TRANSPORT and ROAD
RESEARCH LABORATORY

Department of the Environment
Department of Transport

SUPPLEMENTARY REPORT 626

DEFORMATION RESISTANCE OF DENSE COATED MACADAMS: EFFECT OF COMPACTION AND BINDER CONTENT

by

D Leech and N W Selves

Pavement Design Division
Highways Department
Transport and Road Research Laboratory
Crowthorne, Berkshire
1980
ISSN 0305–1315

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DEFORMATION RESISTANCE OF DENSE COATED MACADAMS: EFFECT OF COMPACTION AND BINDER CONTENT

ABSTRACT

Better compaction achieved at little or no extra cost has been shown to improve the performance of dense roadbase and basecourse macadam. In the present work the deformation resistance of economically attractive coated macadams of low binder content has been measured for a range of aggregates representing the more important petrological types. Samples of material containing 40 mm maximum size aggregate and either 100 pen bitumen or 54 evt tar were cut from experimental pavements and their deformation resistance was measured in realistic tracking tests at 30°C.

The results for all materials emphasise the importance of good compaction to provide adequate deformation resistance. Gravel mixtures had less deformation resistance than crushed rock or slag materials. For a wide range of binder content, which includes that specified for roadbase and basecourse macadam, the deformation resistance of all materials is either improved or is not affected by reducing binder content. It appears particularly advantageous, from the point of view of deformation resistance, to reduce the binder content of basecourse macadam to equal that of roadbase macadam. Other parameters related to pavement performance are also being studied so that broader-based conclusions can be made concerning the possibility of reducing binder content.

1. INTRODUCTION

Previous work[1] has shown that there is considerable scope in the United Kingdom for improving the compaction and consequently the performance of dense roadbase and basecourse macadams. It is now also commonly believed that the current composition specification[2] for these materials can be improved. A joint programme of research has therefore been carried out between the Asphalt and Coated Macadam Association, the British Tar Industry Association, the Refined Bitumen Association and the Transport and Road Research Laboratory to improve the effectiveness of coated macadams in relation to their cost and in particular to investigate the potential of macadams of low binder content compacted to the maximum extent practicable.

This research has consisted of pilot-scale and laboratory studies to determine the compaction characteristics and performance of coated macadam made with a range of bitumen or tar contents combined with aggregates representing the more important petrological types. The performance properties considered were dynamic stiffness, which is a measure of load-spreading ability, resistance to fatigue cracking and deformation, and the deflection of the macadam and its foundation. This report describes that part of the programme of work which involved the measurement, under controlled laboratory conditions, of resistance to internal deformation.

In the UK a considerable proportion of the deformation measured at the surface of a pavement incorporating a bituminous roadbase and surfacing may be associated with internal deformation in these two layers. Thus the deformation characteristics of coated macadams are clearly important in determining the performance of flexible pavements. To measure the resistance to internal deformation of coated macadam, realistic tracking tests have been carried out on large slabs of material cut after laying and compaction with full-scale equipment. A total of 102 slabs covering four types of aggregate and including bitumen or tar binder have been tracked to determine the effect of binder-content, compaction and aggregate type on the resistance to deformation.

2. THE PNEUMATIC TYRED TRACKING MACHINE

The tracking machine is shown in Plate 1 and the test conditions used in this series of experiments are listed in Table 1.

TABLE 1

Test conditions

Specimen size	Length 800 mm Width 660 mm Depth 100 to 180 mm
Temperature	30 ± 1°C
Tyre type	7.50 x 16 – 12 ply
Tyre pressure	690 kN/m^2 (100 psi)
Tyre width (loaded)	132 mm
Wheel load	21 kN
Tracking speed	17 m/min
Lateral movement per cycle	3.4 mm
Total tracked width	432 mm
Test duration	1000 cycles

Each sample was mounted flush with the top of a steel frame and rigidly retained by a sand-cement mixture as shown in Figure 1. The frame retaining the bituminous sample was moved to and fro by a hydraulic ram under a pneumatic lorry tyre loaded to 21 kN and inflated to the recommended working pressure of 690 kN/m^2. The load applied to the sample, through the tyre, was measured periodically in-situ by replacing the sample with a portable weighbridge[3].

To simulate a distributed traffic pattern the wheel was moved 3.4 mm laterally across the sample after each double pass until it had completed the transverse pattern over a total covered width of 432 mm. The lateral movement was then reversed. To ensure that the wheel passes over the bituminous sample at a constant speed in a straight line, the lateral movements and acceleration and deceleration of the load wheel were carried out with the wheel moving on metal plates that extended from both ends of the sample frame. One complete pattern of lateral movements involved 160 reciprocal movements of the sample; this produced a uniform distribution of 80 passes in the central region of the sample as shown in Figure 1.

The machine was contained in a temperature-controlled cabinet kept at a temperature of 30°C. This temperature was selected as being typical of those achieved in roadbase layers of flexible roads in the UK during the hottest days in summer, when most deformation occurs. Temperatures within the test sample were measured using thermocouples at a depth of 60 mm.

Deformation in the central region of the slab was measured by six displacement transducers positioned as shown in Figure 1. The transducers were fixed to a reference beam that was mounted to give measurements for two cross-sections of the slab. Four of the transducers were located in the central region where there was a uniform distribution of passes, and one transducer on each side of the tracked area measured any movement of the untracked region relative to the frame. The average of each set of four readings in the central region was recorded after the wheel completed each transverse pattern, that is after 80 passes on the centre.

3. STRESS CONDITIONS IN THE TEST

In the tracking machine the bituminous materials, laid on a cement-bound base of higher elastic modulus, will be subject to compressive stresses only. In fact these stress conditions closely simulate those found in flexible pavements with bituminous courses laid on a strong cement bound roadbase of substantial thickness. In the tracking machine and in comparable composite roadbase structures, the calculated vertical stresses generated by a given wheel load in the bituminous materials are almost identical and the horizontal stresses, although influenced by the lateral restraint of the frame in the tracking machine, are in good agreement with calculated results over the tracked width of material. Because of this good correspondence of stresses this test is considered to be a valid indicator of the resistance to internal deformation, in practice, of bituminous material laid on strong cemented roadbases.

Where bituminous roadbases are laid on conventional granular sub-bases of lower stiffness it can be shown that traffic loading generates tensile stresses towards the interface between the two layers, stresses that are not simulated in the tracking machine. However, the limited evidence available suggests that more deformation takes place in the upper bituminous layers, ie where the temperatures are highest, and the stress regime primarily compressive, rather than in the lower roadbase where the tensile stress conditions are most conducive to the development of deformation but where temperatures are lower and the bituminous materials therefore innately more resistant to deformation. The tracking machine should, therefore, also give a reasonable indication of the relative resistance to internal deformation of dense bituminous roadbases laid on granular sub-bases. The percentage deformation observed in the materials tested was in the range 2 to 8 per cent of layer depth; this is not untypical of the deformation occurring for dense coated macadam in the road situation.

4. TEST PROGRAMME

The aggregates in the bituminous mixtures were chosen to represent the different types commonly used in the UK, and included crushed granite, crushed limestone, blast furnace slag, partially crushed flint gravel, and uncrushed quartzite gravel. All the aggregate gradings were close to the targets specified for 40 mm maximum-size roadbase and basecourse macadams[2]; the gravel mixtures contained 2 per cent by weight of Portland cement to meet the Specification requirement in relation to resistance to stripping. Two main binder types were investigated, 100 pen bitumen and 54 evt coke-oven tar, but a small amount of work was carried out with Coalite low-density tar. The materials tested covered a wide range of binder contents that included the values currently specified for roadbase and basecourse materials. The present specified values are given in Table 2.

TABLE 2

Binder contents currently specified for the roadbase and basecourse materials tested

Aggregate	Binder per cent by mass of total mixture (Tolerance in all cases ± 0.6 per cent)			
	Roadbase		Basecourse	
	Bitumen 100 pen	Tar 54 evt	Bitumen 100 pen	Tar 54 evt
Crushed rock, steel slag or electric furnace slag	3.5	4.3	4.5	5.0
Blast furnace slag Bulk density 1200 kg/m^3	4.8	6.0	6.2	6.6
Gravel	4.5	5.0	4.8	5.3

All the samples containing bitumen and some of those with tar were cut from material laid in the pilot-scale facility at TRRL[4] by a Blaw Knox PF 90 paver and compacted using a controlled number of passes of an 8.5 tonne deadweight tandem roller. The remainder of the tar samples, including the Coalite material, were mixed and compacted by the British Carbonization Research Association using a laboratory rolling-drum compactor. Limestone aggregate only was used in the manufacture of the tar samples.

