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ACCELERATED FULL-SCALE LOAD TESTING OF RECYCLED HEAVY DUTY MACADAM ROADBASE MATERIAL

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This report describes work commissioned by the Road Engineering and Environmental Division of the Highways Agency under E048A/HM, Recycled Bituminous Material.

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EXECUTIVE SUMMARY

The work described in this paper was carried out for the Road Engineering and Environmental Division, Highways Agency, Department of Transport.

A trial comparing the performance, under repeated loadings of a moving wheel, of off-site recycled Heavy Duty Macadam (HDM) incorporating 50 per cent of reclaimed material in the mix and conventionally manufactured HDM was carried out in the Pavement Test Facility at TRL. The source of the reclaimed material in the recycled mix was previously manufactured but unused bituminous materials.

The construction of the trial was arranged to complement that of a field trial on the A23 at Bolney in West Sussex in which recycled HDM roadbase containing 18 and 30 per cent reclaimed material was being evaluated.

The work has shown that HDM containing 50 per cent of reclaimed but previously unused bituminous mixes can be manufactured, placed and compacted in accordance with the Specification for Highway Works (MCHW1).

In-situ measurements were made on the subgrade, sub-base, roadbase and wearing course to assess the variability in the structural strength of each pavement layer and that of the finished structure. During trafficking the rate of development of permanent deformation and rutting caused by repeated applications of a loaded moving wheel were recorded together with measurements of dynamic strain generated in the subgrade and periodic measurements of deflection measured using the Falling Weight Deflectometer. Samples were also taken from the compacted pavement for the laboratory determination of elastic stiffness and resistance to permanent deformation.

In the laboratory tests the HDM manufactured with 50 per cent reclaimed material incorporated in the mix behaved similarly to the conventionally produced material. Furthermore, in the PTF no measurable difference in the performance of recycled and conventional HDM was observed when they were subjected to repeated applications of moving wheel loads.

The wear produced in the pavements trafficked by the super single assembly after 0.5 million equivalent standard axle applications was 4 times greater than that produced by 1.8 million equivalent standard axles applied through the dual wheel assembly, the majority of which were at a significantly higher wheel load.

ACCELERATED FULL-SCALE LOAD TESTING OF RECYCLED HEAVY DUTY MACADAM ROADBASE MATERIAL

ABSTRACT

This report describes a trial carried out in the Pavement Test Facility at TRL to assess the performance, under repeated loadings of a moving wheel, of off-site recycled Heavy Duty Macadam (HDM) roadbase incorporating 50 per cent of reclaimed material in the mix. The trial also included a section of conventionally produced HDM, laid at the same time as the recycled material, to act as a control against which the performance of the recycled material could be evaluated.

In-situ measurements were made, on the subgrade, sub-base, roadbase and wearing course to assess the variability in the structural strength of each pavement layer and that of the finished structure. During trafficking the rate of formation of permanent deformation and rutting caused by repeated applications of a loaded moving wheel were recorded together with measurements of dynamic strain generated in the subgrade. Periodic measurements were taken with the Falling Weight Deflectometer to monitor pavement deflection and modulus.

Samples of both materials were taken from the compacted pavement for laboratory determination of elastic stiffness, resistance to permanent deformation and composition analysis.

1. INTRODUCTION

Recent work at TRL has shown that recycled bituminous roadbase materials can be produced to comply with relevant specifications and used under normal contractual conditions (Cornelius and Edwards, 1991). Two field trials of recycled Hot Rolled Asphalt (HRA) and Heavy Duty Macadam (HDM) are indicating that the performance of the materials after one year in service is equivalent to that of conventionally produced materials (Potter and Mercer, 1995).

One of the field trials was constructed on the A23 at Bolney in West Sussex; it incorporated recycled HRA roadbase containing 18 per cent reclaimed material and HDM roadbase containing 18 and 30 per cent reclaimed material in the mixes. The trial described in this report contained 50 per cent reclaimed material in the HDM roadbase, obtained from the same source as the trial on the A23. The objective of this trial was to carry out accelerated load testing under realistic wheel loading and controlled environmental conditions in TRL's Pavement Test Facility (PTF), to obtain an indication of the expected in-service performance of the recycled material under conventional traffic.

The PTF, illustrated in Plate 1, consists essentially of a gantry frame spanning the 10 metres width of a 25 metres

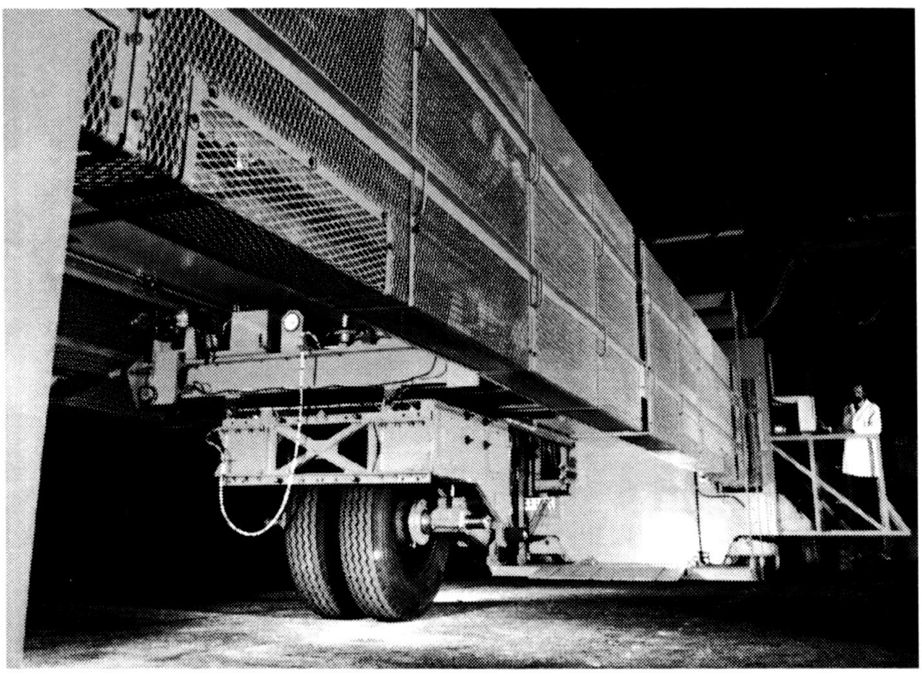

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Plate 1. Pavement Test Facility Machine

long by 3 metres deep pit. The pit contains a subgrade on which experimental pavements are constructed. Beneath the gantry, a carriage containing a loaded test wheel is driven backwards and forwards over the experimental pavement. The most important characteristics of the machine applicable to this work are as follows :

Test wheel load	Variable up to 100 kN
Accuracy	± 2% of set load
Test wheel speed	Variable 1 to 20 km/h
Accuracy	± 0.25 km/h
Tested length	7 metres (at constant speed)
Maximum rate of loading	1000 applications/hour
Test wheel type	Dual or Super Single

The gantry frame is supported on rails at each end, enabling it to be positioned at a number of fixed points along the length of the pit. As well as the close control exercised over test wheel load and speed, the test pavement temperature may also be maintained within specified limits.

2. DESIGN OF TRIAL

A flexible pavement, measuring 10 metres by 6.7 metres, was constructed within the confines of the PTF pit on an existing Gault clay subgrade of average CBR 13%. The layout of the trial is shown in Figure 1.

One half of the paved area (5 metres by 6.7 metres) was constructed using HDM roadbase manufactured with 50 per cent by weight of reclaimed material in the mix and the other half was constructed using conventional HDM roadbase, to act as a control. This arrangement enabled rolling wheel loads to be applied simultaneously under the same conditions to paved areas containing both recycled and conventional materials.

3. MATERIALS

The sources, composition and compliance testing carried out on the constituents of each pavement layer are detailed below.

3.1 SUB-BASE

The sub-base material, comprising a Mendip limestone aggregate, was manufactured to the Type 1 specification in compliance with Clause 803 of the Specification for Highway Works (MCHW1).

