TRANSPORT RESEARCH LABORATORY

Assessment of MILLOM HITEX, the Bardon thin asphalt surface course

Prepared for Bardon Aggregates Limited

J C Nicholls

TRL REPORT 292

First Published 1998
ISSN 0968-4107

Transport Research Foundation Group of Companies
Transport Research Foundation (a company limited by guarantee) trading as Transport Research Laboratory. Registered in England, Number 3011746.

TRL Limited. Registered in England, Number 3142272.
Registered Offices: Old Wokingham Road, Crowthorne, Berkshire, RG45 6AU.

CONTENTS

	Page
Executive Summary	1
1 Introduction	3
2 Constituents of MILLOM HITEX	3
2.1 Aggregate	3
2.2 Binder	3
2.3 Mixture design	3
3 Assessment of MILLOM HITEX	4
3.1Highways Agency procedure for evaluating new materials	4
3.1.1 Stage 1, desk study	4
3.1.2 Stage 2, laboratory study	4
3.1.3 Stage 3, pilot-scale trial	4
3.1.4 Stage 4, full-scale road trial	4
3.1.5 Stage 5, specification trial	4
3.2 Properties required	4
4 Standard properties	5
4.1 Texture depth	5
4.2 Skid-resistance	6
4.2.1 SCRIM	6
4.2.2 GripTester	6
4.2.3 Pendulum	6
4.3 Profile	6
4.4 Deformation resistance	7
4.4.1 Wheel-tracking test	7
4.4.2 Repeated load creep under axial strain	8
4.5 Stiffness	8
4.6 Fatigue	9
5 Additional desirable properties	9
5.1 Thickness	9
5.2 Noise	9
5.3 Spray	10
6 Adverse properties	10
7 Durability	10
7.1 Air voids content	10
7.2 Binder content	10
7.3 Visual condition	10
8 Discussion	11

Page

9 Conclusions 12

10 Acknowledgements 12

11 References 12

Appendix A: Draft UK specification for thin surface course systems 13

Appendix B: Highways Agency procedure for evaluating new materials 14

Notes 14

Abstract 15

Related publications 15

Executive Summary

Thin surfacing systems were developed in France and brought into the United Kingdom in 1992 and initially two were approved by the Highways Agency for use on the trunk road network. To gain similar approval, other thin surfacing systems need to be assessed using the *Highways Agency 5-Stage Procedure for Evaluating New Materials* until the British Board of Agrément's *Highway Authorities Product Approval Scheme* is in operation.

MILLOM HITEX is the thin surfacing system that has been developed in the UK and is offered by Bardon Aggregates Limited. The aggregate used is an Andesitic Tuff of 14 mm nominal size and the material is laid at a nominal thickness of 30 mm, although it can be laid as thin as 20 mm. Bardon Aggregates Limited have commissioned TRL to carry out an assessment of the MILLOM HITEX thin surfacing material with reference to the *Highways Agency 5-Stage Procedure for Evaluating New Materials* using evidence from the trial length that was laid on the A635 near Doncaster and at Bushey Arches, Watford.

This review of the available data on MILLOM HITEX shows that:

- MILLOM HITEX can achieve the minimum texture depth of 1.5 mm required for new surfacings on high-speed trunk roads, although care needs to be taken to ensure the value is obtained
- MILLOM HITEX can provide the appropriate skid-resistance that would be expected with a 67 PSV aggregate, with the aggregate being fully exposed soon after laying
- MILLOM HITEX can be laid at a 30 mm nominal thickness, thereby improving the surface profile by reducing the number of irregularities
- MILLOM HITEX has good deformation resistance when measured by the wheel-tracking test at 45°C
- MILLOM HITEX has a stiffness modulus and fatigue characteristics which, while being marginally less than those for rolled asphalt, are similar to those of other thin surfacings
- MILLOM HITEX will probably generate less noise than a rolled asphalt surfacing
- MILLOM HITEX, when trafficked by 1,000 cv/l/d for two years, shows no obvious defects or signs of distress.

As such, MILLOM HITEX has successfully complied with all stages of the *Highways Agency 5-Stage Procedure for Evaluating New Materials* and has therefore gained Departmental type approval from the Highways Agency as

a thin surfacing in accordance with Clause 942AR.

1 Introduction

Thin surfacing systems were developed in France and brought into the United Kingdom in 1992. The early systems were monitored by the Transport Research Laboratory (TRL) on behalf of the Highways Agency (HA) to determine their suitability for UK conditions, in particular the requirements for skid-resistance and texture depth on high-speed trunk roads. These trials proved successful (Nicholls et al, 1995), and two thin surfacing systems were approved by the HA for use on the trunk road network through a new specification clause (Clause 942AR), reproduced as Appendix A in this report.

The Highways Agency has a 5-stage procedure for evaluating new materials which can be applied to thin surfacings. The five stages (desk study, laboratory study, pilot-scale trials, full-scale trials and HA specification trials) are described in Appendix B of this report. The first four stages can be carried out by any suitable body on behalf of the promoter of the new material; however, the HA requires that TRL evaluates the results in order to assess the stage which has been reached and advises them accordingly. The HA will give approval to use a material when they are satisfied that all stages have been successfully completed.

For thin surfacings, those systems that are being promoted and have been laid on local authority roads, or as trials on trunk roads, generally have sufficient supporting evidence to demonstrate compliance with Stages 1, 2 and 3. Stage 5, which is carried out by the HA, is unnecessary for thin surfacings because the draft specification is already available. Therefore, it is the position with regard to the Stage 4 *Full-Scale Trials* that needs to be assessed. The main points that need to be demonstrated in order for the material to comply with this stage are:

- The thin surfacing can be laid successfully with all the properties required of any wearing course (texture depth, profile, lack of surface defects, etc., as set out in the *Specification for Highway Works* (MCHW 1))
- The thin surfacing can achieve a skid-resistance value, as measured by SCRIM, above the relevant investigatory level
- The thin surfacing can maintain a texture depth of at least 1.0 mm and a skid-resistance above the relevant investigatory level after two years in service with a traffic flow of at least 1,000 commercial vehicles per lane per day, but preferably at least 2,000 cv/l/d.

  Other data on the thin surfacing system will also be useful in obtaining an overall assessment of the material.

However, HA approval is only provisional until the British Board of Agrément's *Highway Authorities Product Approval Scheme* (HAPAS), under which *Roads and Bridges Certificates* will be issued for thin surfacings, is in operation. Once HAPAS has been implemented, Departmental type approval will be withdrawn although it may be assumed that approval under the *Highways Agency 5-Stage Procedure for Evaluating New Materials* will be strong supporting evidence that a thin surfacing is suitable for a *Roads and Bridges Certificate*.