Table 3 defines the composition of materials employed, the compactive efforts applied and the compaction achieved. The compaction results are the averages obtained from the two 150 mm diameter cores removed from each end of the sample before it was cut to shape for tracking. The compacted state is quoted in terms of percentage voids in the mineral aggregate (VMA) because this allows the levels attained for each aggregate to be directly compared[4]. Also shown in Table 3 is the VMA and deformation of the materials when compacted by normal practice.

In the present work deformation in the central area of the slab after 1,000 passes has been taken as a measure of resistance to deformation because this number of passes can be completed in one day of testing and it causes a realistic deformation which can be measured accurately. Figure 2 shows the typical development of rut depth measured from the initial surface level with increasing number of passes at the centre of a poorly compacted and a well compacted slab: well compacted material is clearly more resistant to deformation.

5. EFFECT OF COMPACTION AND MATERIAL COMPOSITION ON DEFORMATION RESISTANCE

5.1 *Crushed-rock aggregates with bitumen binder*

Figure 3 shows that there is a good correlation between deformation resistance and VMA for granite aggregate. Deformation resistance is largely dependent on the state of packing of the aggregate matrix, that is on the VMA and there appears to be no effect of binder content on deformation. The variation of deformation with level of compaction for limestone materials of different binder contents is shown in Figure 4. Although deformation is again dependent on compaction level binder content also has a significant effect upon deformation. There is clearly a separate relationship between deformation and VMA for each binder content, with material containing

TABLE 3

Composition of test samples and deformation results

Aggregate type	Binder		Experimental compaction		Typical compaction practice*	
	Type	(per cent) by wt.	No. of roller passes	Range of VMA (per cent)	VMA (per cent)	Deformation after 1000 passes (mm)
Croft granite	Bitumen	2.6	3, 9, 20, 40	13.7–20.1		
		3.0	3, 9, 25	14.9–20.1	18	5.5
		4.0	3, 9, 25	14.4–18.8		
		5.2	3, 9, 25	14.5–21.9		
Mendip limestone	Bitumen	2.4	3, 9, 24, 40	13.7–20.1	17	5.5
		3.4	3, 9, 24, 40	12.5–20.6	17	7.0
		4.6	3, 9, 24, 40	13.0–19.1	17	8.5
Mendip limestone	Coke oven tar	3.3	3, 9, 24, 40	12.8–20.9	17	5.5
		3.3	Rolling drum	11.6–16.0		
		4.1	3, 9, 24, 40	10.2–17.5	17	7.0
		4.3	Rolling drum	12.4–19.6		
Mendip limestone	Coalite tar	3.3	Rolling drum	11.2–12.9	Too few samples	
		4.3	Rolling drum	14.5	Too few samples	
Laleham flint gravel (partially crushed)	Bitumen	2.9	24, 40	13.4–16.3	17	8.0
		3.7	9, 24, 40	12.1–15.4	16	8.5
		4.9	9, 40	11.4–14.1	14	7.5
Branston quartzite gravel (uncrushed)	Bitumen	2.9	9, 25	14.1–15.0	Too few samples	
		3.4	3, 9, 25	12.6–15.4	Too few samples	
		5.0	9, 25	12.6–13.4	Too few samples	
Llanwern blast furnace slag	Bitumen	4.3	4, 8, 24, 40	17.5–25.1		
		4.9	4, 8, 24, 40	16.9–24.8	22	5.5
		6.3	4, 8, 24, 40	18.2–24.3		

* Values corresponding to 7 passes of a 8.5 tonne tandem deadweight roller; typical of those obtained in the critical wheel path zones of pavements by present compaction practice.

4.6 per cent binder deforming most and material with 2.4 per cent binder deforming least. Figure 4 also includes results obtained with granite for comparison with those obtained with limestone. There is little difference between the deformation in the granite materials and that for the limestone material containing 2.4 per cent bitumen. It is clear however that the richer limestone materials are less resistant to deformation.

Analysis of cores showed that the aggregate gradings of the three limestone materials were identical: neither were there any significant differences in the recovered penetration values of the bitumen. It was however noticeable that when the richer limestone mixes were tracked a layer of bitumen accumulated at the surface of the samples; Plates 2 and 3 show two slabs after tracking. During tracking, the materials had been further compacted, as shown in Figure 5, and, when the void content of the richer material approached zero, bitumen appeared at the surface. The deformation resistance of granite materials, which showed no flushing of bitumen to the surface, was unaffected by binder content.

Differences in aggregate properties may also contribute to the observed difference in the resistance to deformation of limestone and granite materials. For example since the water absorption of Croft granite is 1.0 per cent whereas that for Holcombe limestone is less than 0.3 per cent, there is a possibility that Croft granite can absorb more binder than Holcombe limestone. Further contributing factors may be differences in density, texture and chemical nature of the two aggregates.

5.2 *Crushed-rock aggregate and tar binder*

Figure 6 shows the variation of deformation with VMA for tar mixtures containing crushed Mendip limestones. The results obtained with bitumen samples containing limestone aggregate are also summarised in Figure 6 for comparison. Because of the difference between the densities of tar and bitumen, this comparison is made possible by giving in Figure 6 the tar content in terms of the percentage weight of bitumen which occupies the same volume. The results again show the dependence of resistance to deformation on the initial compacted state; greatest deformation generally occurs at high values of VMA and the deformation resistance of both materials decreases with increasing binder content. The viscosity of the tars was lower than that for the bitumen at 30^{o}C, which suggests that the deformation of the tarmacadams should be greater than that for the bitumen macadam at equal values of VMA and at equivalent binder volumes. However there is considerable scatter in the results for tar because more than one source of aggregate and binder was used and therefore it is difficult to draw any firm conclusion. The results presented in Figure 6 suggest that the deformation resistance of the tar material is broadly similar to that for the bitumen-bound macadam for binder contents equivalent on a volumetric basis.

5.3 *Blast-furnace slag and bitumen binder*

The relationship between deformation and VMA for blast furnace slag is shown in Figure 7. The deformation is linearly related to VMA and reduction in binder content has no apparent effect on resistance to deformation.

5.4 *Gravel aggregate and bitumen binder*

Although a few results with uncrushed quartzite gravel have been reported in Table 3 the main programme of work on gravels was performed with a partly crushed flint gravel and these results are given in Figure 8. The number of test samples was considerably smaller and the range of values of VMA was less than for other aggregates because of the relative ease with which gravel mixtures are compacted. However the results in Figure 8 are not incompatible with the evidence for all other materials that mixtures of low VMA are more deformation resistant. The reduction in deformation when binder content is lowered in the range of binder content studied is also in line with the behaviour of limestone aggregates.

The tests with uncrushed gravel were too few in number to establish the effect of binder content and compaction on deformation resistance. However for a given binder content and a given VMA the deformation of uncrushed-gravel mixtures after 1000 passes was consistently greater than that for partly crushed aggregates; the differences ranged from 30 to 100 per cent.

It was noticeable that, of the aggregate types studied, the gravel mixtures showed the greatest tendency to flow outwards from the tracked area. The material typically rose above its original level by 4 to 5 mm and the corresponding deformation in the central region was about 8 mm. In comparison, crushed-rock materials rose by less than 2 mm.

6. THE RELATIONSHIP BETWEEN DEFORMATION RESISTANCE AND COMPACTED STATE

All the data show the importance of improved compaction, which results in a marked improvement in deformation resistance irrespective of other variables. Figure 9 shows the relationship between deformation and VMA for the different aggregates tested: for those materials where deformation is also a function of binder content, the results shown relate to the lowest binder content studied. The absolute value of deformation for a given VMA clearly depends on the type of aggregate. Slag, which is angular, very rough and difficult to compact, has the greatest deformation resistance for a given VMA whereas partly crushed gravel, which is smooth textured and relatively easy to compact, has much less resistance; only uncrushed gravel, a more rounded aggregate has a lower resistance. However, the rate of change of deformation with VMA is approximately equal for all materials.

It is instructive to compare the deformation resistance of different materials in relation to their compacted state on a basis which takes into account that materials have different states of ultimate or refusal compaction. Thus, in Figure 10 the compaction level is given in terms of reducible VMA; this is defined as the difference between initial VMA and the VMA at the refusal condition measured using a vibratory hammer technique developed to measure refusal density on 150 mm diameter cores cut from dense coated macadam; a report on the test is in preparation. The refusal values of VMA for a particular aggregate are independent of binder content within the specification tolerances, provided that the voids are not completely filled with binder. When the results are plotted in terms of reducible VMA the relationship between deformation and compaction is shown to be independent of aggregate type except for the gravel which is seen to be much more deformable.