3.2 ROADBASE

The recycled and control mixes were prepared in Foster Yeoman's, computer controlled, Genco-Bitumadrum mix plant at Purfleet. The composition of both macadams was determined from laboratory tests performed on samples of the delivered materials (binder content, penetration and aggregate grading) to ensure compliance with the Specification. The results showed that the manufacture of both the conventional and recycled HDM materials complied with Clause 930 of the Specification for Highways Works (MCHW1), except that the recycled mix had 1.0 per cent less material passing the 6.3mm sieve than required by the Specification. This shortfall is not regarded as being significant and should not affect the trafficability of the material.

The source of the reclaimed material in the recycled mixes was previously mixed, unused, tar-free, road building materials stockpiled at Foster Yeoman's Purfleet depot. The stockpiled material originated from three sources: the Purfleet plant, the Theale plant and small quantities from a plant at Crawley. At Theale and Purfleet, which are both continuous drum mix plants, every production run is preceded by the purging of uncoated or partly coated aggregate through the drum; likewise, each closes down by removing aggregate tailings from the drum, both these materials are stockpiled for the recycling process. Coated materials which are rejected on visual grounds by technical staff, materials from cancelled orders and loads returned from site surplus to requirements are also stockpiled for recycling.

The virgin aggregates in the reclaimed material originated from a number of sources: Torr limestone, Glensanda granite, Bardon Hill porphyry and BIS/Pearson asphalt sand.

3.3 WEARING COURSE

The wearing course layer was a Hot Rolled Asphalt (HRA) material manufactured with a 30 per cent stone content (maximum size 14mm) and with a stability in the range 4-8kN complying with BS594; Table 3, Column 9 (British Standards Institution, 1985).

4. CONSTRUCTION DETAILS

4.1 SUBGRADE PREPARATION

To accommodate the trial in the PTF some of the existing pavements were excavated and the exposed subgrade trimmed to provide a finished level 340mm below the pit-edge surround.

To characterise the subgrade, in-situ CBR and MEXE penetrometer measurements were taken at a number of

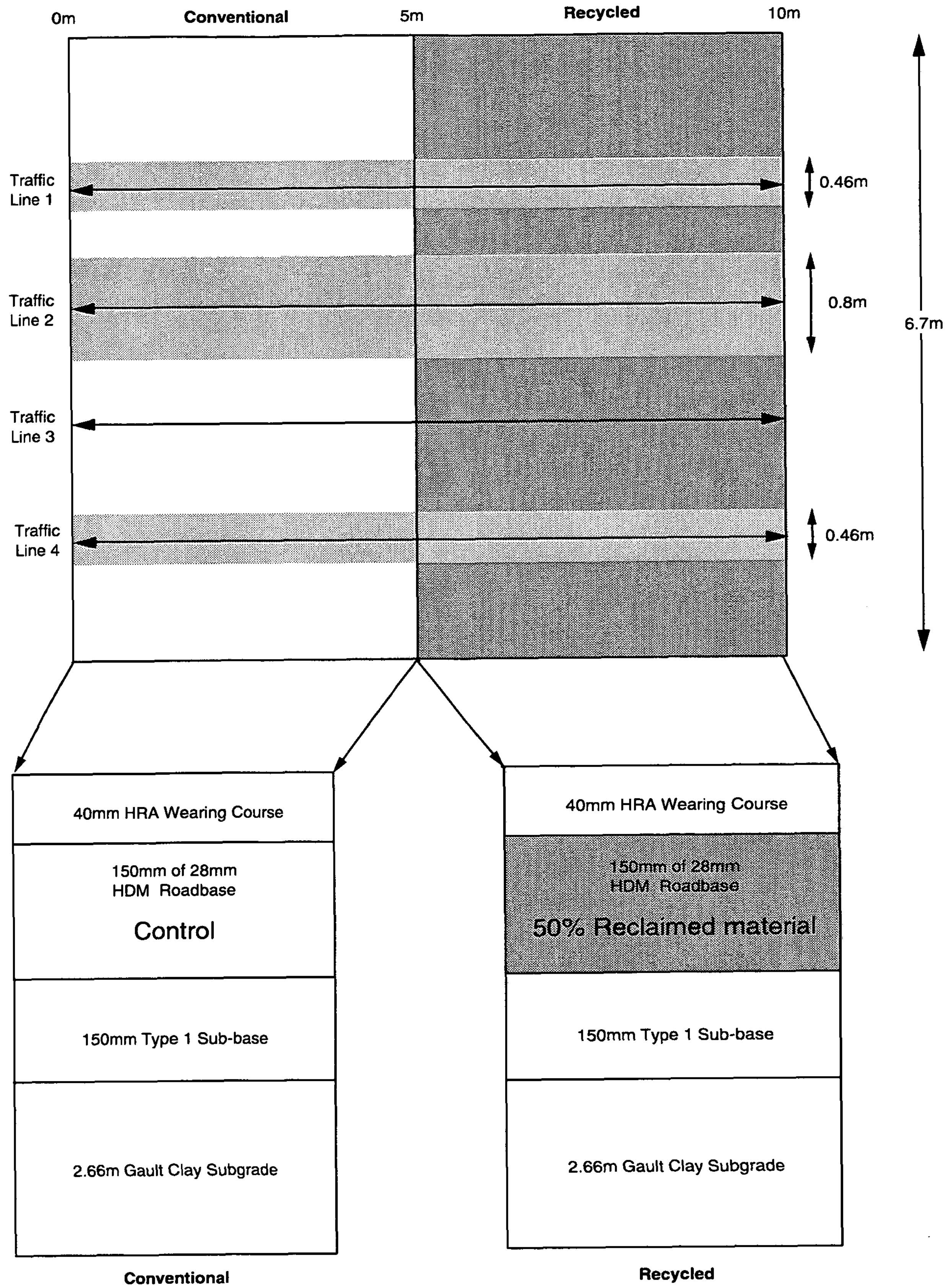


Fig. 1 Plan and nominal construction of PTF trial pavement

locations, both to confirm the bearing capacity of the subgrade and also to highlight any variations in strength within the chosen area of pavement construction. The results of these measurements are given in Table 1.

Table 1 shows that the CBR is reasonably consistent over the test area, considering the high values measured. The area on which the recycled material of trafficking line 4 was founded was however, slightly weaker than the other areas.

The suggested reduction in subgrade strength associated with trafficking line 4 could be attributed to an ingress of moisture which occurred during the saw cutting activities undertaken to remove previously constructed pavements.

4.2 PAVEMENT LAYER CONSTRUCTION

The pavements were constructed in accordance with the Specification for Highways Works (MCHW1). Compaction was in the direction of the 10 metre width of the pit and material not receiving compaction by both drums of the roller was additionally compacted using a manually operated vibrating plate compactor.

The sub-base and roadbase materials were each hand laid and compacted in two 75mm thick lifts. The upper layer of the roadbase was placed immediately following compaction of the lower layer. The wearing course was machine laid over the entire area to provide a nominal 40mm thick compacted mat.

During construction of the pavement, optical level measurements were taken on each composite layer to determine thicknesses, the results are given in Table 2. Table 2 shows that consistent thicknesses were achieved for the sub-base and roadbase layers. However, some variation in the laid thickness of the wearing course did occur, particularly in the area containing the conventional HDM material, which was in general 10mm thicker than that over the recycled HDM.