Bardon Aggregates Limited commissioned TRL to carry out an assessment of their MILLOM HITEX thin surfacing material with respect to the *Highways Agency 5-Stage Procedure for Evaluating New Materials* with particular reference to the trial length that was laid on the A635 Doncaster to Barnsley Road, together with the material laid at Bushey Arches in Watford. Most of the data provided for the assessment was derived by organisations separately commissioned by Bardon Aggregates Limited, although some measurements were carried out by Bardon Aggregates Limited.

2 Constituents of MILLOM HITEX

2.1 Aggregate

MILLOM HITEX is restricted to mixtures manufactured with selected aggregate, in particular Millom from Ghyll Scaur quarry. Millom aggregate is an Andesitic Tuff with the following properties, as measured by various laboratories:

- Relative density apparent of 2.76 Mg/m^3 and water absorption of 0.73 per cent
- Polished stone value (PSV) of between 66 and 69
- Aggregate abrasion value (AAV) of between 4 per cent and 6 per cent
- Aggregate crushing value (ACV) of 14 per cent
- Ten percent fines value of 300 kN
- Aggregate impact value (AIV) of 11 per cent
- Magnesium sulphate soundness value of 98 per cent.

The final selection of aggregate is dependant on the particular site conditions. Nevertheless, all aggregate is subject to the Net Adsorption test as developed under the Strategic Highway Research Program (SHRP) (Woodside, 1997).

2.2 Binder

The binder used to date for MILLOM HITEX is Hiplas 2 from Nynas UK AB. If other binders were used for the mixture, then they would need to have the same properties as Hiplas 2. The typical properties of Hiplas 2 (Nynas, undated) are:

- softening point (Ring and Ball) of 57^{o}C
- penetration at 25^{o}C of 65 dmm
- density at 20^{o}C of greater than unity
- minimum Flash Point (Cleveland open cup) of 200^{o}C
- viscosity at 100^{o}C of 4.5 Pa.s
- stiffness modulus at 20^{o}C in excess of 3,000 N/m^2
- recommended binder storage temperature of 180^{o}C
- long-term binder storage temperature of 155^{o}C
- usual mixing temperature of 160^{o}C.

2.3 Mixture design

The target grading for a mixture of MILLOM HITEX, as specified by Bardon Aggregates Limited, is selected from the envelope given in Table 1 for the particular plant to be used; the target grading for a typical mixture is also shown together with the tolerances to be applied to the target grading during production.

Table 1 Mixture composition of MILLOM HITEX

		Proportion of total aggregate by mass (per cent)		
		Envelope	*Typical mixture*	
			Target	*Tolerance*
Aggregate passing BS Sieve	20 mm	100	100	-
	14 mm	95 - 100	97	± 2.5
	10 mm	62 - 78	70	± 5
	6.3 mm	40 - 50	45	± 5
	5 mm	33 - 43	38	± 5
	3.35 mm	23 - 33	28	± 5
	75 μm	6.5 - 8.5	8	± 2
Binder		4.2 - 4.8	4.5	± 0.3

The maximum mixing temperature is 180°C and the minimum rolling temperature is 125°C.

The quality is controlled using analysis of samples taken from the plant. The tolerance on the bitumen content should be within ± 0.3 per cent of the target on a running mean of six determinations and no individual determination should be outside the range ± 0.5 per cent of the plant standard binder target.

3 Assessment of MILLOM HITEX

3.1 Highways Agency procedure for evaluating new materials

3.1.1 Stage 1, desk study

There has been no formal record of a desk study of the viability of MILLOM HITEX. However, the current interest in thin surfacings and the successful laying of the material on the pilot-scale (Section 3.1.3) and full-scale (Section 3.1.4) trials indicates that the understanding of the situation required from a desk study has been gained.

3.1.2 Stage 2, laboratory study

The laboratory study has been carried out as part of the various trials of MILLOM HITEX; both laboratory tests on samples taken from the trials and the compliance tests have been carried out.

3.1.3 Stage 3, pilot-scale trial

MILLOM HITEX was laid on the 3-lane quarry road to Bardon Aggregates Limited’s Heights Quarry, County Durham in April 1994. The quarry road trial is considered to be the pilot-scale trial (under the severe traffic conditions encountered in quarries) rather than a full-scale road trial because the traffic is atypical of that found on most roads and, more important, there is no control section with which to compare the performance of the thin surfacing.

3.1.4 Stage 4, full-scale road trial

Sites where MILLOM HITEX has been laid include:

- A635 Marr Village, Yorkshire
- Bushey Arches, Watford
- Trinity Road, Wandsworth
- Haltwistle by-pass, Crossovers, Northumbria
- Newton Aycliff Industrial Estate, County Durham
- Millom, Cumbria.

The A635 site, which carries approximately 1,000 commercial vehicles per lane per day (cv/l/d), has been monitored as the full-scale road trial. MILLOM HITEX was laid on the A635 site between 29 and 31 August 1995 as part of a trial organised by Doncaster Metropolitan Borough Council with sections of rolled asphalt and several other thin surfacings. Hence, there exist the independent records of performance necessary for a full-scale road trial. The other sections in this trial, which can all be considered as controls for the purposes of assessing MILLOM HITEX, are surfaced with:

- surface dressing
- ultra-thin surfacing
- stone mastic asphalt
- stone mastic asphalt with slag aggregate
- 30 per cent stone rolled asphalt with pre-coated chippings
- existing rolled asphalt.

The material laid at Bushey Arches, Watford, has been studied by Kent County Council and the results from that study are also included in the assessment.

3.1.5 Stage 5, specification trial

The Highways Agency has already produced Clause 942AR for use in specifying thin surfacings. Therefore, there is no requirement for carrying out a specification trial specifically for MILLOM HITEX.

3.2 Properties required

The requirements for a satisfactory thin surfacing material are that it should:

- be capable of providing the properties required of all surfacing materials (texture depth, skid-resistance, surface regularity, etc) (Section 4)
- provide the additional properties claimed by the promoter (noise reduction, quick construction, etc) (Section 5)
- not result in any adverse aspects (such as limited texture depth with reduced noise or vice versa; a property that can only be attained with great care, etc) which have not been identified (Section 6)

- remain durable whilst maintaining those properties referred to above compared with those of conventional surfacing materials (Section 7).

  The properties of MILLOM HITEX that have been investigated will be discussed in that order.