Seven passes of the roller is a compactive effort typical of that applied in the critical wheel path zones of the pavement, the zones that largely determine its structural performance[5]. In Table 3 the deformation at this level of compaction is seen to be about 5 mm for all granite and slag materials and for the limestone material of low binder content. In the case of limestone, an increase of binder content from 2.4 to 4.6 per cent resulted in an increase in deformation of about 60 per cent and the deformation resistance of all gravel materials was significantly less than that for crushed rock or slag. Therefore, when deformation resistance is related to compaction expressed either in terms of the VMA likely to be achieved in the wheel path zones or in terms of the VMA in excess of the VMA at refusal, the same conclusions can be drawn; the benefits of improved compaction are independent of the type of aggregate, except for gravel mixtures, and the binder content, provided that the material does not contain so much binder that it can attain or closely approach the zero void condition when trafficked.

7. APPLICATION OF RESULTS

In the UK coated macadams have been widely used as roadbase and basecourse materials on roads carrying medium and heavy traffic. The first aim of the present work was to investigate the potential for reducing the binder content of basecourse macadam by about one per cent to equal the currently specified binder content of dense roadbase macadam. This would make the two materials identical in composition and would give greater freedom in the selection of the thicknesses of layers in which the combined roadbase and basecourse layers could be constructed. There would be a cost advantage associated with any reduction in binder content and a second aim of this work was to examine the possibility of reducing the binder content of roadbase macadam by about 0.5 per cent. This might reduce the cost of the laid roadbase by about 4 per cent but the structural implications and the possibility of problems in laying and compacting the material also need detailed consideration.

7.1 *A single specification for roadbase and basecourse*

A reduction in binder content of the granite and slag materials below that specified for basecourse to a value equal to that specified for roadbase was found to have no effect on deformation resistance of these materials. On the other hand, for limestone aggregates, conventional roadbase material is more resistant to deformation than the basecourse material. There should therefore be no danger of reducing the deformation resistance of basecourse macadams if the binder contents were reduced to equal those of roadbase macadams and compaction levels were the same as those currently achieved. If basecourse and roadbase macadam were made identical in composition it would then be possible to increase the thickness of the basecourse layer with a corresponding reduction in thickness of roadbase. The current basecourse thickness is typically 60 mm. An increase in the thickness laid should result in better compaction because of greater heat retention during compaction and this in turn would produce a marked improvement in deformation resistance. Present results emphasise the desirability of attaining the maximum level of compaction.

Other performance parameters such as fatigue resistance and dynamic stiffness modulus are also affected by changes in binder content and in state of compaction. They have been studied and the results taken into consideration before advocating a reduction in binder content of basecourse macadam[6]. Clearly, however, deformation resistance is one of the most important performance parameters to be considered for basecourse material.

7.2 *Further reduction in binder content*

Again, the results of the test programme indicate that a reduction in binder content of roadbase macadam would improve or have no effect on deformation resistance. However, fatigue resistance and dynamic stiffness modulus are likely to be of greater relative importance than is the case for basecourse macadam and they may have greater influence in selecting the appropriate binder content. The possibility of problems in laying and compacting a roadbase of lower binder content has also been considered[7]. This work has shown that there is little scope for general reductions in binder content below those presently specified for roadbase macadam. However, there are design situations in which there is little danger of fatigue cracking taking place and where local aggregates can be mixed satisfactorily at low binder contents; some reduction in binder content is possible in these situations.

7.3 *Tarmacadams*

Although one aggregate only was investigated and the range of binder contents studied was limited, the results suggest that the conclusions drawn for bitumen macadams also apply for tarmacadams.

8. CONCLUSIONS

1. The resistance to deformation of all coated macadams tested increased with increasing compactive effort. The results emphasise the importance of improving compaction in the critical wheel path zones in order to provide better resistance to deformation, a particularly important requirement for heavily trafficked roads.

2. Irrespective of whether deformation is related to compaction expressed in terms of the voids in the mineral aggregate (VMA) usually achieved in the wheel path zones or in terms of the VMA in excess of the VMA-at-refusal, materials containing slag and crushed rock aggregate give similar performance provided that the material does not contain so much binder that it approaches the zero void condition when trafficked. All gravel mixtures had less resistance to deformation than crushed rock or slag materials, but the rate of change of resistance with VMA was shown to be similar for all materials.

3. The deformation resistance of all materials is either improved, or is not affected, by reducing the binder content, for a range of binder content greater than that covered by the existing specification. From the point of view of deformation resistance it appears particularly advantageous to reduce the binder content of basecourse macadam to equal that of roadbase macadam. The two courses can then be considered as one and this would permit the use of combined layers of greater thickness than the 60 mm thickness of the conventional basecourse. The thicker layers would be easier to compact and their deformation resistance improved.

9. ACKNOWLEDGEMENTS

The work described in this Report was carried out in the Pavement Design Division (Division Head: Mr J Porter) of the Highways Department of TRRL and forms part of the programme of co-operative research between the Asphalt and Coated Macadam Association, the British Tar Industry Association, the Refined Bitumen Association, and the Transport and Road Research Laboratory. The assistance of the British Carbonization Research Association in preparing some of the tar samples is gratefully acknowledged.

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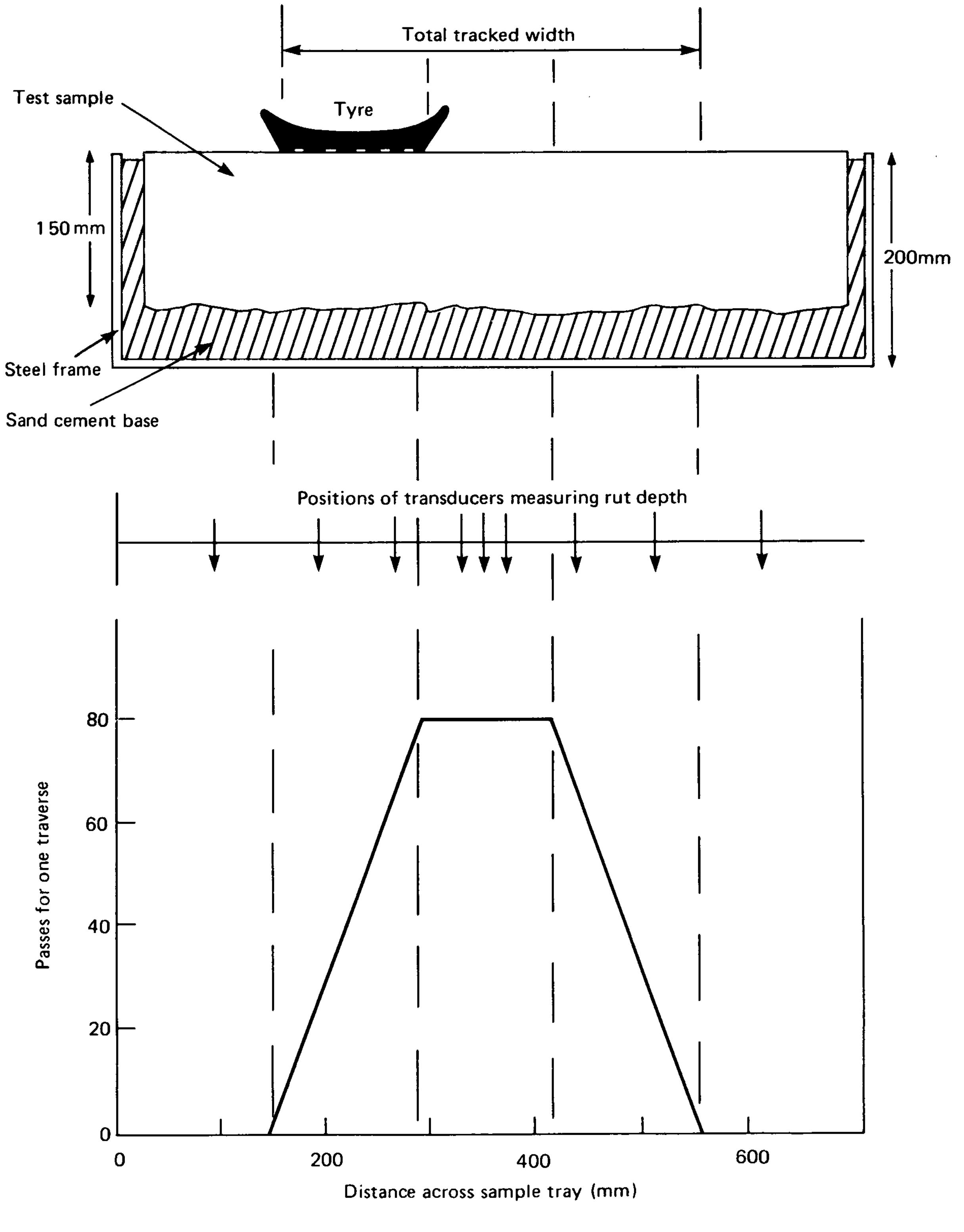