TABLE 1

Results of in-situ CBR determinations (%) on subgrade [MEXE penetrometer derived CBR's in ( )]

	Conventional HDM Zone		Intermediate Zone	Recycled HDM Zone	
			Chainage (m)		
	2	2.5	5	7.5	8
Trafficking Line 1	14.0	(14.1)	15.2	(12.3)	13.6
Trafficking Line 2	16.2	(14.9)	10.3	(11.9)	12.0
Trafficking Line 3	13.2	(13.3)	12.0	(14.3)	14.5
Trafficking Line 4	12.4	(10.6)	(10.6)	(12.7)	(9.6)

TABLE 2

Achieved layer thickness (mm) [Standard deviation in ( )]

	Conventional HDM Zone		Recycled HDM Zone	
Trafficking Line 1				
Sub-base	143.6	(8.0)	141.5	(6.3)
Roadbase	149.9	(4.8)	147.7	(5.3)
Wearing course	54.7	(4.0)	54.7	(4.0)
Trafficking Line 2				
Sub-base	138.4	(8.6)	141.5	(7.6)
Roadbase	150.5	(3.0)	149.0	(5.1)
Wearing course	62.6	(3.6)	52.3	(4.3)
Trafficking Line 3				
Sub-base	142.5	(8.3)	138.0	(9.0)
Roadbase	150.8	(4.0)	152.3	(4.3)
Wearing course	62.3	(3.4)	53.1	(4.8)
Trafficking Line 4				
Sub-base	171.9	(23.7)	147.6	(14.6)
Roadbase	156.0	(4.6)	154.8	(3.6)
Wearing course	59.9	(2.8)	49.3	(3.7)

4.3 LAYER CHARACTERISATION

4.3.1 Nuclear Density Meter Measurements

Following compaction of the roadbase materials the density of the compacted material was determined using a nuclear density meter in back scatter mode. The results of these density measurements are given in Table 3.

These results indicate that there were no significant differences in the density of the compacted roadbases over the trial pavement and that all areas had received adequate compaction.

4.3.2 Falling Weight Deflectometer

After compaction of each layer Falling Weight Deflectometer (FWD) tests were carried out. Stiffness moduli for the sub-base, roadbase and roadbase/wearing course were then calculated by back analysis of the FWD data using the Evaluation of Layer Moduli and Overlay Design (ELMOD) software package (Dynatest Engineering A/S, 1987). The results are given in Tables 4, 5 and 6 respectively.

These results indicate that there were no significant differences in the stiffness of the sub-base layer underlying the recycled and conventional roadbase materials. However,

TABLE 3

Nuclear Density Meter Determinations on Roadbase Materials (kg.m^{-3})

	Conventional HDM Zone			Recycled HDM Zone		
	Chainage (m)					
	2	3	4	6	7	8
Trafficking Line 1	2233	2336	2269	2338	2237	2287
Trafficking Line 2	2108	2229	2209	2338	2347	2092
Trafficking Line 3	2094	2288	2224	2178	2199	2232
Trafficking Line 4	1971	2069	2158	2263	2323	2100

TABLE 4

Stiffness moduli determined for sub-base by FWD (MPa)

	Conventional HDM Zone			Recycled HDM Zone		
	Chainage (m)					
	2	3	4	6	7	8
Trafficking Line 1	54	35	44	44	45	36
Trafficking Line 2	47	42	42	35	36	37
Trafficking Line 3	37	41	34	38	29	32
Trafficking Line 4	59	39	51	44	27	32

TABLE 5

Stiffness moduli determined for roadbase by FWD (MPa)

	Conventional HDM Zone			Recycled HDM Zone		
	Chainage (m)					
	2	3	4	6	7	8
Trafficking Line 1	6550	7650	6750	7550	6450	6450
Trafficking Line 2	6600	6600	6250	6100	6000	5350
Trafficking Line 3	5500	6150	5200	4900	5500	4900
Trafficking Line 4	4550	5100	3000	4750	3350	2950

TABLE 6

Stiffness moduli determined for roadbase/wearing course by FWD (MPa)

	Conventional HDM Zone		Chainage (m)		Recycled HDM Zone	
	2	3	4	6	7	8
Trafficking Line 1	9450	9800	9950	10600	10050	9400
Trafficking Line 2	8350	7250	6900	6850	7600	7150
Trafficking Line 3	7850	7200	6900	6150	7200	6750
Trafficking Line 4	6050	6000	5300	5500	4100	4850

the stiffness moduli calculated for the roadbase and roadbase/ wearing course layers indicate that the bound materials on trafficking line 4 were weaker, particularly in the recycled zone.

5. TRAFFICKING PROGRAMME

At the start of the experiment, it was intended to traffic two of the four lines bi-directionally using different combinations of wheel load and wheel type at a pavement temperature of 25°C. However, to obtain initial information of the likely performance of the two different HDM materials, the approach of using one traffic line as a pilot trial was adopted.

The fourth line was retained in case the traffic programme needed to be repeated for one wheel type. If this was not required then the area would be used to obtain samples of untrafficked roadbase for laboratory testing.

Before constructing the sub-base, strain gauges of the type described by Potter (1969) were installed in the subgrade to measure the vertical components of strain during the subsequent trafficking of the finished pavement. Each of the four trafficking lines was instrumented along its centre line with six gauges, three in the area to be covered by conventional HDM, spaced one metre apart and with their longitudinal centres 100mm below the subgrade surface and similarly the other three in the area to be covered by the recycled material.

On completion of pavement construction, each of the traffic lines was subjected to 500 repetitions of a 40kN load applied through a super single wheel assembly, at a speed of 20 km/h and a pavement temperature of 20°C to assess the response of these buried gauges. Two gauges from trafficking line 4 and one from trafficking line 2 were found to respond poorly to transient loads; the outputs from these gauges have been omitted from the data presented in this report.

From the results of the tests carried out at that time it was decided to use trafficking line 4 for the pilot trial. The reasons for this were that the CBR tests indicated that the subgrade was slightly weaker than on the other traffic lines, there was greater variation in the thickness of the sub-base between the conventional and reclaimed HDM zones, the calculated moduli values for the HDM were lower and only four of the six strain gauges were functioning satisfactorily.

The traffic lines were spaced with their centre lines 1.2 metres apart and traffic lines 1 and 4 were located at distances of 1.7 metres and 1.4 metres respectively from the longitudinal edges.

Extensive bi-directional trafficking was then applied, in turn, to traffic lines 4,1 and 2 as illustrated in Figure 1. During the trafficking the pavement temperature was maintained constant at 25°C at 40mm depth.

Traffic line 4 was subjected to 95 300 applications of a 40kN load, followed by 100 000 applications of a 56.5kN load using a super single wheel assembly (Tyre type: 385/65 R22.5 (15R22.5) XZA) and tyre inflation pressures of 110 psi and 130 psi respectively. The combined loading was equivalent to 0.49 million standard axles (msa).

The initial 2 500 load applications were canalised. However, this generated an excessive rate of rutting, so to reduce this, and more closely simulate in-service traffic loading patterns as well as providing a sufficiently wide flat rut profile to accommodate the loading plate of the FWD, a limited amount of lateral distribution of the wheel was introduced. This lateral distribution extended to 80mm on either side of the wheelpath centre line.

Having completed the initial assessment on traffic line 4, traffic line 1 was subjected to a similar loading spectrum up to the equivalent of 0.49 million standard axles, but without the initial canalised loading.

To compare the performance of the two roadbase types under different wheel configurations, the load on trafficking line 2 was applied using a more conventional dual wheel assembly (Tyre type 11.00R20 16PR). Loads of

40kN, 56.5kN and 80kN were applied for 100 180, 19 600 and 100 800 passes respectively. The sum total of the applied loads was equivalent to 1.79 msa. The tyre manufacturer's recommended inflation pressures of 80, 106 and 110 psi for the selected loads and speed were adopted for these tests. To provide the flat rut profile necessary for FWD testing the lateral distribution was extended to 120mm on either side of the wheelpath centre line to cater for the different tyre contact pattern of the dual wheel assembly.

These wheel loadings were chosen to promote accelerated wear, 57.5kN is the proposed EEC maximum legal limit which will be introduced in the UK in 1999. The 80kN wheel load had previously been used on pavements in the PTF and based on a fourth power relationship between applied load and rate of wear each pass at this load is equivalent to 16 standard axles.

The performance of traffic lines 1,2 and 4 provided sufficiently consistent data that trafficking of line 3 was deemed unnecessary and it was used to obtain core samples of the untrafficked materials.

6. INTER-TRAFFICKING MEASUREMENTS

In addition to measurements obtained during pavement construction, transient strain, pavement modulus, permanent deformation and surface rutting were measured during the periods of trafficking on each of the traffic lines.

Transient strains measured in the subgrade as the rolling load passes along the pavement generally provide a good indication of the load spreading properties of the structure. More importantly they provide an indication of changes in the structural condition of the pavement which might occur with repeated loading. The results of the measured strains recorded during trafficking are shown in Figure 2.