4 Standard properties

4.1 Texture depth

The results of texture depth measurements made by the

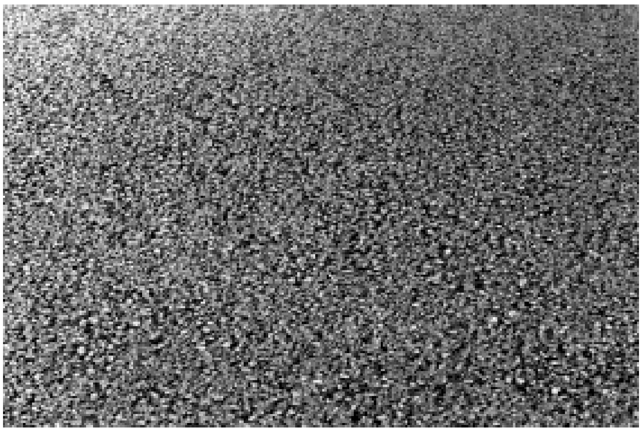

Figure 1 Texture of MILLOM HITEX after nearly 2 years on A635

sand patch method (BSI, 1990), both at Heights Quarry and on the A635 (Figure 1), are given in Table 2; the results on the A635 after 21 months and after 24 months were made by South Yorkshire Laboratory, the remainder by Bardon Aggregates Limited. The mean texture depth from six cores taken by Kent County Council from Bushey Arches prior to opening to traffic was 1.8 mm.

The values for Heights Quarry are all well in excess of the requirements in the *Specification for Highway Works* (MCHW 1) for high-speed trunk roads. The three results (each result being the average of 10 determinations) from the A635 were above the 1.2 mm minimum and averaged at the 1.5 mm mean required for each 1000 m of carriageway, although (to 2 decimal places) the mean was only marginally above this value with one of the values being below it. Therefore, MILLOM HITEX is capable of being laid with adequate texture, but care is required in the manufacture and laying in order to ensure that this requirement is met consistently.

The texture depth after 21 months had reduced by about a quarter and had a wider range; the results after 24 months were very similar. The range was variable, with the texture much higher in some parts of the site than others.

Table 2 Sand-patch texture depth results for MILLOM HITEX

Site	*Date (Age)*	*Lane*	*Chainage*	*Texture depth (mm)*	
				Mean	*Range*
Heights Quarry	April 1994 (New)	Incoming		2.0	1.5 - 2.5
		Centre		2.3	1.6 - 2.9
				1.9	1.2 - 2.4
		Outgoing		2.6	1.5 - 3.8
A635	August 1995 (New)	Eastbound	100 - 145	1.6	1.2 - 2.1
			400 - 445	1.5	1.2 - 1.8
			450 - 495	1.5	1.4 - 2.0
	May 1997 (21 months)	Eastbound	0 - 50	0.8	0.6 - 1.1
			150 - 200	0.8	0.5 - 1.1
			300 - 350	1.2	0.9 - 1.5
			450 - 500	1.2	0.8 - 1.6
			600 - 650	1.2	1.1 - 1.4
			750 - 800	1.3	1.1 - 1.5
		Westbound	0 - 50	1.2	1.1 - 1.5
			150 - 200	1.2	0.9 - 1.8
			300 - 350	1.3	1.0 - 1.6
			450 - 500	1.4	1.3 - 1.6
			600 - 650	1.2	0.9 - 1.4
			750 - 800	1.2	0.8 - 1.4
	August 1997 (24 months)	Eastbound	0 - 50	1.0	0.8 - 1.3
			150 - 200	0.8	0.4 - 1.4
			300 - 350	1.3	1.2 - 1.4
			450 - 500	1.3	1.1 - 1.8
			600 - 650	1.3	1.1 - 1.8
			750 - 800	1.3	1.0 - 1.8
		Westbound	0 - 50	1.4	1.2 - 1.6
			150 - 200	1.4	1.1 - 1.8
			300 - 350	1.2	0.8 - 1.9
			450 - 500	1.5	1.3 - 2.0
			600 - 650	1.2	0.8 - 1.4
			750 - 800	1.3	0.9 - 1.6

Table 3 Comparative sand-patch texture depth results

Material	*Max. agg. size (mm)*	*Age when tested (months)*	*Texture depth*	
			Mean (mm)	*Range (mm)*
MILLOM HITEX	14	1	1.5	1.3 - 1.8
		10	1.2	0.9 - 1.6
		21	1.2	0.5 - 1.8
Stone Mastic Asphalt	14	1	1.6	1.4 - 1.6
		10	1.2	0.9 - 1.5
Stone Mastic Asphalt with Slag Aggregate	10	1	1.3	1.0 - 1.5
		10	1.1	0.9 - 1.3
30 per cent stone HRA with chippings	14	10	1.1	0.9 - 1.4

Nevertheless, the development of texture, as measured by the sand patch method (BSI, 1990) and given in Table 3 (Guile, 1996) indicate that the texture of the MILLOM HITEX is being maintained with trafficking to the extent that would normally be expected and in a similar manner to that of the stone mastic asphalt.

4.2 Skid-resistance

4.2.1 SCRIM

Table 4 SCRIM results from A635

	SCRIM Coefficients @ 10 months (June 1996)			
	Eastbound		*Westbound*	
Material	*Mean*	*Std. dev.*	*Mean*	*Std. dev.*
MILLOM HITEX	0.44	0.035	0.50	0.031
Surface dressing	0.50	0.044	0.46	0.037
Ultra-thin surfacing	0.50	0.059	0.49	0.025
Stone mastic asphalt	0.45	0.036	0.46	0.017
Stone mastic asphalt with slag agg.	0.44	0.025	0.39	0.034
30 per cent stone HRA with chippings	0.38	0.028	0.36	0.045
Existing rolled asphalt	0.55	0.022	0.58	0.021

The A635 has not been regularly monitored with a sideway force coefficient routine investigation machine (SCRIM) (Hosking, 1996). However, one run was made in June 1996 by Doncaster Metropolitan Council and the results are given in Table 4. The differences in the skid resistance properties are primarily attributable to the properties of the aggregates used in the different materials.

4.2.2 GripTester

Although only limited SCRIM results are available, GripTester surveys were carried out by Durham County Council, both at Heights Quarry and on the A635 (Table 5). The GripNumbers can be converted to equivalent SCRIM coefficients.

The results indicate that the GripNumbers, and hence the probable values of SCRIM coefficient, for MILLOM HITEX were initially greater than those for the stone mastic asphalt and similar to that of the ultra-thin surfacing. The relative performance is, however, dependent on the aggregates used, with the relatively low GripNumbers for the stone mastic asphalt slag aggregate probably being due to the aggregate used.

Plotting out (equivalent) SCRIM coefficient against time (Figure 2) shows that, within the normal seasonal variations, the skid-resistance of MILLOM HITEX is being maintained with trafficking in a similar manner to the other thin surfacings. However, there has not been sufficient time for the mean summer SCRIM coefficient (MSSC) to have reached an equilibrium level.

Table 6 Skid-resistance value at Bushey Arches

	Skid resistance value at 20°C	
	On wet surface	*On dry surface*
Values	67, 66, 73, 67, 61, 60	* , * , * , * , 95, 96
Mean	66	96

** Not measured*

4.2.3 Pendulum

The skid resistance was measured by Kent County Council on six cores taken from Bushey Arches prior to opening to traffic using the portable skid-resistance pendulum (RRL, 1960). The results on both a wet and dry surface are given in Table 6, which show good resistance with average values of 66 on a wet surface and 96 on a dry surface.