Fig. 1 CROSS SECTION OF TEST SAMPLE AND DISTRIBUTION OF WHEEL PASSES

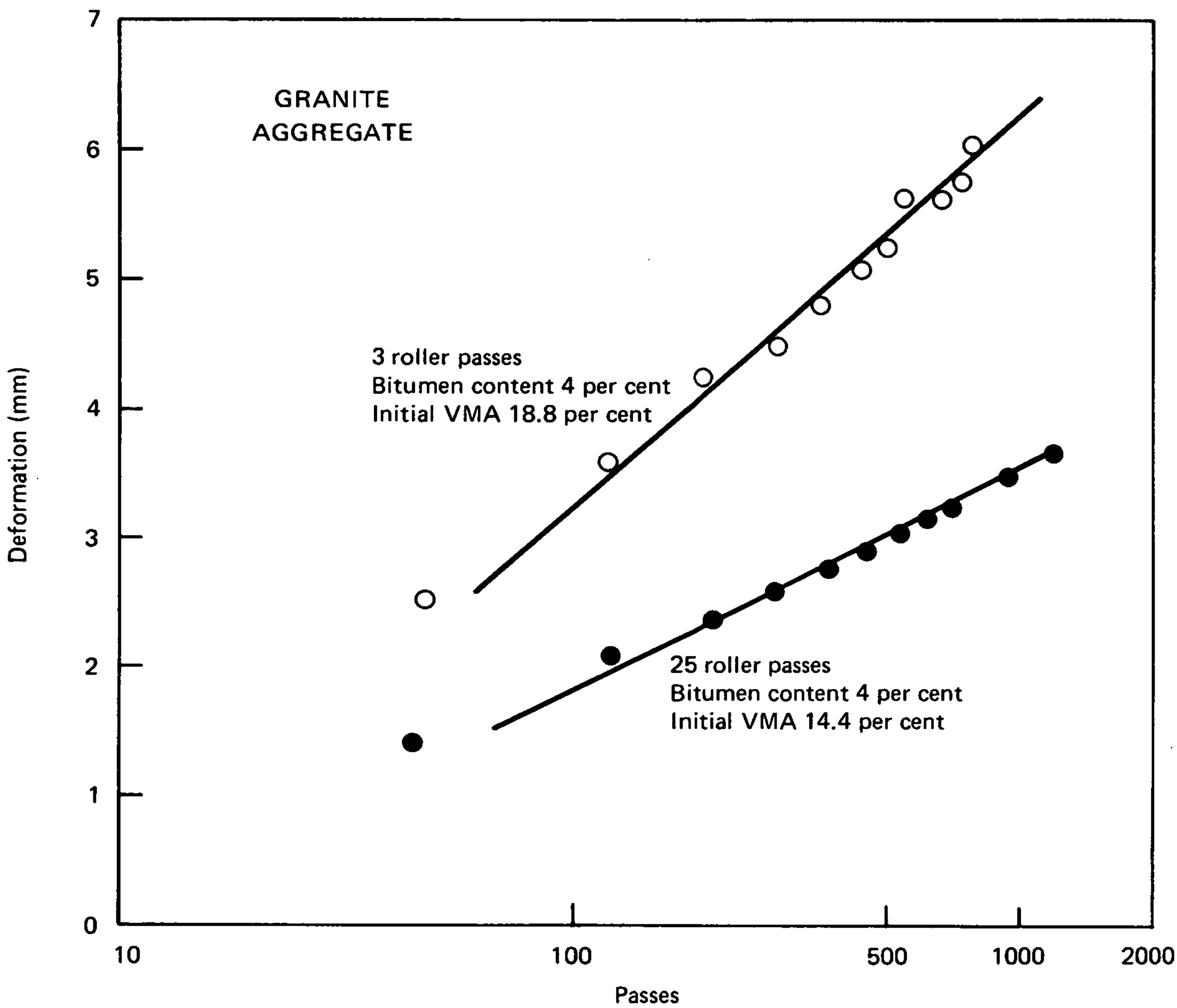

Fig.2 VARIATION OF DEFORMATION WITH LOGARITHM OF PASSES

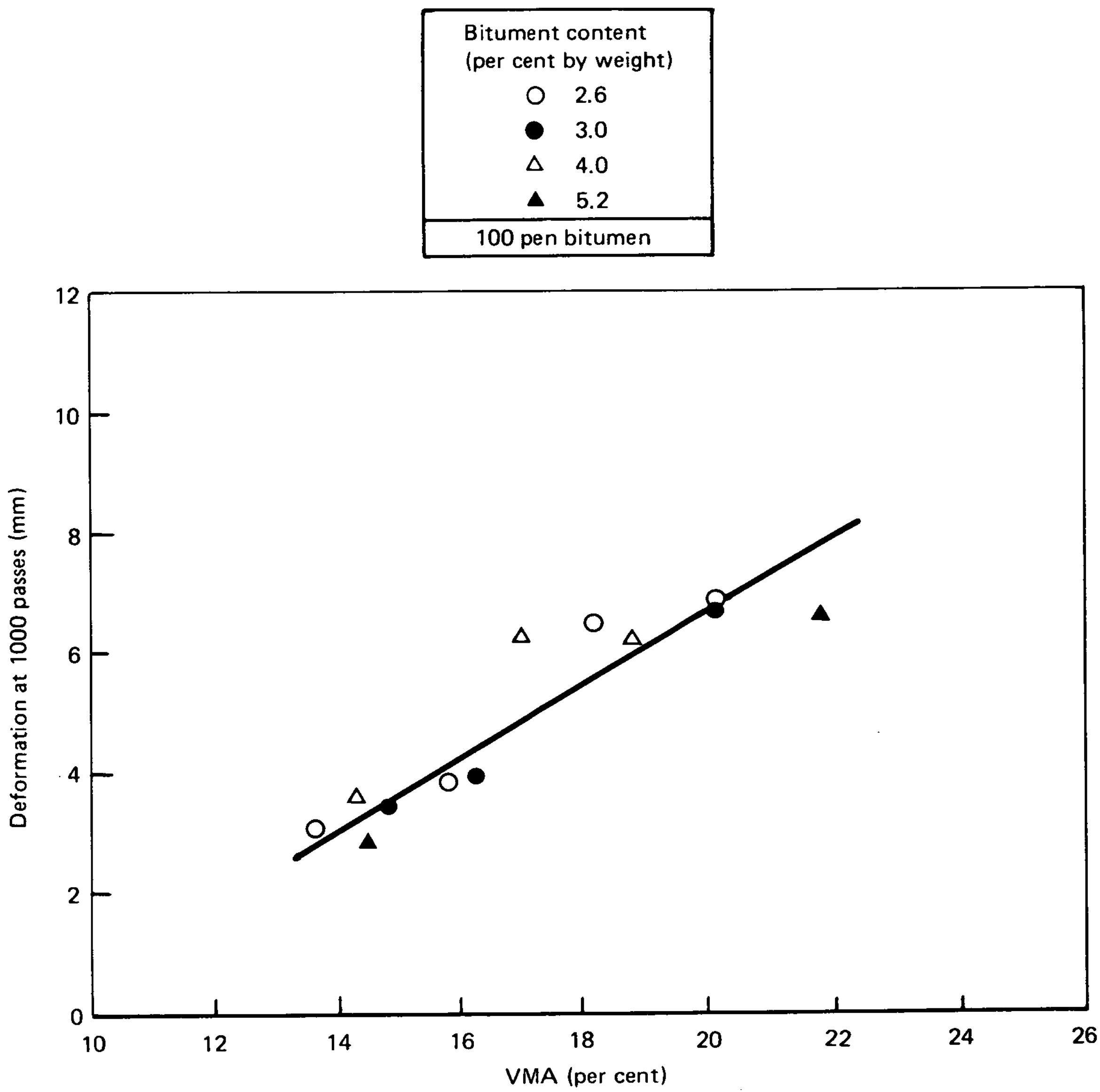

Fig. 3 VARIATION OF DEFORMATION WITH COMPACTION FOR GRANITE MATERIALS

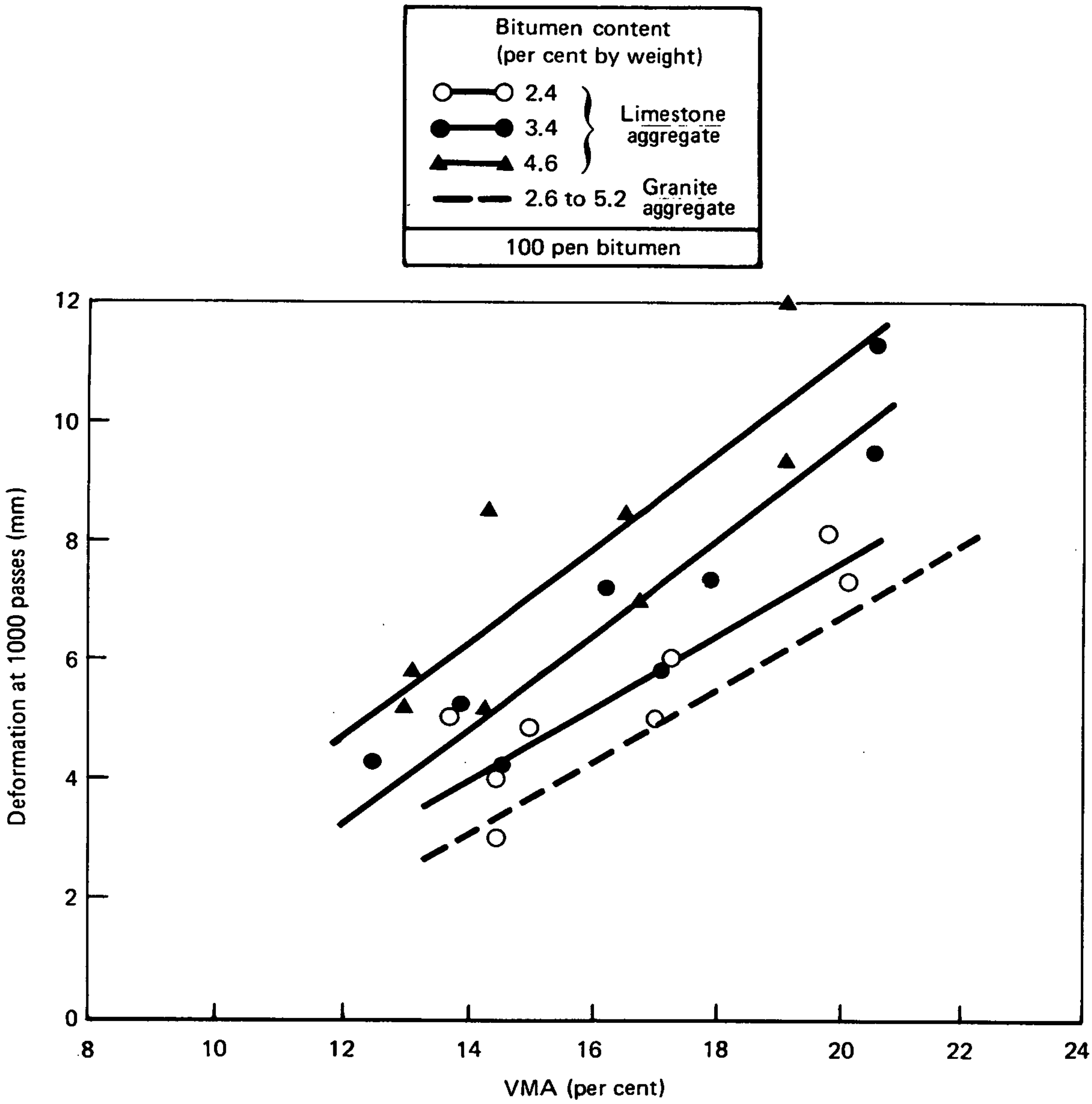

