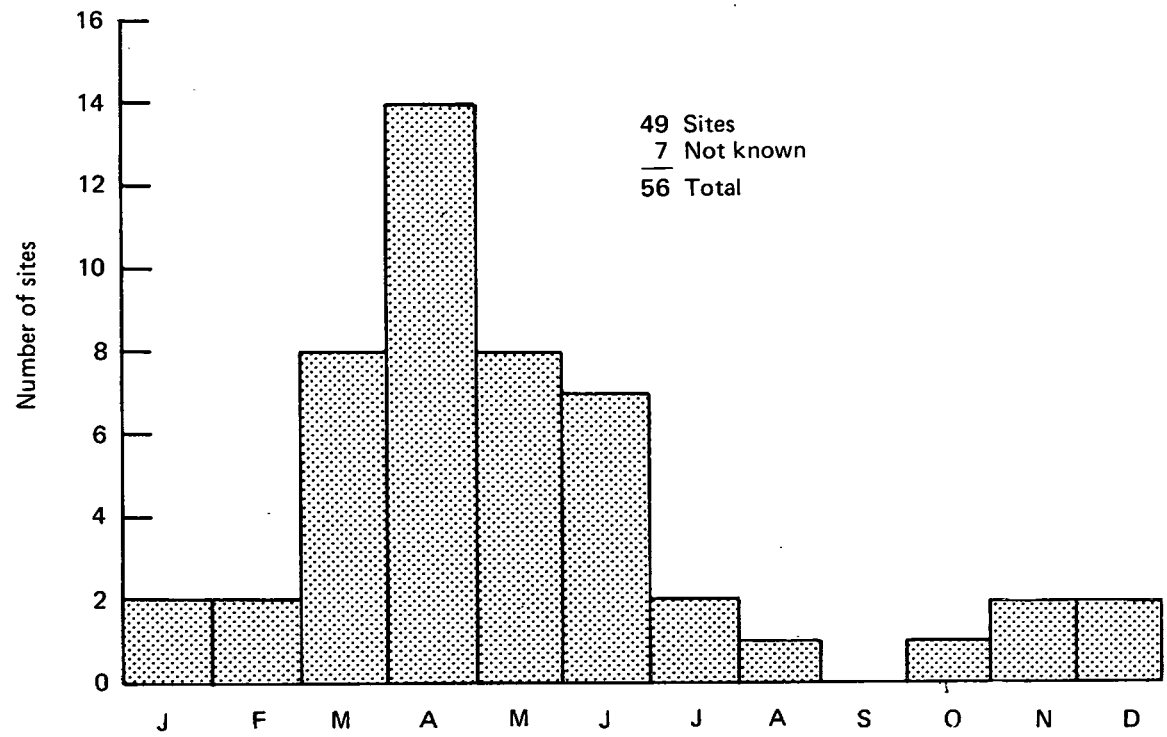

Fig. 2 MONTH WHEN FAILURE WAS FIRST OBSERVED

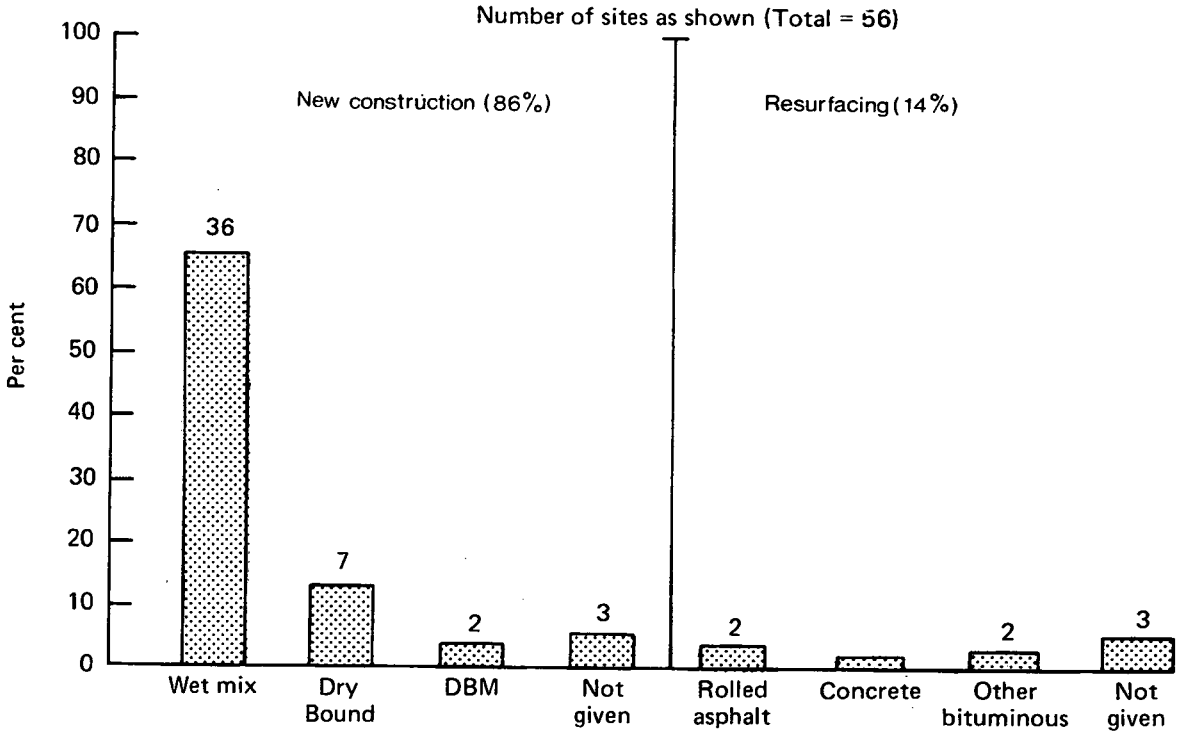

Fig. 3 TYPE OF ROAD BASE