Table 5 GripTester results

Heights Quarry		*Speed corrected GripNumber*		*Equivalent SCRIM coefficient**	
Material	*Lane*	*Feb. '95 (10 month)*	*Mar. '96 (23 month)*	*Feb. '95 (10 month)*	*Mar. '96 (23 month)*
MILLOM HITEX	Entry	0.78	0.72	0.57	0.52
	Mid.	0.79	0.75	0.57	0.54
	Exit	0.75	0.77	0.54	0.56

A635		*Speed corrected GripNumber*			*Equivalent SCRIM coefficient**		
Material	*Lane*	*Nov. '95 (3 month)*	*Mar. '96 (7 month)*	*Feb. '97 (18 month)*	*Nov. '95 (3 month)*	*Mar. '96 (7 month)*	*Feb. '97 (18 month)*
MILLOM HITEX	East	0.74	0.86	0.84	0.53	0.63	0.61
	West	0.69	0.88	0.80	0.50	0.65	0.58
Ultra-thin surfacing	East	0.75	0.86	0.89	0.54	0.63	0.65
	West	0.79	0.85	0.77	0.57	0.62	0.56
Stone mastic asphalt	East	0.60	0.84	0.86	0.42	0.61	0.63
	West	0.60	0.84	0.79	0.42	0.61	0.57
SMA with slag agg.	East	0.64	0.76	0.77	0.46	0.55	0.56
	West	0.66	0.70	0.69	0.47	0.50	0.50

** Based on SCRIM coefficient = 0.789 x GripNumber - 0.049*

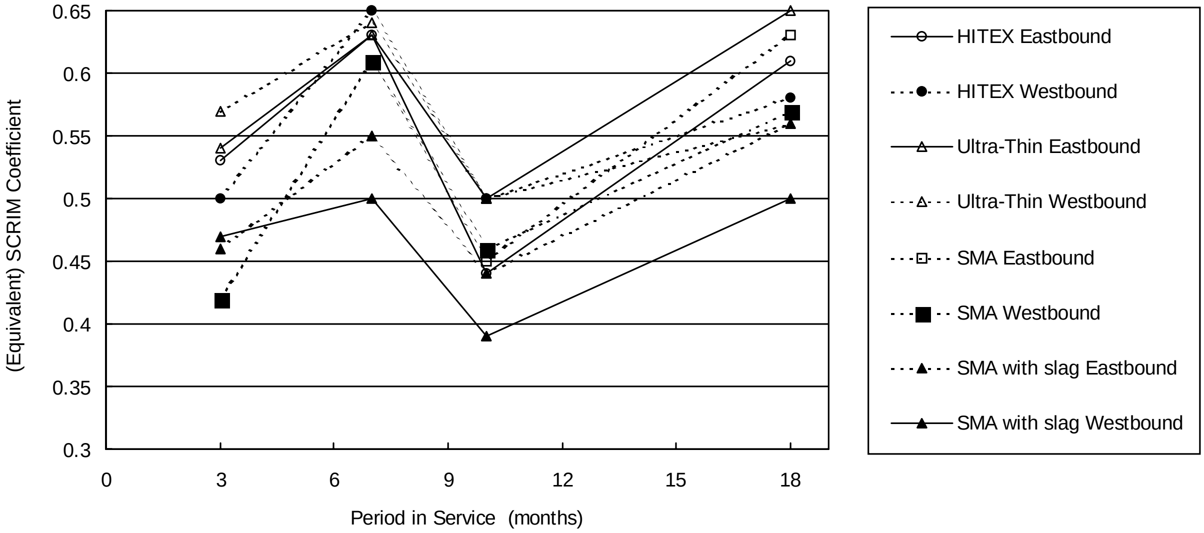

Figure 2 Skid-resistance of thin surfacings on A635

Table 7 Surface irregularity results

			Number of surface irregularities		
Material	*Lane*	*Age*	*4 mm*	*7 mm*	*10 mm*
Maximum permitted for	300 m length		20	2	-
category A roads (*SHW*)	75 m length		9	1	-
MILLOM HITEX	Eastbound	Before	45	3	0
		1 month	3	0	0
		10 months	2	0	0
	Westbound	Before	43	5	1
		1 month	5	0	0
		10 months	3	1	0
Ultra-thin surfacing	Eastbound	10 months	23	5	0
	Westbound	10 months	26	2	0
Stone mastic asphalt	Eastbound	Before	105	14	7
		1 month	5	1	0
		10 months	4	2	0
	Westbound	Before	104	10	3
		1 month	3	1	0
		10 months	3	1	0
Stone mastic asphalt with slag aggregate	Eastbound	1 month	16	1	0
		10 months	11	2	0
	Westbound	1 month	18	2	0
		10 months	15	2	0
30 per cent stone rolled asphalt with pre-coated chippings	Eastbound	10 months	128	24	6
	Westbound	10 months	92	17	2

4.3 Profile

The results from the rolling straightedge on the trial sections on the A635 are given in Table 7 (Guile, 1996) and show that the MILLOM HITEX, amongst others, complied with the requirements of Clause 702 of the *Specification for Highway Works* (MCHW 1) when laid along the 902 m length. This uniformity was a significant improvement over that for the substrate and has been maintained over the first ten months, supporting the deformation resistance found from the wheel-tracking test (Section 4.4).

The surface regularity with MILLOM HITEX produced a significant improvement in the profile, as did the stone mastic asphalt, which started with twice as many irregularities but finished with a comparable number. Of all the treatments used, the rolled asphalt, with a length of 700 m, produced the poorest surface regularity when measured after 10 months, but there is no information on

Table 8 Wheel-tracking data from cores

Site	*Thick -ness (mm)*	*Bulk density (Mg/m³)*	*Air voids (per cent)*	*Wheel-tracking* Rate @ 45°C (mm/h)	*Wheel-tracking* Rut @ 60°C (mm/h)	*Wheel-tracking* Rut after 2 h @ 45°C (mm)
Heights Quarry	26	1.92	24.2	1.8	-	6.5
	28	1.96	22.7	0.4	-	1.6
	30	2.06	18.7	1.2	-	4.6
	32	2.15	15.2	0.4	-	1.5
	32	1.97	22.3	0.2	-	0.8
	32	2.06	18.7	0.5	-	1.7
	34	2.09	17.5	0.3	-	1.2
	36	1.99	21.5	0.4	-	2.0
	39	2.04	19.5	0.8	-	*
	40	2.14	15.5	2.2	-	*
	42	2.11	16.7	0.6	-	3.2
	45	2.09	17.5	1.1	-	4.0
Mean	35	2.05	19.2	0.8	-	2.7
A635	27	2.50 †	2.5 †	0.10	-	
	30	2.35	8.5	0.13	-	
	30	2.34	8.7	0.28	-	
	32	2.34	8.7	0.09	-	
	32	2.37	7.7	0.06	-	
	33	2.37	7.7	0.32	-	
Mean	31	2.38	7.3	0.16	-	
Mean ‡		2.35	8.3			
Bushey Arches	-	2.43	4.1	-	0.9	
	-	2.43	3.8	-	0.7	
	-	2.44	3.6	-	1.4	
	-	2.40	5.3	-	0.7	
	-	2.45	3.2	0.3	-	
	-	2.42	4.5	0.6	-	
Mean	-	2.43	4.1	0.4	1.0	

** Initial tracking data corrupted; no result*
† Suspect result
‡ Without suspect result

the initial condition of this section.