Fig. 4 VARIATION OF DEFORMATION WITH COMPACTION FOR CRUSHED ROCK MATERIALS

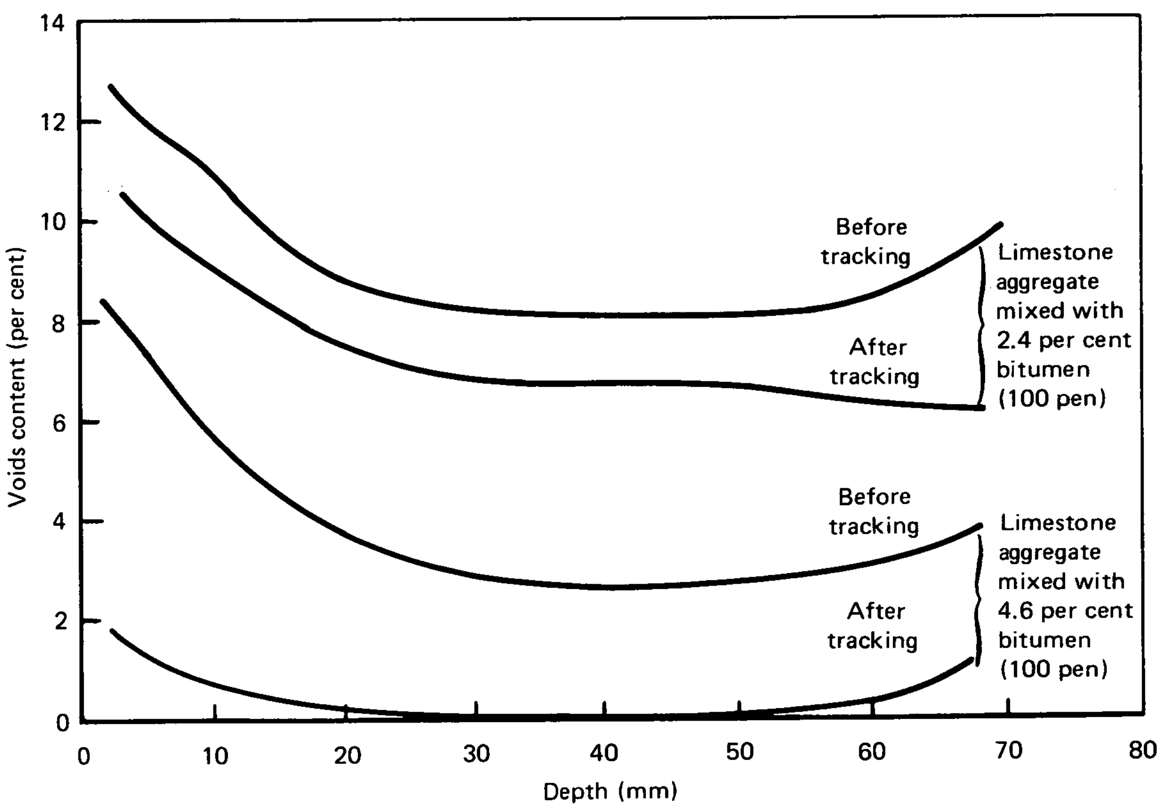

Fig. 5 VARIATION OF COMPACTION WITH DEPTH BEFORE AND AFTER TRACKING

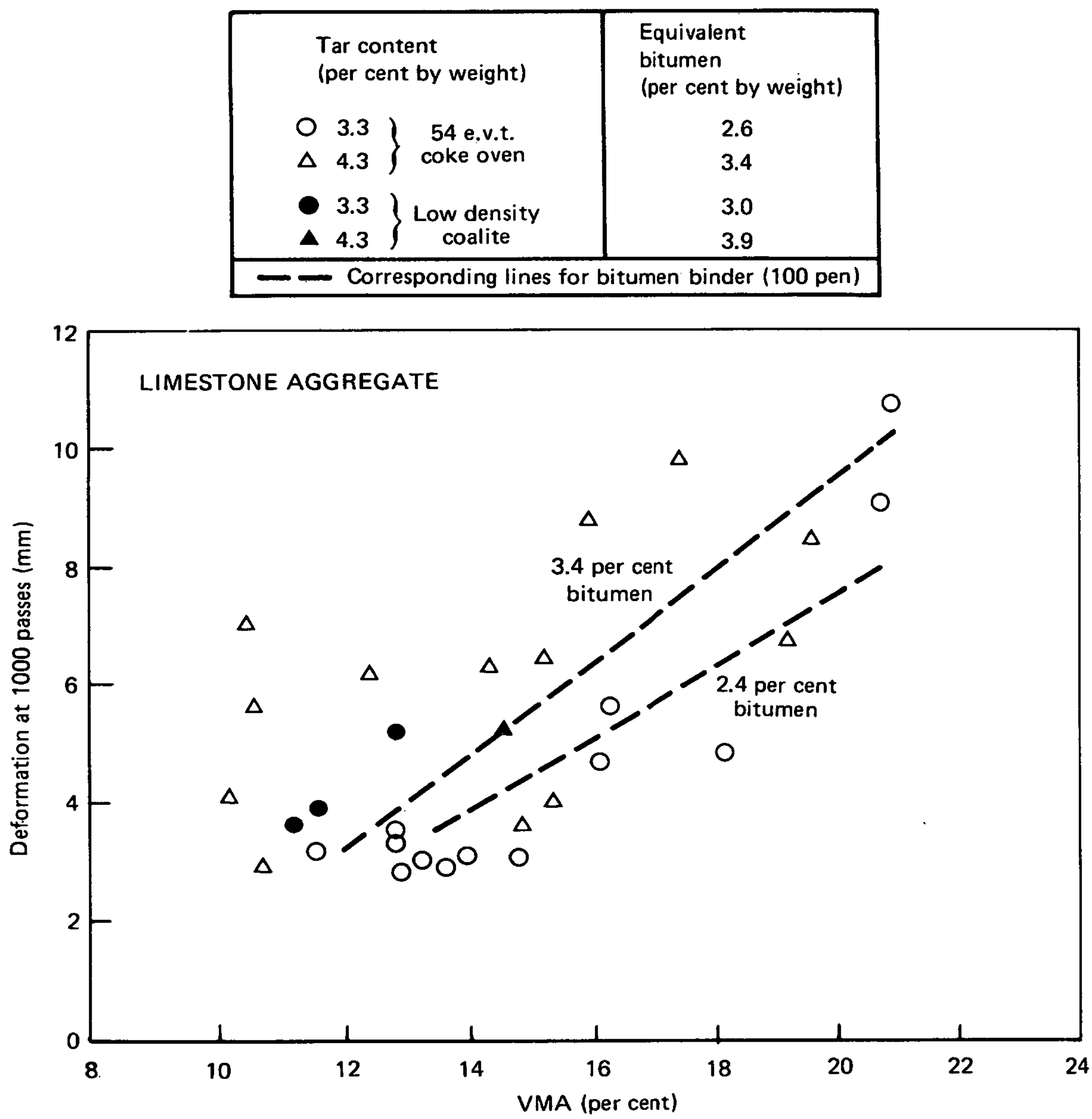

Fig. 6 VARIATION OF DEFORMATION WITH COMPACTION FOR LIMESTONE MATERIALS