Magnitudes of the measured strains were not consistent from gauge to gauge, these differences can in part be attributed to the unavoidable, localised material variability. Consequently the assessment of relative pavement performance should be guided primarily by rates of change rather than by absolute levels.

Adopting this approach it would appear that rates of change in strain with repeated loading within areas covered by both the conventional and recycled materials are similar. However, a comparison of absolute levels, indicates that in general, lower strains are generated under areas covered by the conventional material.

This difference is more noticeable for traffic lines 2 and 4 and from Table 2 it can be seen that this may be partly attributable to the wearing course being 10mm thicker over the conventional HDM roadbase.

To identify any changes in structural condition occurring as a result of trafficking, FWD tests were performed on the wearing course at intervals during trafficking. Modulus values for the combined bound layers and the combined foundation (subgrade/sub-base) were calculated using the ELMOD program. The measurements were obtained at positions corresponding with those of the buried strain gauges; the results are shown in Figures 3 and 4 for the subgrade/sub-base and the bituminous layers respectively.

Figure 4c indicates that the bituminous material on trafficking line 4 is of lower modulus than on the other lines. Furthermore, the recycled zone of trafficking line 4 is of lower modulus than the zone covered by the conventional material. These structural differences were confirmed by the recorded measurements of transient strain illustrated in Figure 2.

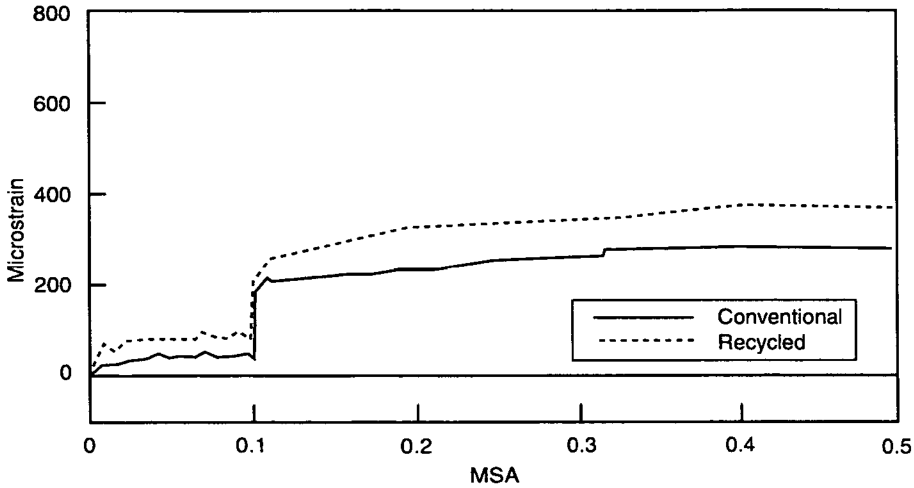
Wheelpath rut depth was measured using a straight edge and wedge, at 0.5 metre intervals along the central 7 metre length of each traffic line but with the exception of the mid-point position where conventional and recycled materials abutted. The results shown in Figure 5 indicate that rut development on traffic lines 1 and 4 were similar for each material type and that rut development on traffic line 2, under the dual wheel assembly, was significantly less on both material types reflecting the lower damaging effect of the dual assembly.

Optical level measurements were made at regular intervals throughout the trafficking programmes and used to determine the amounts and rates of permanent deformation occurring within the trafficked areas. Sufficient measurement positions were also chosen to provide adequate resolution of the transverse profiles of the traffic lines.

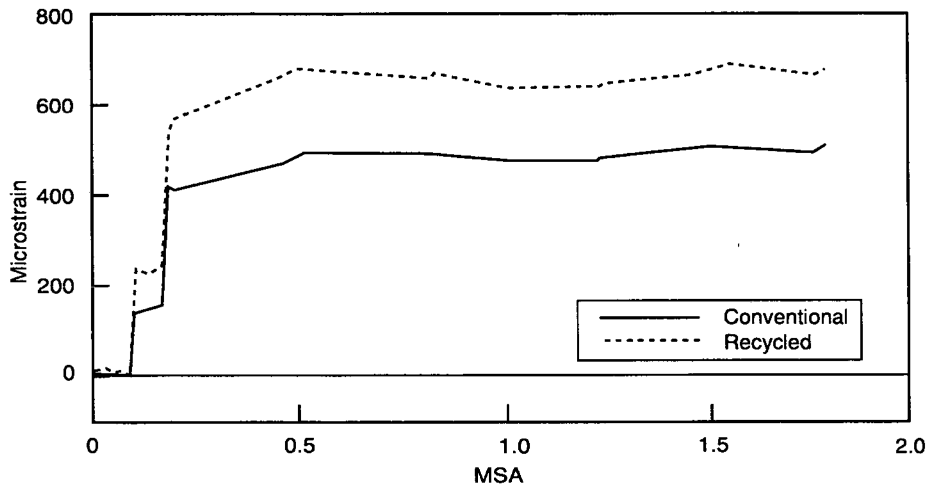
Figure 6 shows that rates of permanent deformation occurring in the conventional and recycled macadams are generally similar on individual trafficking lines. Differences occurring between trafficking lines can be attributed to structural variations and, in particular, the type of wheel assembly.

On traffic line 4 deformations of 11.5mm in the area covered by the recycled material and 8mm in that covered by the conventional material were recorded. Conversely, on traffic lines 1 and 2 more deformation occurred within areas covered by the conventional material, 8mm compared with 5mm and 2mm compared with 1mm respectively.

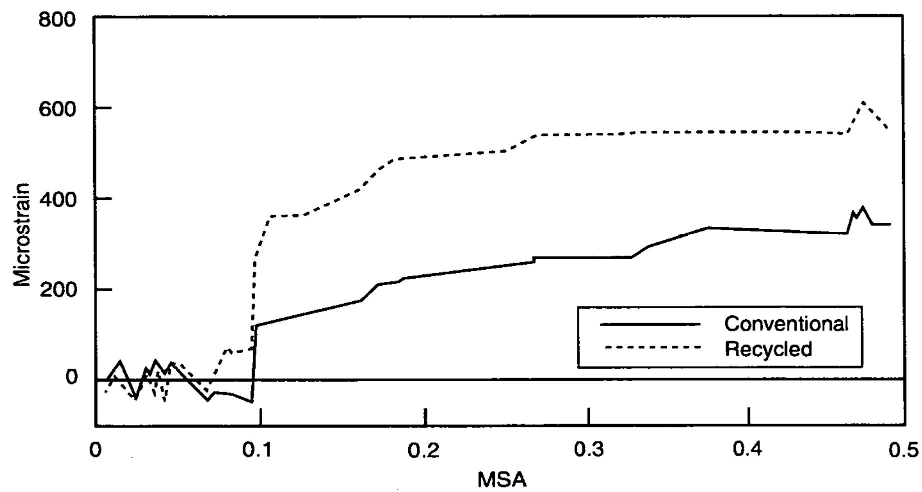
Loads applied to traffic line 1 using the super single wheel generated 4 times more deformation than the dual assembly on traffic line 2. The benefits of the dual assembly are