4.4 Deformation resistance

4.4.1 Wheel-tracking test

Wheel-tracking tests (BSI, 1996a) have been carried out on cores from Heights Quarry by SWK Pavement Engineering at 45°C, from the A635 by Surrey County Council at 45°C and from Bushey Arches by Kent County Council at both 45°C and 60°C; the results are given in Table 8.

The results from Heights Quarry gave a mean value less than half the 2 mm/h maximum at 45°C allowed for rolled asphalt to Class 1 in Clause 943AR (Highways Agency, 1996); those from the A635 were significantly less at 0.16 mm/h. A material which gives a wheel-tracking result of 0.16 mm/h at 45°C would be expected to have a wheel-tracking result that was at or below the maximum limit of 5 mm/h at 60°C for the more heavily trafficked Class 2 roads. The results from Bushey Arches confirm that the material can comply with wheel-tracking requirements of Class 2 in Clause 943.

The bulk density of the Heights Quarry cores were significantly less, and the air voids contents greater, than the A635 and Bushey Arches cores, which is consistent with the greater deformation resistance of the latter. However, there is no information as to whether the apparent ability to compact the material more efficiently was due to improved rolling techniques, to minor modifications in the grading or because the method of measurement used on the Heights Quarry cores included ‘surface voids’ whereas that used on the other cores did not (Section 7.1). Given the large difference, it is assumed to be a different measurement method producing more apparent voids in the mixture.

4.4.2 Repeated load creep under axial strain

Both the dynamic (BSI, 1996b) and static (BSI, 1995) repeated load creep under uniaxial strain at 30°C were measured by Kent County Council on two cores taken from Bushey Arches prior to opening to traffic. The mean results were 1.4 per cent after 1800 load pulses for dynamic creep and 1.1 per cent after 3600 s with an axial stress of 100 kPa. These results indicate a relatively high resistance to deformation.

Table 9 Indirect tensile stiffness modulus results

Site	*Thickness (mm)*	*Bulk density (Mg/m³)*	*Air voids (per cent)*	*Stiffness @ 20°C (GPa)*
Heights Quarry	33	1.95	23.1	0.85
(New)	34	2.06	18.7	2.28
	36	1.96	22.7	1.21
	40	2.06	18.7	1.92
	40	2.01	20.7	0.70
	43	2.17	14.4	1.42
	43	2.16	14.8	1.33
	45	2.12	16.3	1.57
	48	2.01	20.7	1.13
Mean	40	2.06	18.9	1.38
Heights Quarry	-	-	-	2.46
(3 years)	-	-	-	2.50
	-	-	-	2.41
	-	-	-	1.51
	-	-	-	2.58
	-	-	-	2.34
Mean	-	-	-	2.30
A635	26	2.25	12.3	1.20
(New)	27	2.23	13.1	1.62
	29	2.20	14.2	1.38
	29	2.22	13.5	1.90
	30	2.17	15.4	1.92
	30	2.21	13.8	1.56
Mean	29	2.21	13.7	1.60
A635	26	-	-	1.65
(New)	27	-	-	1.40
	27	-	-	1.83
Mean	27	-	-	1.63
Bushey Arches	-	2.42	1.4	1.36
(New)	-	2.44	0.6	0.94
	-	2.40	1.1	1.10
	-	2.42	0.5	1.33
Mean	-	2.42	0.9	1.18

4.5 Stiffness

The indirect tensile stiffness modulus (BSI, 1993) of MILLOM HITEX has been carried out on cores from Heights Quarry by SWK Pavement Engineering, from the A635 by SWK Pavement Engineering and Lincs Lab and from Bushey Arches by Kent County Council soon after laying; further tests were carried out on cores from Heights Quarry after 3 years in service by Weeks Materials Consultancy. The results are given in Table 9.

The A635 cores had a mean stiffness modulus of 1.6 GPa whilst those from Heights Quarry, with the lower bulk density (Section 4.4), was 1.4 GPa rising to 2.3 GPa after 3 years; the mean stiffness of the Bushey Arches cores, with the highest bulk density, was the lowest at 1.2 GPa. Hence, the initial values for MILLOM HITEX are of the same order as that of other surfacing materials but less than that of stone mastic asphalt at the TRL trial sites (Nunn, 1994) with 2.0 GPa (4 tests) using 50 pen bitumen and 1.7 GPa (single result) using 100 pen bitumen. This difference between MILLOM HITEX and stone mastic asphalt is not due to ageing as both materials were tested about 3 months after laying. Nevertheless, the stiffness is of secondary importance for wearing courses.

4.6 Fatigue

The fatigue properties of MILLOM HITEX have been measured on laboratory-prepared samples by Liverpool University, on cores from Heights Quarry and from the A635 by SWK Pavement Engineering and on cores from Bushey Arches by Kent County Council. The results are shown graphically in Figure 3, which also show typical curves for 30/14 rolled asphalt and 28 mm dense bitumen macadam basecourse for comparison.

The results indicate that the material taken from the roads is not as good in fatigue as rolled asphalt but equivalent to dense bitumen macadam. This ranking order is consistent with the relative binder contents. The fatigue properties of the laboratory-prepared samples are superior to those of the samples from site, but this may be due to the greater control applied when manufacturing them.

Overall, the fatigue properties appear consistent with other surfacing materials. However, this conclusion is of secondary importance because MILLOM HITEX is to be used as a wearing course material for which fatigue is not normally a mode of deterioration.

5 Additional desirable properties

5.1 Thickness

Bardon Aggregates Limited claim that MILLOM HITEX should be laid at a nominal thickness of 30 mm but can be laid as thin as 20 mm. The thickness of the cores tested from the Height Quarry road varied from 26 mm to 45 mm whilst those from the A635 varied from 26 mm to 33 mm (see Tables 8 and 9). Therefore, MILLOM HITEX can be laid successfully as a thin wearing course at a nominal 30 mm thickness.