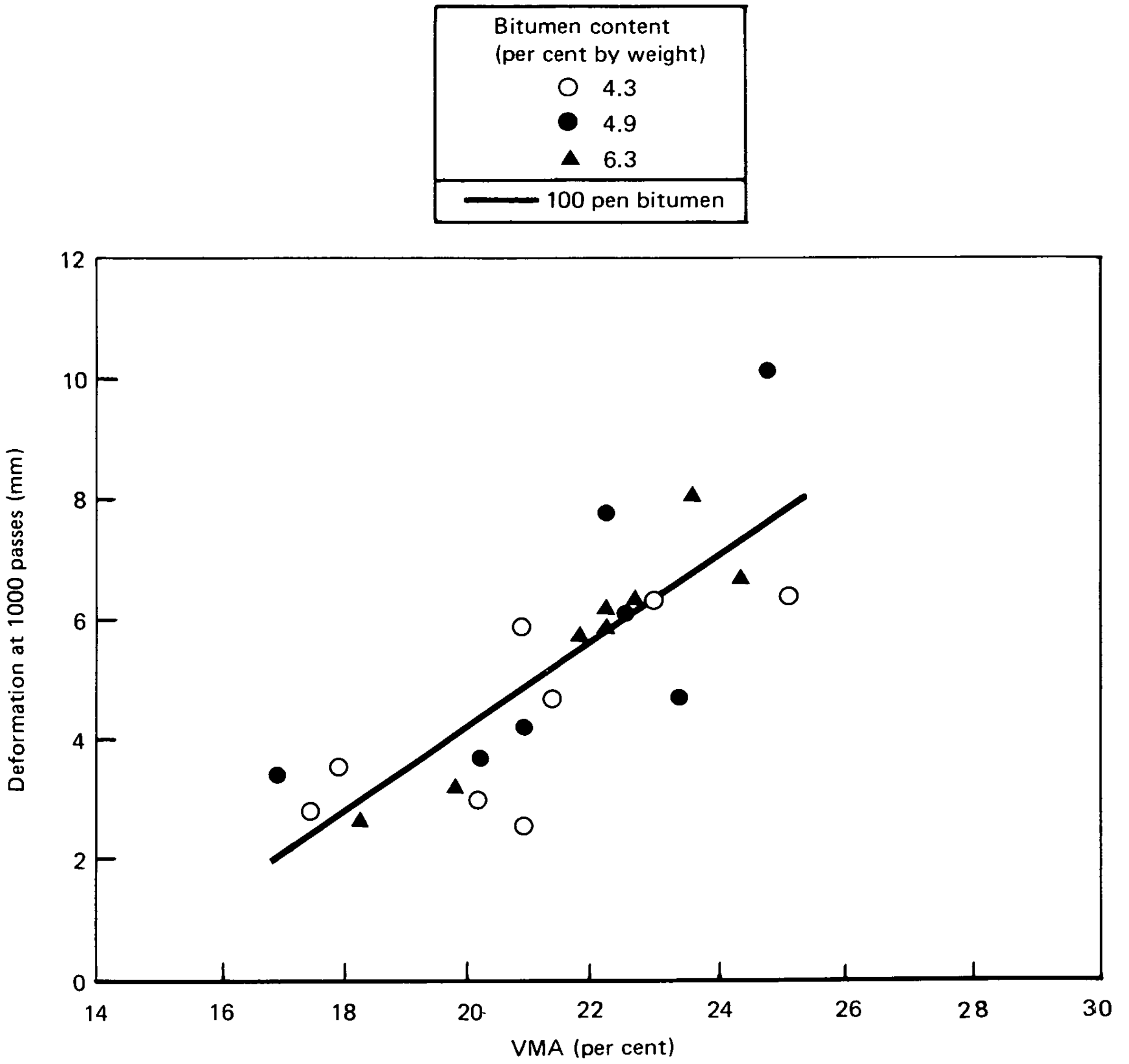

Fig. 7 VARIATION OF DEFORMATION WITH COMPACTION FOR A BLAST-FURNACE SLAG

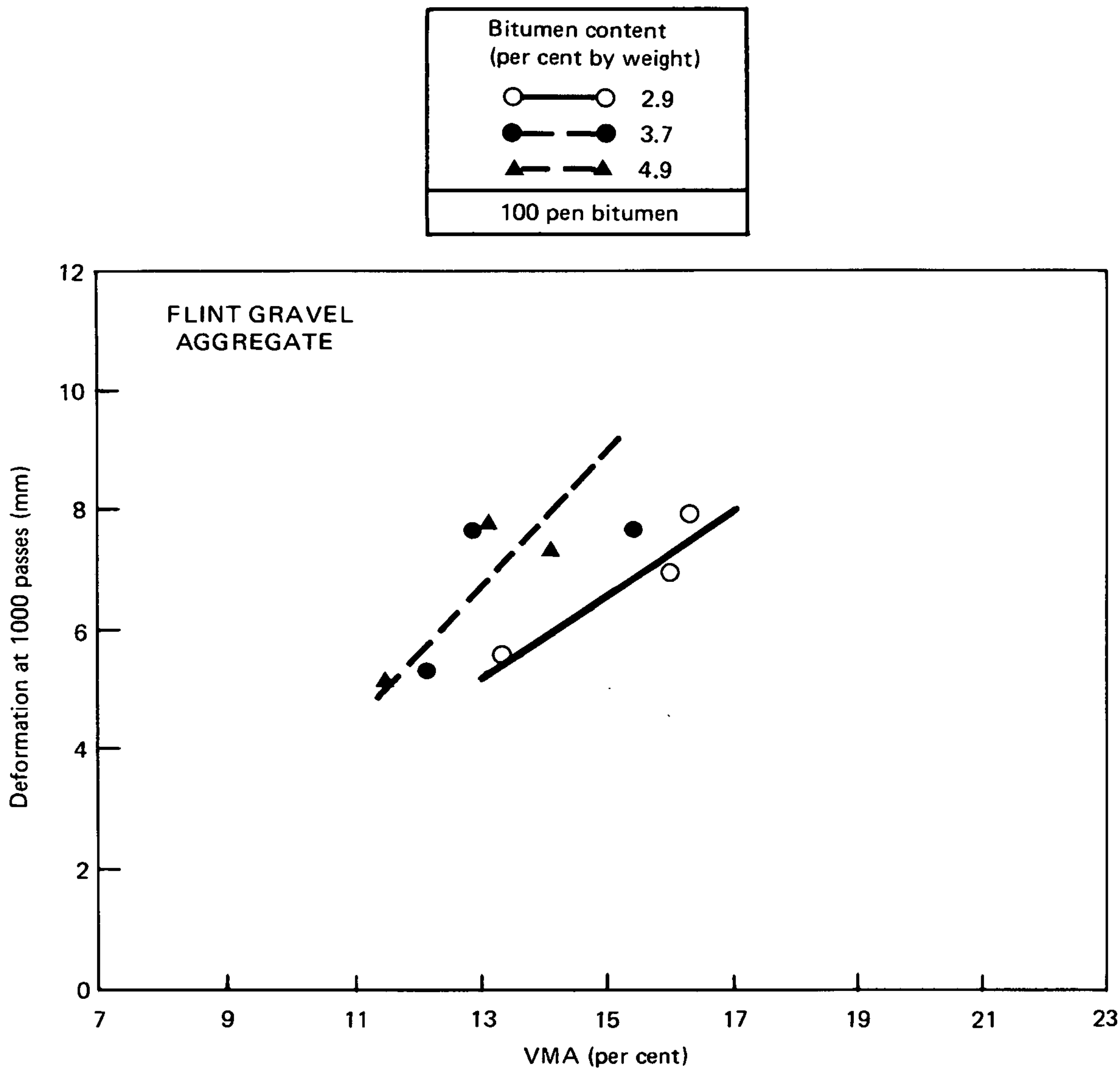

Fig. 8 VARIATION OF DEFORMATION WITH COMPACTION FOR FLINT GRAVEL MATERIALS

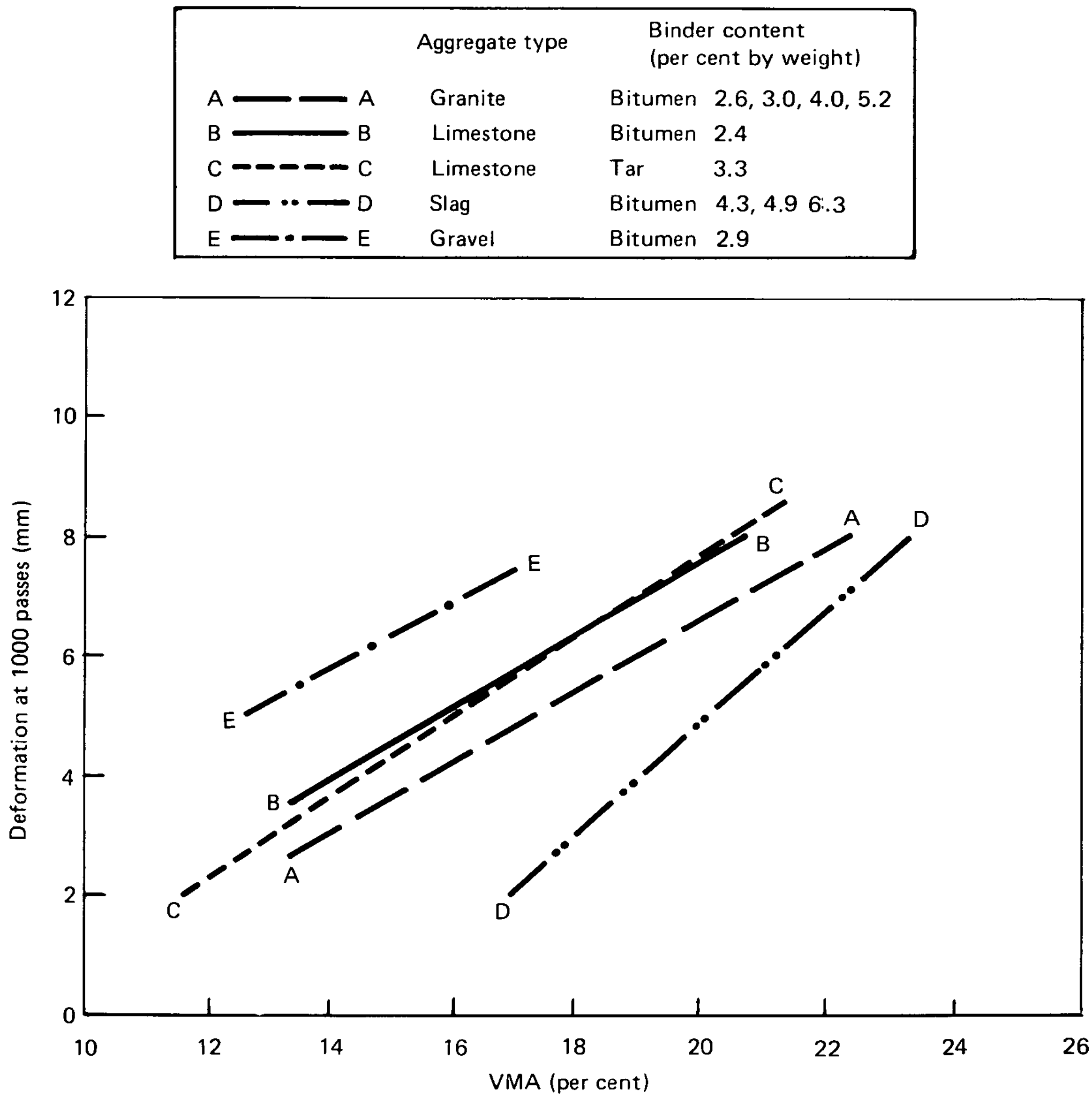

Fig. 9 VARIATION OF DEFORMATION WITH COMPACTION LEVEL FOR DIFFERENT AGGREGATE TYPES

	Aggregate type	Binder content (per cent by weight)	Refusal VMA (per cent)
A —— —— A	Granite	Bitumen 2.6, 3.0, 4.0, 5.2	11.5
B ———— B	Limestone	Bitumen 2.4	9.5
C – – – – C	Limestone	Tar 3.3	9.5
D —·· — D	Slag	Bitumen 4.3, 4.9, 6.3	14.5
E —· — E	Gravel	Bitumen 2.9	11.5