2a: Trafficking Line 1

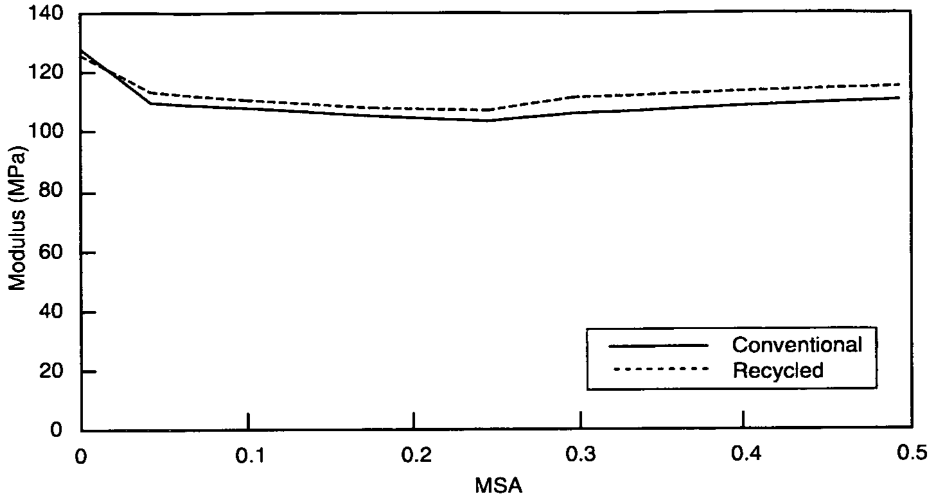


2b: Trafficking Line 2

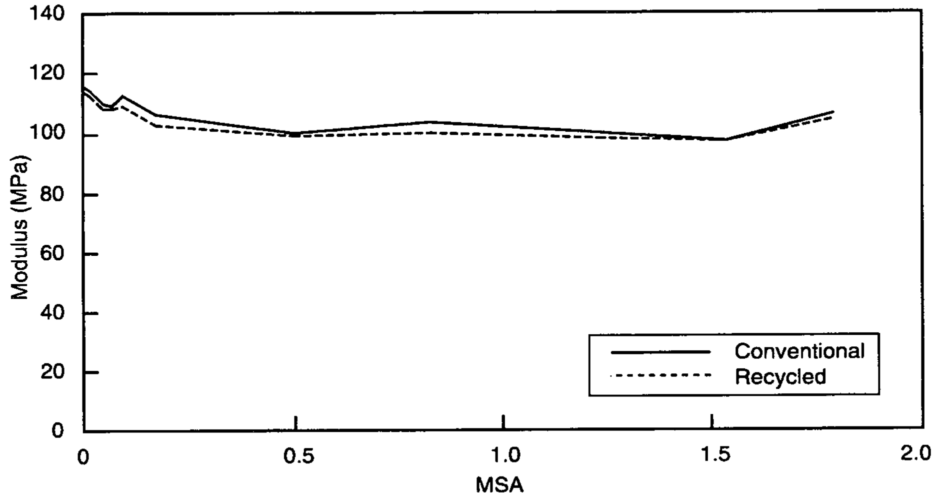


2c: Trafficking Line 4

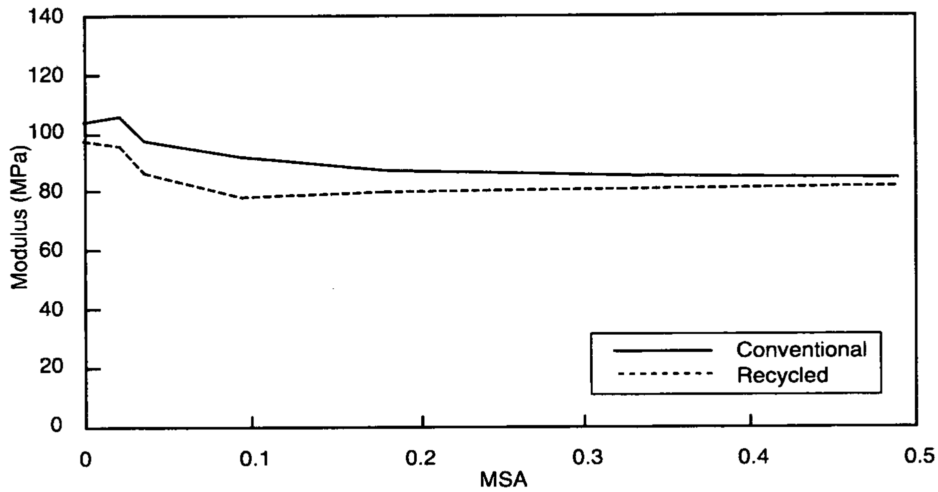
Fig. 2 Transient subgrade strains



3a: Trafficking Line 1

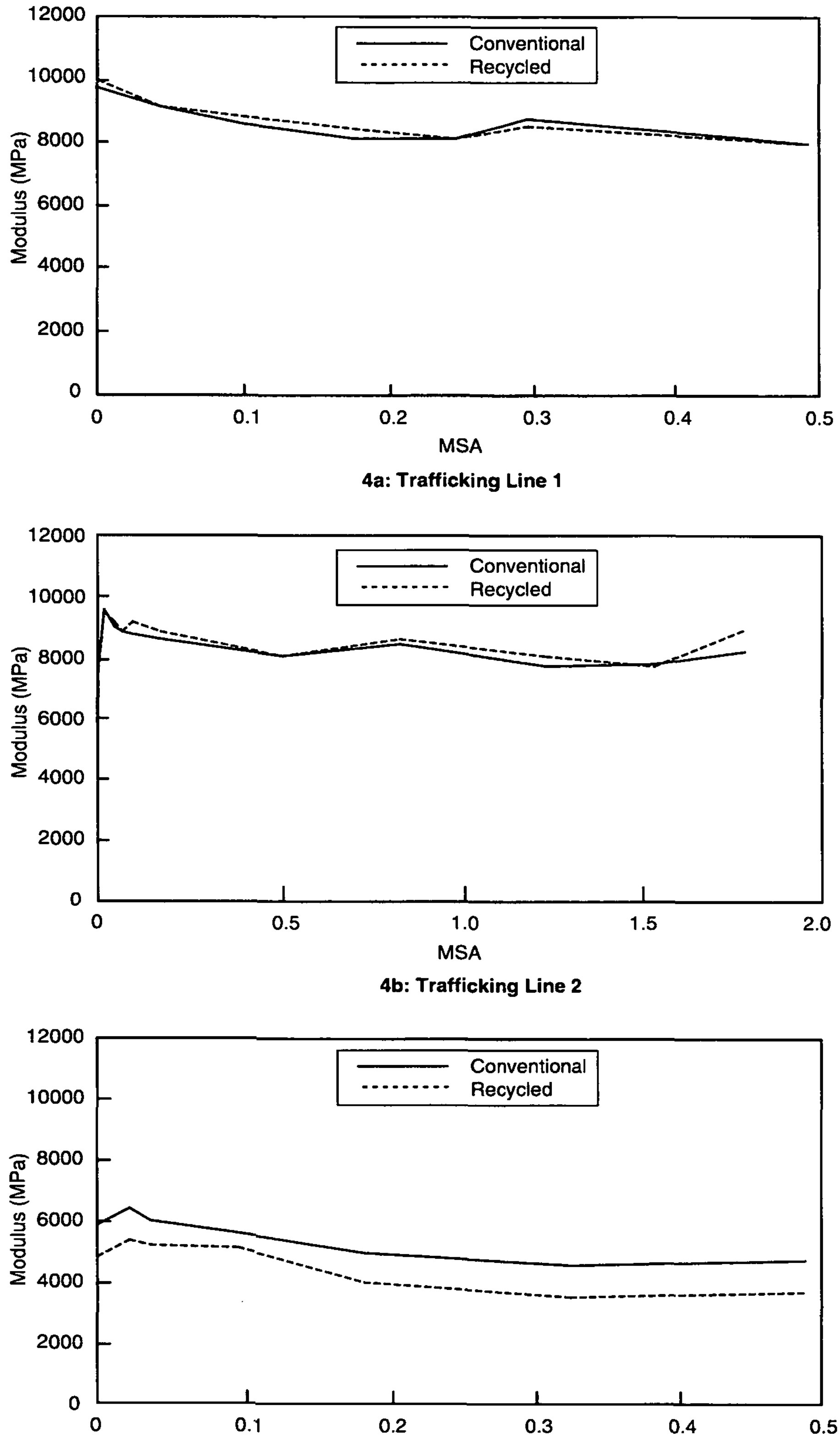


3b: Trafficking Line 2



3c: Trafficking Line 4

Fig. 3 Foundation modulus (ELMOD)