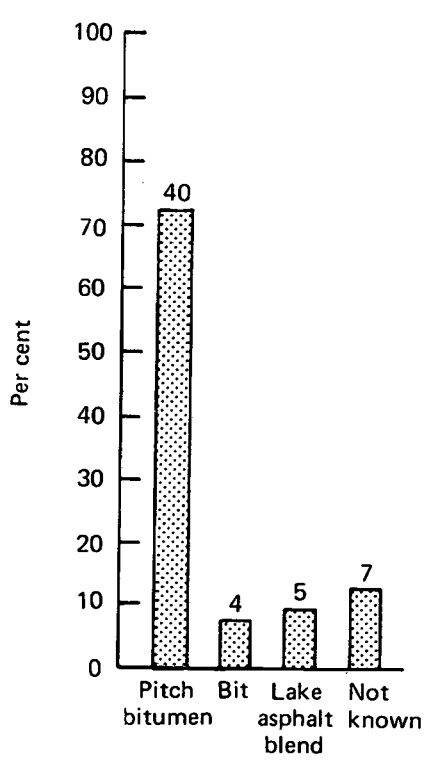

Fig. 4 TYPE OF BINDER USED IN WEARING COURSE

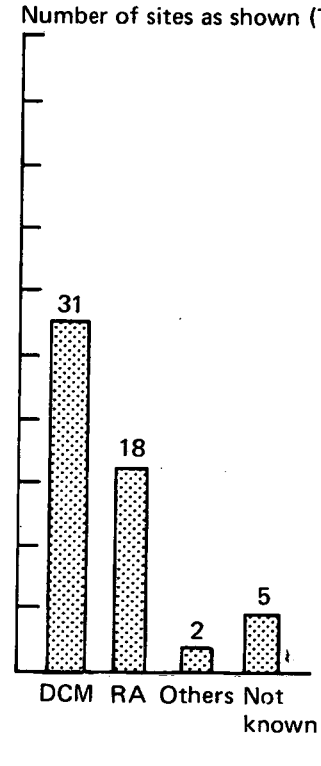

Fig. 5 TYPE OF BASECOURSE