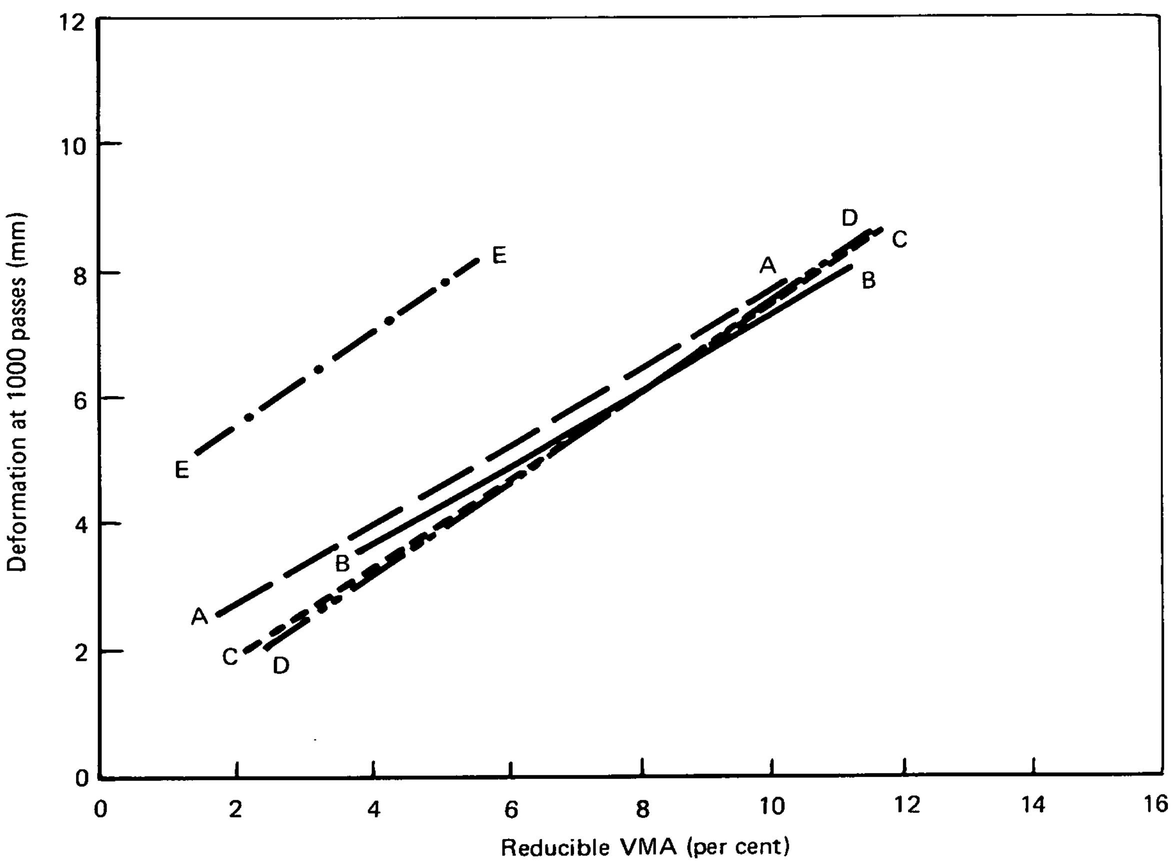

Fig. 10 VARIATION OF DEFORMATION WITH COMPACTION LEVEL RELATIVE TO REFUSAL VMA

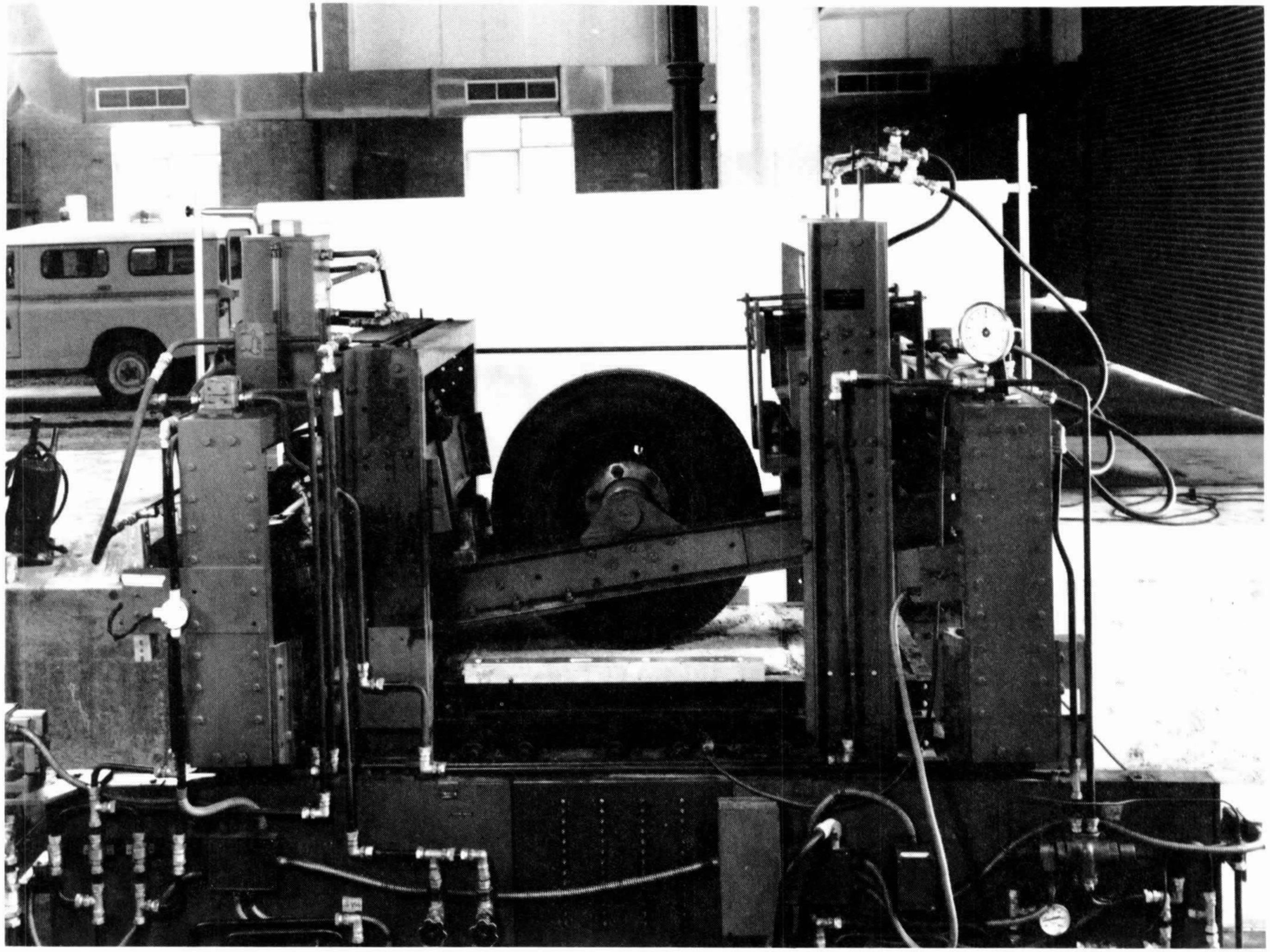

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Plate 1 THE PNEUMATIC-TYRED TRACKING MACHINE

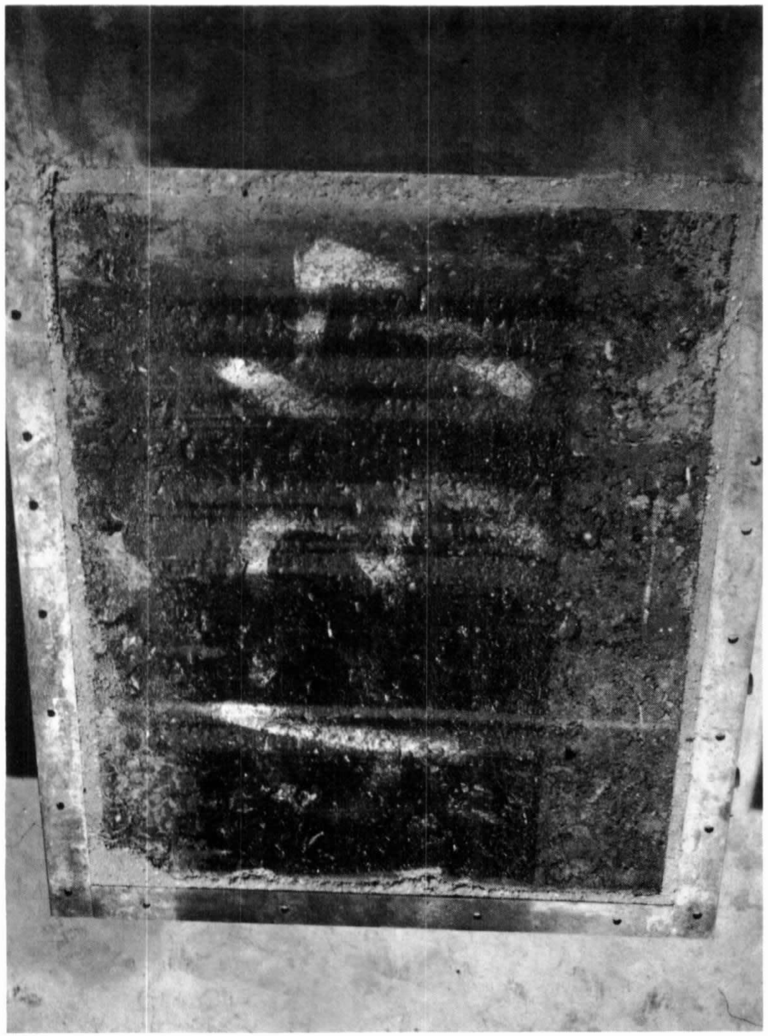

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Plate 2 TEST SLAB AFTER TRACKING
(4.6 per cent bitumen, limestone aggregate)

Neg. no. B292/77

Plate 3 TEST SLAB AFTER TRACKING
(2.4 per cent bitumen, limestone aggregate)

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PRINTED IN ENGLAND

ABSTRACT

DEFORMATION RESISTANCE OF DENSE COATED MACADAMS: EFFECT OF COMPACTION AND BINDER CONTENT: *D Leech and N W Selves:* Department of the Environment Department of Transport, TRRL Supplementary Report 626: Crowthorne, 1980 (Transport and Road Research Laboratory). Better compaction achieved at little or no extra cost has been shown to improve the performance of dense roadbase and basecourse macadam. In the present work the deformation resistance of economically attractive coated macadams of low binder content has been measured for a range of aggregates representing the more important petrological types. Samples of material containing 40 mm maximum size aggregate and either 100 pen bitumen or 54 evt tar were cut from experimental pavements and their deformation resistance was measured in realistic tracking tests at 30°C.

The results for all materials emphasise the importance of good compaction to provide adequate deformation resistance. Gravel mixtures had less deformation resistance than crushed rock or slag materials. For a wide range of binder content, which includes that specified for roadbase and basecourse macadam, the deformation resistance of all materials is either improved or is not affected by reducing binder content. It appears particularly advantageous, from the point of view of deformation resistance, to reduce the binder content of basecourse macadam to equal that of roadbase macadam. Other parameters related to pavement performance are also being studied so that broader-based conclusions can be made concerning the possibility of reducing binder content.

ISSN 0305–1315

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