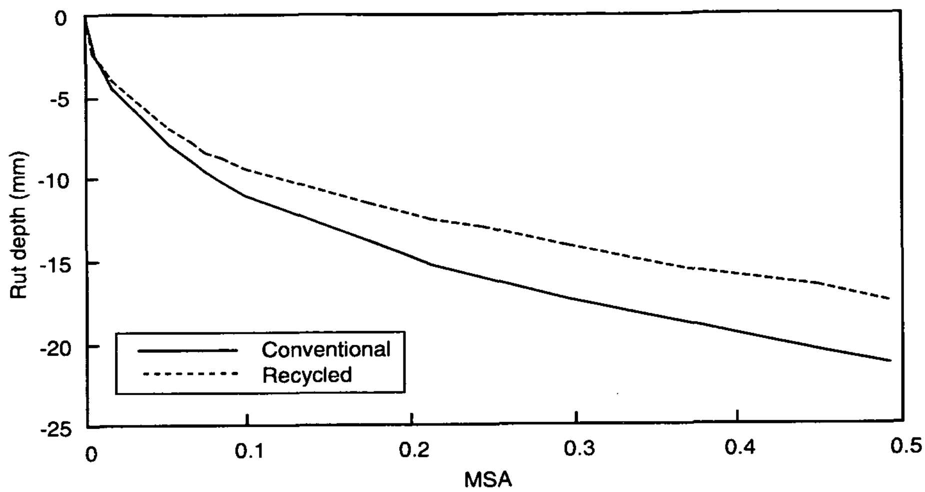


4a: Trafficking Line 1

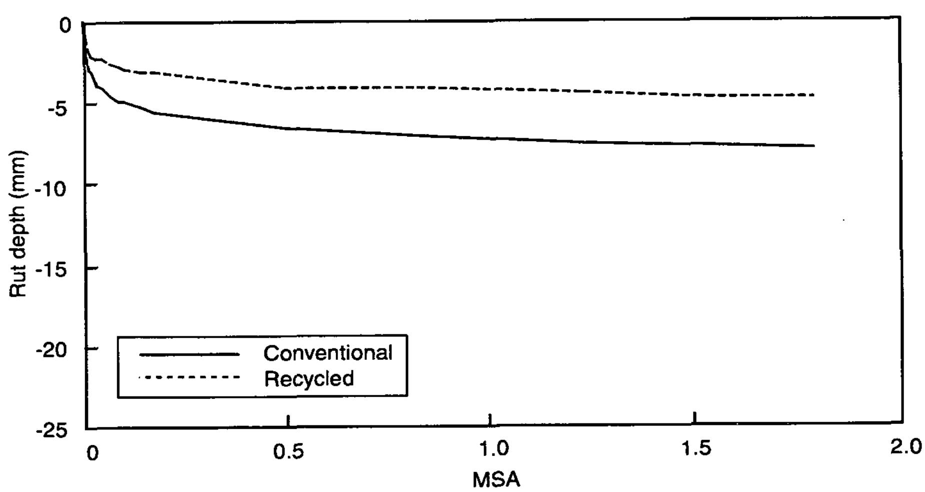
4b: Trafficking Line 2

4c: Trafficking Line 4

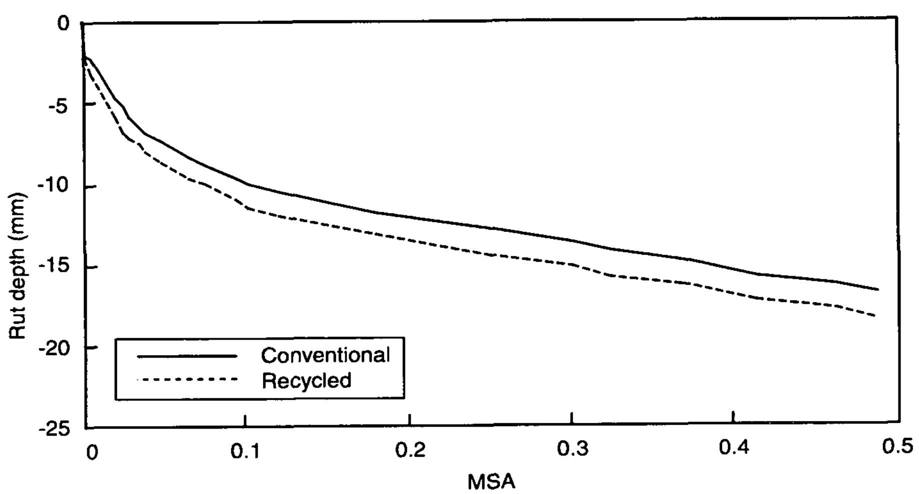
Figure 4: Bound layer modulus (ELMOD)



5a: Trafficking Line 1



5b: Trafficking Line 2



5c: Trafficking Line 4

Fig. 5 Rut development

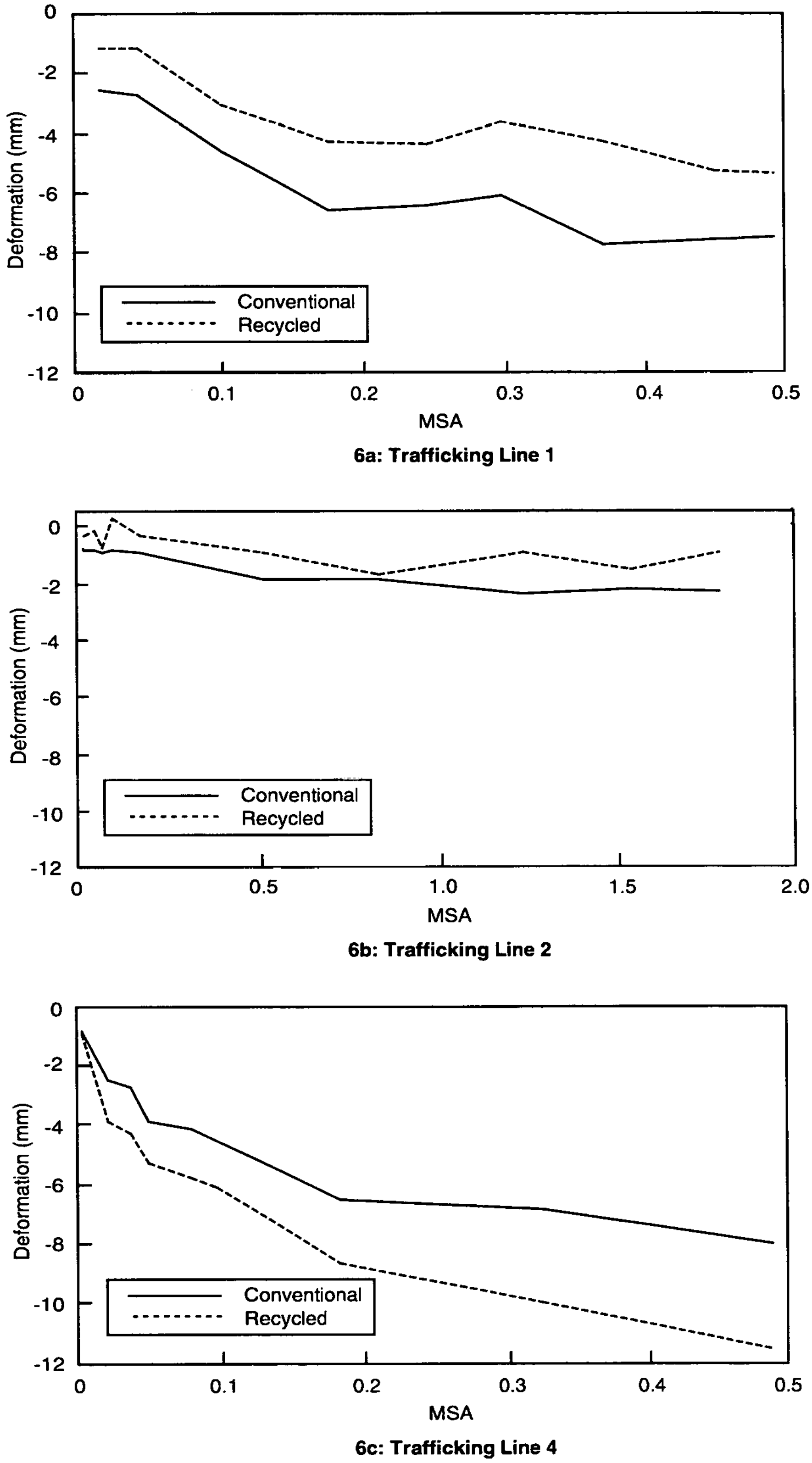


Fig. 6 Progress of permanent deformation

obviously substantial as this traffic line was subjected to 4 times the number of equivalent standard axles, with approximately half of the load applications at 80kN.