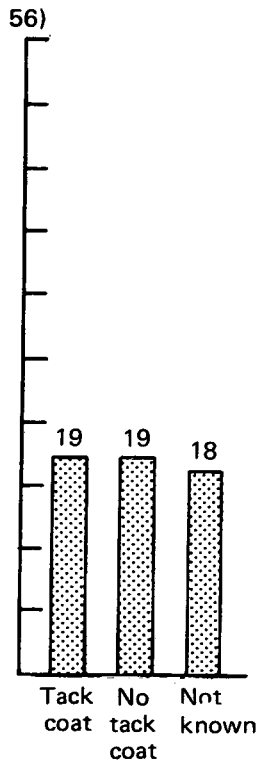

Fig. 6 USE OF TACK COAT

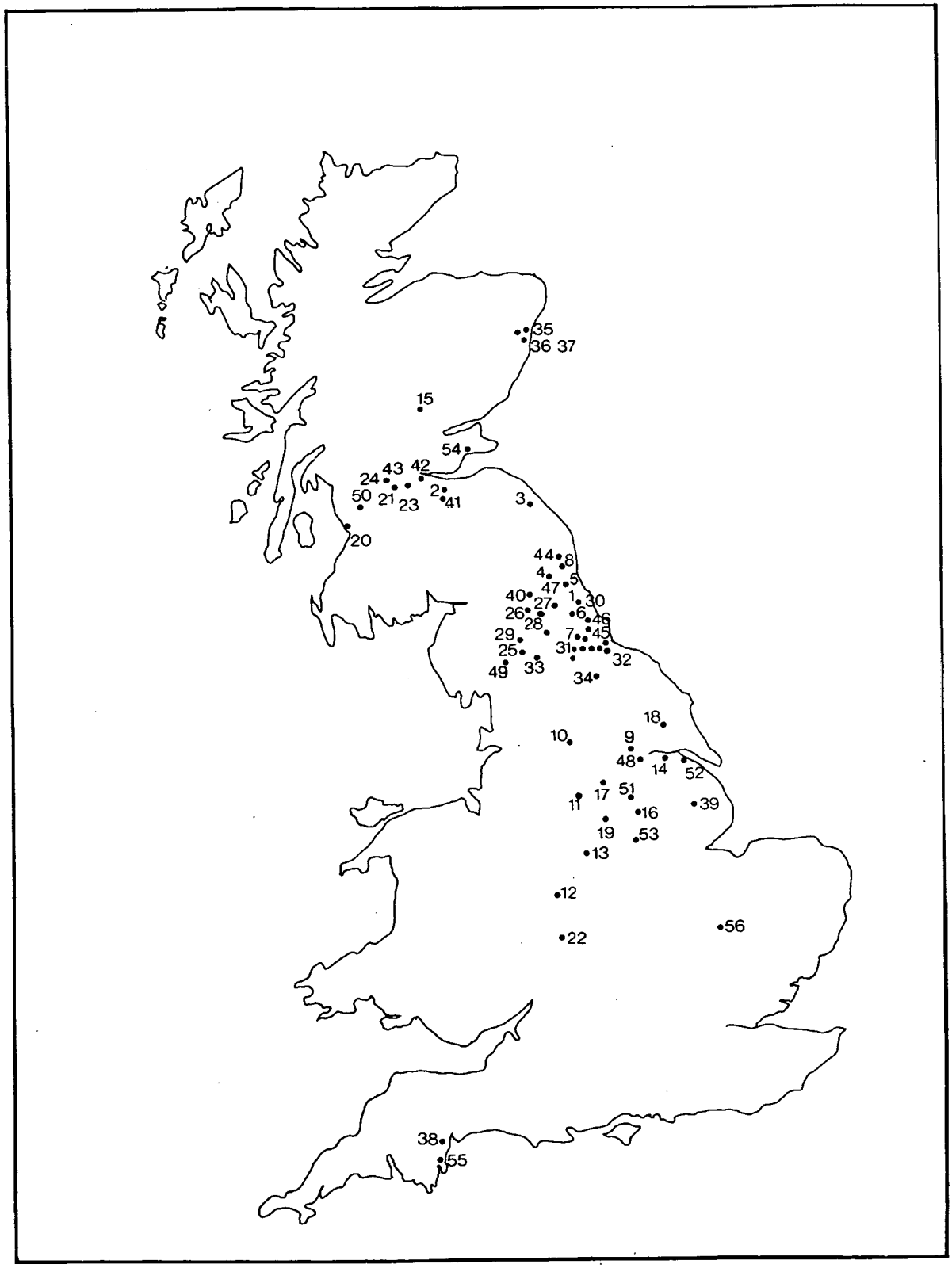

Fig. 7 LOCATION OF SITES WHERE FAILURES HAVE OCCURED