Table 10 Noise measured from the roadside at the A635

	Sound levels (dB(A))					
Material	L_1	L_{10}	L_{50}	L_{90}	L_{99}	L_{eq}
MILLOM HITEX	78.4	71.4	59.3	50.0	46.3	67.5
Ultra-thin surfacing	81.1	75.7	67.1	55.2	49.6	71.3
Stone mastic asphalt	75.5	68.7	59.2	50.2	45.5	70.9
SMA with slag aggregate	80.4	74.4	64.5	53.4	47.8	65.0
30 per cent stone rolled asphalt with pre-coated chippings	79.4	75.1	67.5	57.2	51.0	71.3

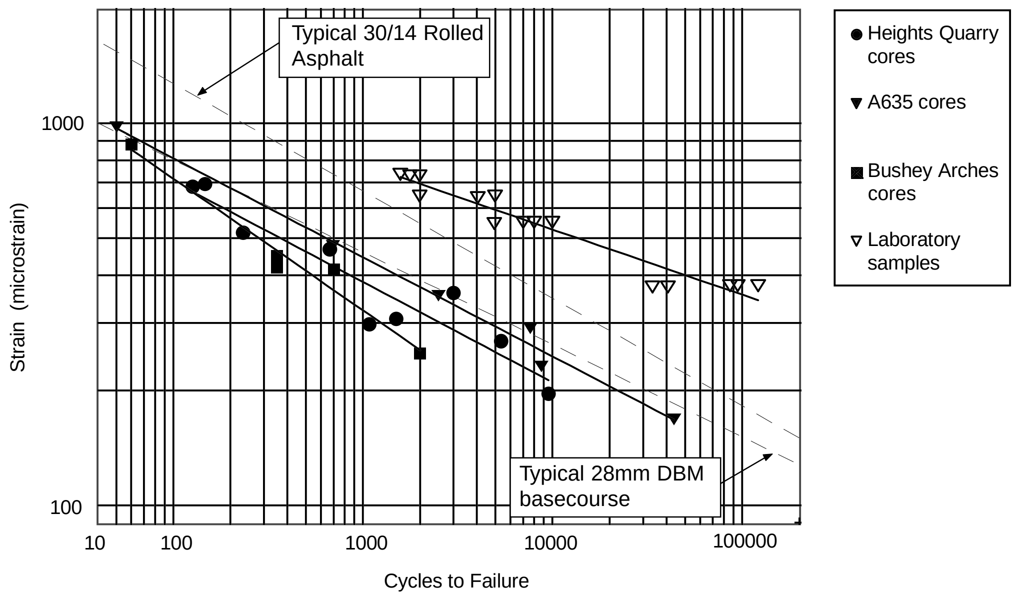

Figure 3 Indirect tensile fatigue test results

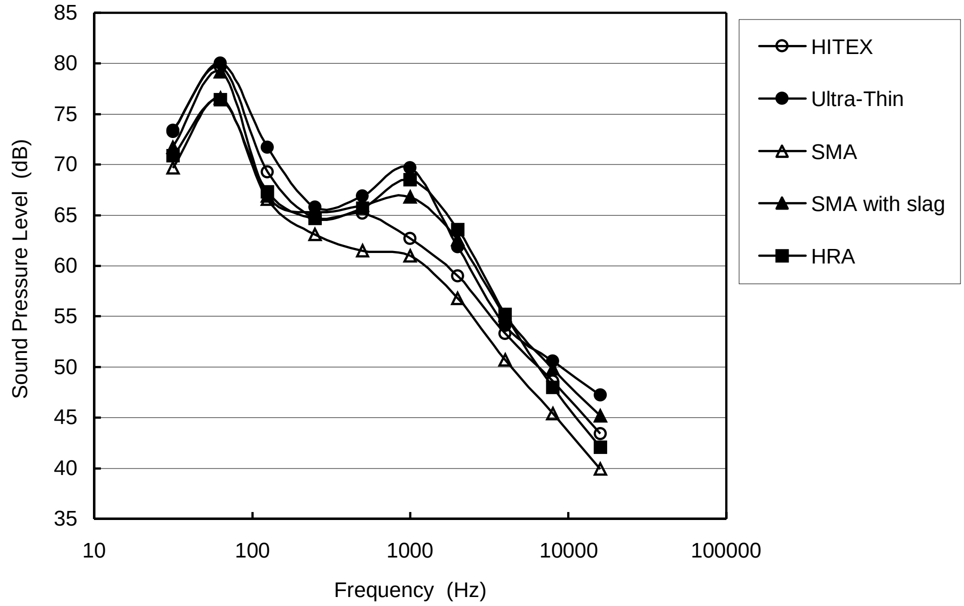

Figure 4 Octave band analysis of sound pressure levels

5.2 Noise

Noise measurements were made by Ulster University on the A635 for several of the trial sections. The results (Table 10 and Figure 4) for the MILLOM HITEX were marginally better than the ultra-thin surfacing and rolled asphalt sections on this site but marginally worse than the stone mastic asphalt or the stone mastic asphalt with slag aggregate, depending on the measure used. The MILLOM HITEX section was 3.7 dB(A) at L_{10}, 3.8 dB(A) at L_{eq}, quieter than the rolled asphalt section while the stone mastic asphalt was 6.4 dB(A) at L_{10}, 0.4 dB(A) at L_{eq}, quieter and the stone mastic asphalt with slag aggregate section was 0.7 dB(A) at L_{10}, 6.3 dB(A) at L_{eq}, quieter than the rolled asphalt section. The result is consistent with results from TRL trials for the Highways Agency, in which stone mastic asphalt appears to be the 'best' of the thin surfacings.

Table 11 Relative hydraulic conductivity results

	Chainage (Eastbound)		
Site	*30 - 70*	*100 - 145*	*400 - 445*
A635	0.03 s^{-1}	0.02 s^{-1}	0.05 s^{-1}
	0.02 s^{-1}	0.04 s^{-1}	0.05 s^{-1}
	0.02 s^{-1}	0.04 s^{-1}	0.06 s^{-1}
	0.03 s^{-1}	0.03 s^{-1}	0.05 s^{-1}
	0.03 s^{-1}	0.07 s^{-1}	0.06 s^{-1}
Mean	0.03 s^{-1}	0.04 s^{-1}	0.05 s^{-1}

5.3 Spray

The relative hydraulic conductivity of MILLOM HITEX was measured on the A635 by Bardon Aggregates Limited with the results given in Table 11. The mean value of 0.04 s^{-1} is intermediate between that of rolled and porous asphalts, which implies that the material will probably have less water on the surface during rainfall so that less will be picked up by vehicle tyres as spray. However, most 'negative-textured' materials tend to exhibit this property.

6 Adverse properties

No particular adverse factors, other than the possible need for care to achieve the required initial texture depth of 1.5 mm sand patch (see Section 4.1), have been found.