The ranking of the conventional and recycled materials in terms of deformation and rutting was not consistent between trafficking lines reflecting the inherent variability of the construction and material properties that occur over short distances within a compacted mat.

Changes in surface transverse profile occurring as a result of cumulative applied load applications, in standard axles (sa), are shown in Figures 7, 8 and 9 for trafficking lines 1, 2 and 4 respectively. These indicate that the shape of the ruts in both the recycled and conventional zones of the pavement are similar and also illustrate the greater damaging effect of the super single assembly compared with the dual assembly. The characteristic 'W' and 'V' shaped profiles resulting from trafficking with the dual and super single wheel assemblies respectively, are also noticeable.

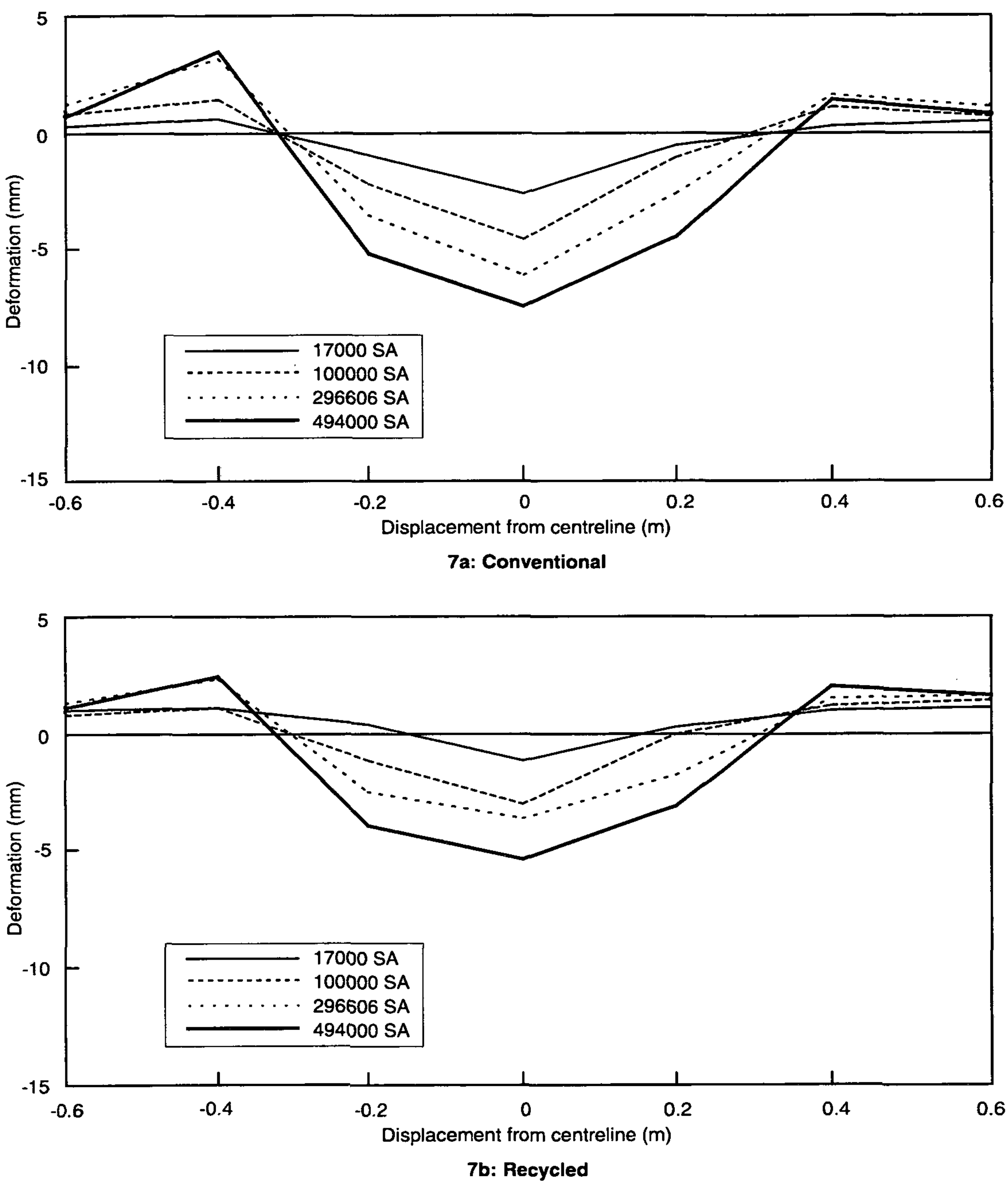
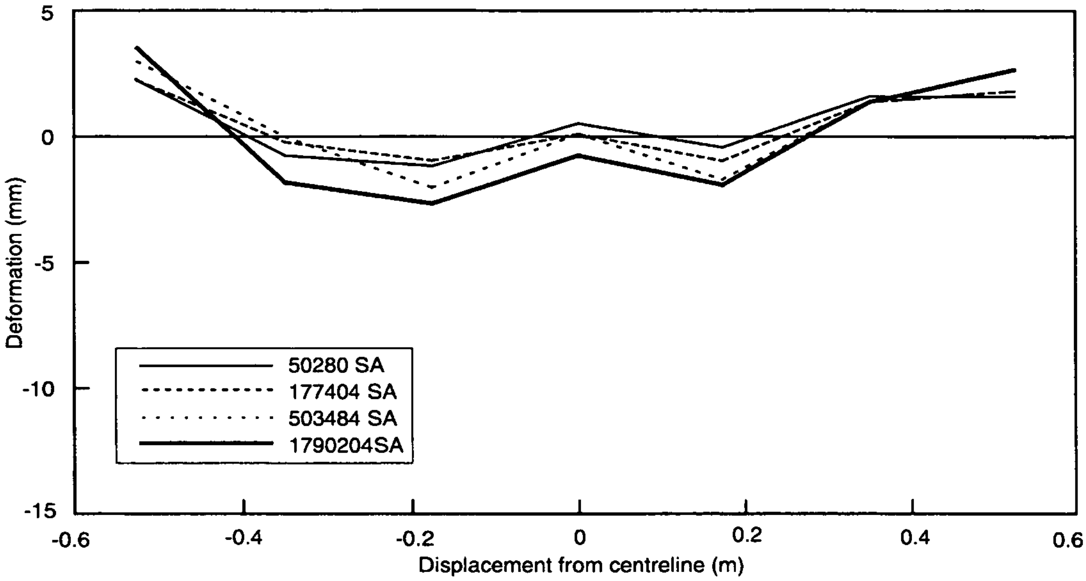
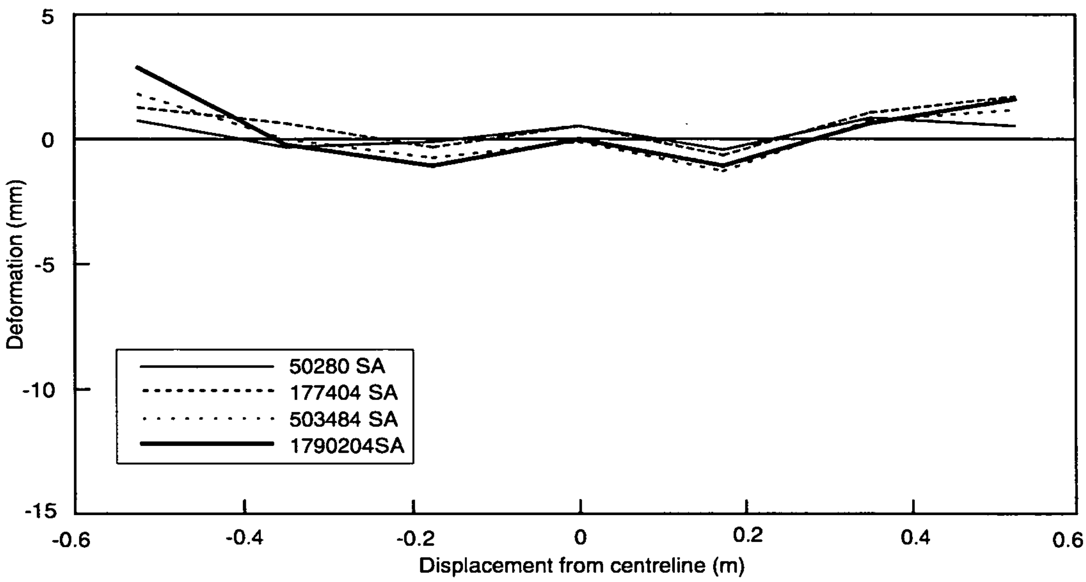