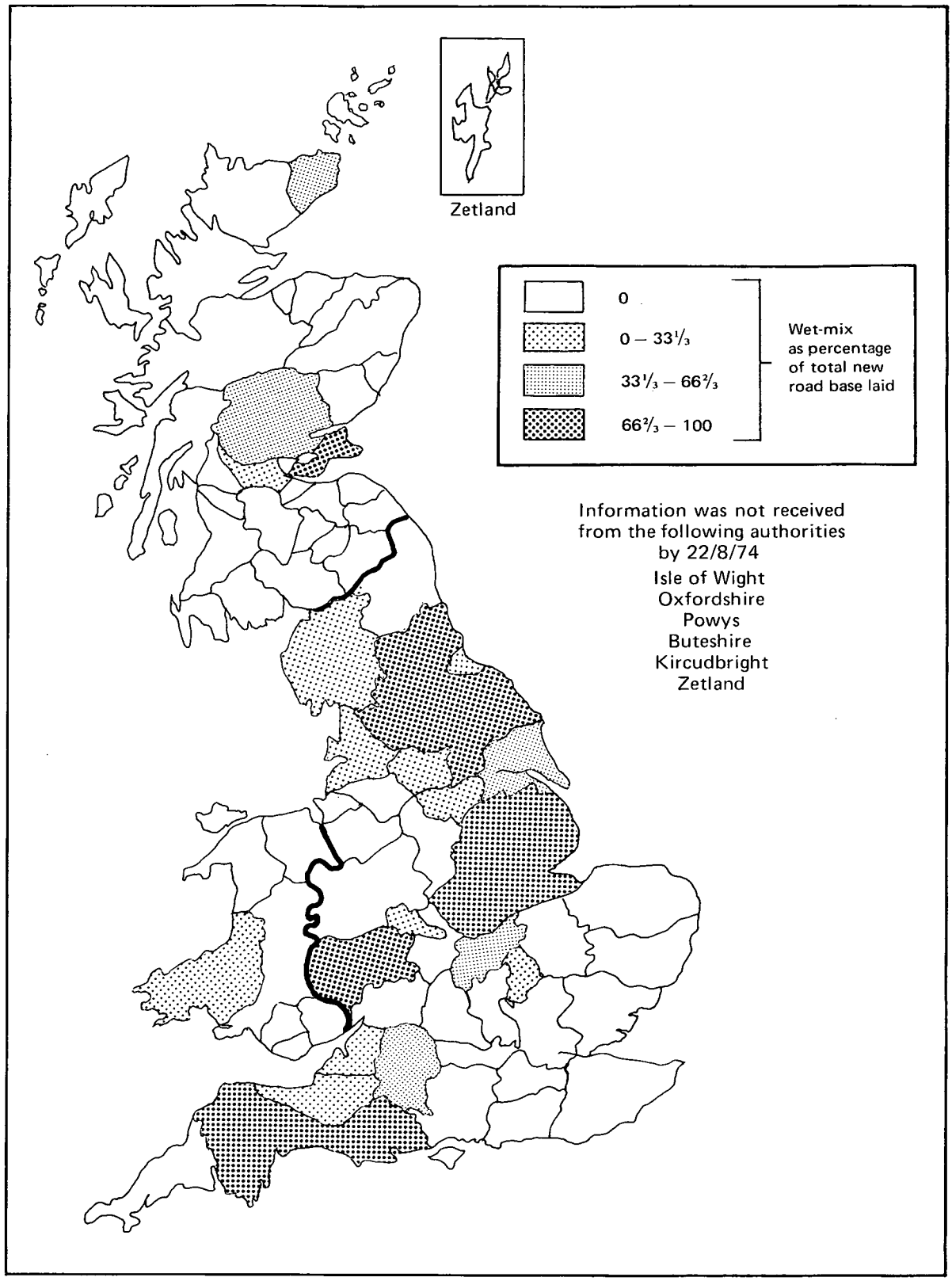

Fig. 8 THE USE OF WET-MIX AS ROADBASE (1970–1974)

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