7 Durability

7.1 Air voids content

The mean air voids content for the cores taken from the A635 (Table 8) is high whilst calculation using the bulk density for the cores tested for the fundamental properties gives an even higher mean air voids content (Table 9). The difference is too great to be random experimental error, and indicates some differences in the procedure between the two laboratories in calculating bulk density. The cores included some of the substrate to bring the sample thickness to 35 mm, which may have affected the result, but this would not have been expected to increase the voids content to that extent. It is more likely to be due to the technique of wrapping the specimen in self-adhesive aluminium foil, which encapsulates some of the surface voids.

7.2 Binder content

The binder content is relatively low compared with stone mastic asphalt, with limits of 4.2 to 4.8 per cent for MILLOM HITEX and 6.5 to 7.5 per cent for 14 mm stone mastic asphalt according to the draft Highways Agency clause (Nunn, 1994). Whilst low binder contents do not, necessarily, indicate poor durability, binder content for a particular mixture type is often used as a surrogate for durability because there is generally a strong correlation. The use of a polymer-modified binder may counterbalance the general adverse effect of low binder content on durability, although this presumes that the binder maintains its properties with time.

7.3 Visual condition

Site visits were made to the A635 site in August 1996 (after one year) and May 1997 (after two years). On the first inspection, all the trial sections along the A635 were in generally good condition, with only the minor blemishes that would normally be expected to occur over the length of the site; the MILLOM HITEX section was in particularly good condition. The coarse aggregate on the surface was more exposed on the MILLOM HITEX section than on the others, where the aggregate still appeared to be fully coated with binder. Hence, the MILLOM HITEX section should be more effectively utilising the micro-texture of the aggregate at an early stage. This effect is probably the result of the relatively low binder content of MILLOM HITEX; there was no indication that the low binder content will have an adverse effect on durability.

The second site inspection showed that the material was still in good visual condition with no obvious physical defects, despite the damp conditions, which would be expected to highlight any differences. There was no indication that the low binder content will have an adverse effect on durability. A blemish that was observed (Figure 5) was the apparent loss of texture in lengths between the wheel paths but, because this also continued into the adjacent section with a different surfacing, the cause is assumed to be associated with the condition of the substrate (possibly a slight excess of binder in the surfacing dressing that had not been worn off and is now filling the voids). This observation is classified as only a minor blemish because it did not show up in the texture depth results taken at about the same time.

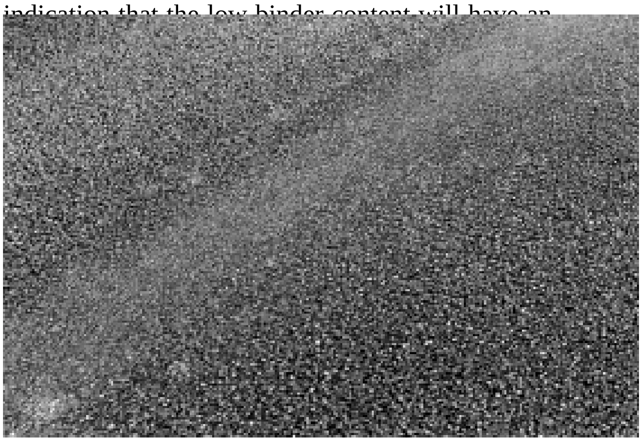

Figure 5 Difference in texture depth across lane of A635 after 2 years

8 Discussion

The range of parameters that have been measured for MILLOM HITEX is relatively extensive, some being important to validate the general use of the material whilst others indicate the additional value that can be gained from using this material. The important material parameters that have been demonstrated are:

- resistance to permanent deformation - a mean wheel-tracking rate of 0.8 mm/h at 45°C, which is suitable for traffic levels up to 17,000 cv/l/d (Szatkowski & Jacobs, 1977) from the early trials and 0.16 mm/h at 45°C, nominally suitable for traffic levels up to 87,000 cv/l/d, from the A635
- rugosity - a mean sand-patch texture depth 2.1 mm from the pilot-scale trial and 1.5 mm from the full-scale road trial prior to opening to traffic, which reduced to 1.2 mm after 2 years in-service
- skid-resistance - (as measured by SCRIM and GripTester) consistent with similar materials although the actual values, which vary with season, cannot be usefully quoted because sufficient measurements have not been made in any year to obtain the mean summer SCRIM coefficients (MSSC).

Because measurements of skid-resistance are dependent on the properties of the aggregate, a high PSV aggregate is required to provide adequate skid-resistance on heavily trafficked sites; the aggregate used in MILLOM HITEX is suitable for this purpose.

Visual observation shows that, after two years, there is no indication of any lack of durability. However, the binder content is relatively low at 4.5 $\pm$ 0.3 per cent and the air voids content relatively high at between 8 and 19 per cent (depending on method of measurement). These values are similar to those for porous asphalt (although the hydraulic conductivity is mid-way between that of porous asphalt and conventional impermeable surfacing materials), which has proven durable at the specified binder content for MILLOM HITEX (Nicholls, 1997).

The properties examined that indicate the particular benefits of using MILLOM HITEX are:

- the reduced thickness (30 mm) at which the material can be laid relative to that for conventional rolled asphalt
- the potential for reduced spray generated relative to conventional surfacings (although less than that on porous asphalt)
- the reduced noise being generated relative to conventional surfacings (although not less than that generated on porous asphalt).

Overall, MILLOM HITEX can be laid thinner than a ‘traditional’ wearing course which, combined with there being no need to apply pre-coated chippings, makes it potentially more economic and quicker to apply than rolled asphalt at 40 mm to 50 mm thick. The finished surfacing should also be quieter, produce less spray and the profile should be improved.

With regard to the fundamental properties, the stiffness modulus of MILLOM HITEX is about 1.6 GPa, which is of the same order as other surfacing materials, whilst the fatigue properties are marginally inferior to that of rolled asphalt. However, both these properties are not usually required of the surfacing layer, only when the surfacing is used to contribute towards the structural strength of the pavement.

The trial length of MILLOM HITEX laid at Heights Quarry is considered to have been a successful Stage 3 pilot-scale trial and the trial length of MILLOM HITEX laid on the A635 Barnsley to Doncaster road at Marr Village is considered to have been a successful Stage 4 full-scale road trial. Therefore, MILLOM HITEX has completed the Highways Agency 5 stage procedure for evaluating new materials and is suitable for Departmental type approval for use with Clause 942AR.

9 Conclusions

The principal conclusion from this review of data on MILLOM HITEX is that the material has completed the Highways Agency 5 stage procedure for evaluating new materials and is suitable for Departmental type approval for use with Clause 942AR. In particular:

1 MILLOM HITEX can achieve the minimum texture depth of 1.5 mm required for high-speed trunk roads, although care needs to be taken to ensure that the value is maintained.

2 MILLOM HITEX can provide the appropriate skid-resistance that would be expected with a 67 PSV aggregate, with the aggregate being fully exposed soon after laying.

3 MILLOM HITEX can be laid at a 30 mm nominal thickness and improve the surface profile by reducing the number of irregularities.