Fig. 7 Transverse profile of Trafficking Line 1



8a: Conventional



8b: Recycled

Fig. 8 Transverse profile of Trafficking Line 2

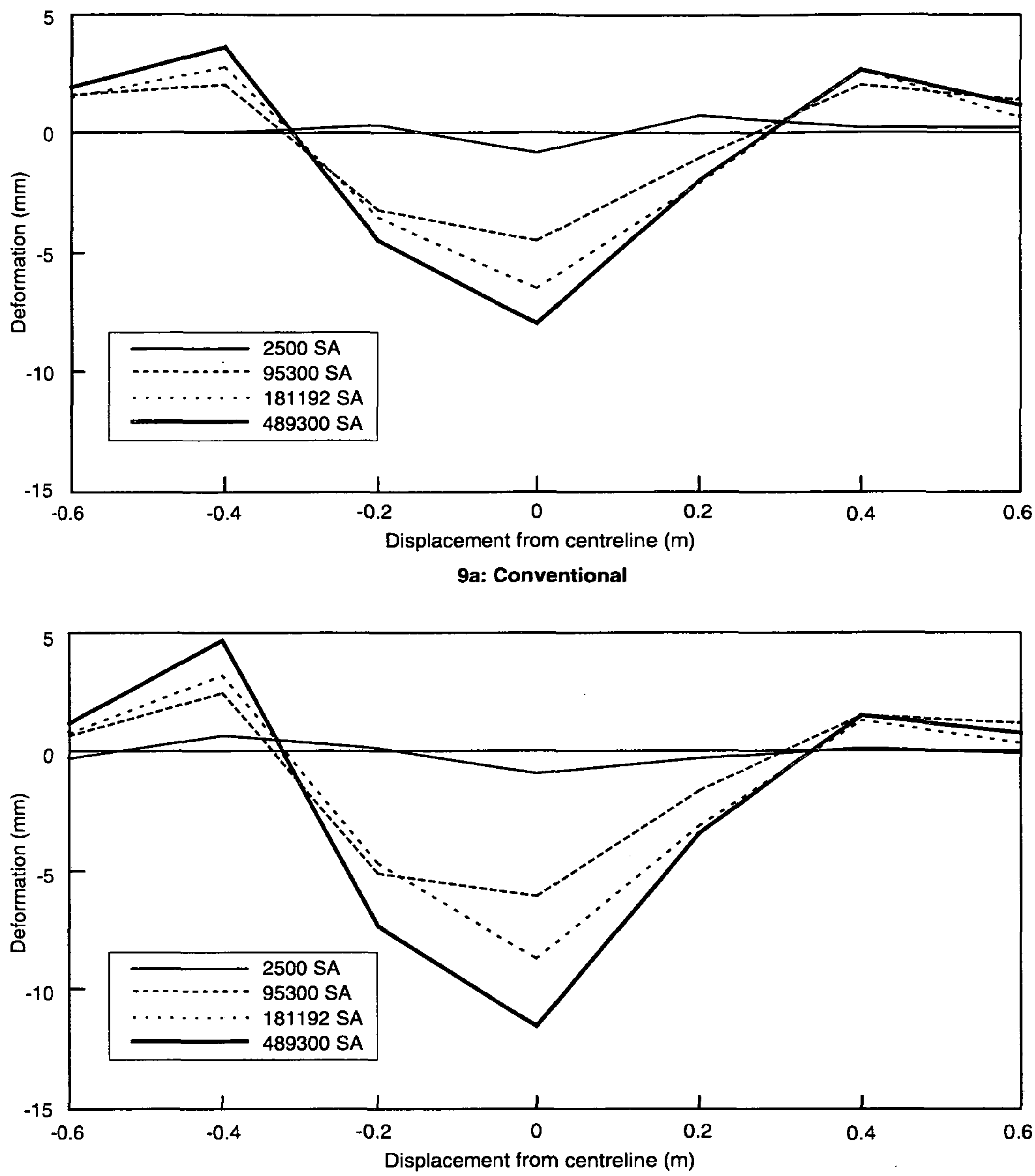
7. LABORATORY TESTS

Following the completion of trafficking, ten cores were extracted from both the conventional and recycled zones of trafficking line 2 along with the same number of cores from the untrafficked line 3. All the cores were prepared for subsequent laboratory testing by trimming them to yield the middle 70mm of the roadbase layer.

The elastic stiffness of each specimen was measured using the Nottingham Asphalt Tester (NAT) in the Repeated Load Indirect Tensile (RLIT) mode. The resistance to permanent deformation of 50 per cent of the specimens from each zone on the two trafficking lines was determined using the Repeated Load Axial (RLA) mode on the NAT machine.

The results of these laboratory tests are given Table 7 and show that the two types of roadbase were of a similar stiffness and that, furthermore, this was unaffected by trafficking.

The stiffness values measured in the laboratory are, in general, slightly less than those derived from the FWD measurements shown in Table 5. However, it should be borne in mind that the FWD tests were carried out under different test conditions, in particular, of pavement temperature and loading frequency.



9a: Conventional

9b: Recycled

Fig. 9 Transverse profile of Trafficking Line 4

8. FUTURE WORK

The measurements in this investigation show that recycled HDM manufactured with unused reclaimed materials has performed similarly to conventional HDM. However, the reclaimed material used was not subjected to trafficking and ageing in the same way as road planings obtained from in service roads.

It is recommended therefore, that the field trials incorporating recycled bituminous planings constructed on the A500 near Stoke-on-Trent and the A20 at Ashford continue to be monitored to assess their inservice performance.

9. CONCLUSIONS

HDM containing 50 per cent of material that was reclaimed from previously manufactured but unused bituminous mixes can be manufactured, placed and compacted in accordance with the UK Specification for Highway Works.

Laboratory tests carried out on samples removed from both trafficked and untrafficked zones of the pavement indicate that there were no significant differences between samples of conventional HDM and HDM containing 50 per cent reclaimed material.

TABLE 7

Results of elastic stiffness and resistance to permanent deformation of the HDM roadbases, determined using the NAT

	Stiffness MPa	Axial Strain %
Trafficking Line 2 (Post Trafficking)		
Conventional Zone	Mean 5700 Range 4500 - 7600	Mean 0.66 Range 0.49 - 1.08
Recycled Zone	Mean 4600 Range 3100 - 6000	Mean 0.85 Range 0.56 - 1.23
Trafficking Line 3 (Untrafficked)		
Conventional Zone	Mean 4500 Range 3400 - 5800	Mean 0.78 Range 0.68 - 0.88
Recycled Zone	Mean 4500 Range 3300 - 5300	Mean 0.73 Range 0.64 - 0.94

After 0.5 million equivalent standard axle applications using a super single wheel assembly and after 1.8 million equivalent standard axle applications with a dual wheel assembly, the performance of the recycled HDM was similar to that of the conventional HDM material.

The wear sustained by the pavements trafficked by the super single assembly after 0.5 million equivalent standard axle applications was 4 times greater than that produced by 1.8 million equivalent standard axles applied through the dual wheel assembly, the majority of which were at a significantly higher wheel load.

10. ACKNOWLEDGEMENTS

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