4 MILLOM HITEX has good deformation resistance properties, as measured by the wheel-tracking test at 45°C and at 60°C.

5 MILLOM HITEX has a stiffness modulus and fatigue characteristics which, while being marginally less than rolled asphalt, are of the same order as those of similar materials.

6 MILLOM HITEX appears to generate less noise than a rolled asphalt surfacing.

7 MILLOM HITEX, when trafficked by 1,000 cv/l/d for two years, shows no obvious defects or any signs of distress.

Based on this assessment, the Highways Agency has granted Department type approval for use with Clause 942AR to MILLOM HITEX.

10 Acknowledgements

The work described in this paper was carried out in the Civil Engineering Resource Centre (Resource Centre Manager, Mr P G Jordan) of the Transport Research Laboratory with Mr J C Nicholls as Project Manager and Mr D M Colwill as Quality Audit and Review Officer.

11 References

Manual of Contract Documents for Highway Works. *Volume 1: Specification for Highway Works (MCHW 1)*. Her Majesty's Stationery Office, London.

British Standards Institution (1990). *Sampling and Examination of Bituminous Mixtures for Roads and Other Paved Areas: Part 105, Methods of Test for the Determination of Texture Depth.* BS 598: Part 105: 1990. British Standards Institution, London.

British Standards Institution (1993). *Methods of Test for Determination of the Indirect Tensile Stiffness Modulus of Bituminous Mixtures*. BS DD 213: 1993, British Standards Institution, London.

British Standards Institution (1995). *Sampling and Examination of Bituminous Mixtures for Roads and Other Paved Areas: Part 111, Method for Determination of Resistance to Permanent Deformation of Bituminous Mixtures Subject to Unconfined Uniaxial Loading*. BS 598: Part 111: 1995, British Standards Institution, London.

British Standards Institution (1996a). *Sampling and Examination of Bituminous Mixtures for Roads and Other Paved Areas: Part 110, Methods of Test for the Determination of Wheel-Tracking Rate*. BS 598: Part 110: 1996, British Standards Institution, London.

British Standards Institution (1996b). *Method for Determining Resistance to Permanent Deformation of Bituminous Mixtures Subject to Unconfined Dynamic Loading.* BS DD 226: 1996, British Standards Institution, London.

Guile D (1996). *Thin Layer Trial A635 Doncaster to Barnsley Road between Marr and Hickleton Villages.* University of Ulster Seminar: The Next Generation of Highway Surfacings. Doncaster Metropolitan Borough Council.

Highways Agency (1996). *Clause, 943: Hot Rolled Asphalt Wearing Course (Performance-Related Design Mix).* Draft Specification Clause. Department of Transport.

Hosking R (Ed.) (1996). *Highways: Principles to Practice.* TRL Report 234. Transport Research Laboratory, Crowthorne.

Nicholls J C, Potter J F, Carswell J and Langdale P (1995). *Road Trials of Thin Wearing Course Materials.* Department of Transport TRL Project Report 79. Transport Research Laboratory, Crowthorne.

Nicholls J C (1997). *Review of UK Porous Asphalt Trials.* TRL Report 264, Transport Research Laboratory, Crowthorne.

Nunn M E (1994). *Evaluation of Stone Mastic Asphalt (SMA): A high stability wearing course material.* Department of Transport TRL Project Report 65, Transport Research Laboratory, Crowthorne.

Nynas UK AB (undated). *Hiplas 2, Polymer Modified Binder for Thin Overlays*. Product Data Sheet, Nynas UK AB.

Road Research Laboratory (1960). *Instructions for using the portable skid-resistance tester.* Department of Scientific and Industrial Research, Road Note No. 27. Her Majesty's Stationery Office, London.

Szatkowski W S and Jacobs F A (1977). *Dense Wearing Courses in Britain with High Resistance to Deformation.* Colloquium 77, Plastic deformability of bituminous mixes, pp 65-67. Zurich.

Woodside A R (1997). *Asphalt Surfacings; Chapter 2, Aggregates and Fillers.* Asphalt Surfacings, Editor J C Nicholls. E & F N Spon, London.

Appendix A: Draft UK specification for thin surface course systems

1 Thin wearing course systems shall comply with sub-Clauses 2 to 26 of this Clause and the requirements of Appendix 7/1.

2 Thin wearing course systems shall have a British Board of Agrément Roads and Bridges Certificate. In the event that no such Certificates have been issued, thin wearing course systems shall have Departmental type approval.

Aggregates and filler

3 Coarse aggregate shall be crushed rock complying with Clause 901 and BS 63: Part 2: Table 2, unless agreed otherwise by the Engineer before commencement of work.

4 When tested in accordance with the procedure of BS 812, the coarse aggregate shall additionally have the following properties:

Polished Stone Value (PSV) - as specified in Appendix 7/1.

Ten Per Cent Fines Value (TPV) - not less than 180 kN, or as specified in Appendix 7/1.

Maximum Aggregate Abrasion Value (AAV) - not more than 12, or as specified in Appendix 7/1.

Flakiness Index (I_F) - not more than 25 per cent.

5 Fine aggregate shall comply with Clause 901 and shall be either crushed rock fines or natural sand or a blend of both. Fine aggregate shall be added as required to suit the particular system.

6 Filler shall be crushed limestone complying with the requirements of BS 594: Part 1. Filler shall be added as required to suit the particular system.

7 When sampled and tested in accordance with the procedures of BS 598: Parts 100, 101 and 102, the aggregate grading shall fall within the envelope formed by the limits given in Table A1, unless agreed otherwise by the Engineer before the commencement of work.

8 The design and selection of aggregates, filler and bitumen proportions shall be the responsibility of the Contractor, who shall supply the necessary details to the Engineer for information only.

Table A.1 Aggregate grading

	Per cent by mass of total aggregate passing	
	Nominal size	
BS Sieve size	*14 mm*	*10 mm*
20 mm	100	
14 mm	80 - 100	100
10 mm	50 - 80	55 - 100
6.3 mm	15 - 50	20 - 55
5.0 mm	10 - 45	15 - 55
2.36 mm	8 - 45	15 - 45
1.18 mm	7 - 30	10 - 35
600 µm	5 - 25	7 - 30
300 µm	5 - 20	5 - 25
75 µm	0 - 15	0 - 15

Binder

9 The binder shall be petroleum bitumen complying with BS 3690: Part 1. The penetration of the bitumen shall be grade 70, 100 or 200 penetration, as selected by the Contractor, unless stated otherwise in Appendix 7/1. A polymer may be added, as selected by the Contractor.

10 The choice of bitumen grade and the penetration and softening point of the modified or unmodified binder shall be notified to the engineer before the commencement of work.

11 When sampled and tested in accordance with the procedures of BS 598: Parts 100, 101 and 102, the binder content of the surfacing material shall be in the range 3.5 to 7.5 per cent, by mass of total mixture.

12 Where appropriate to the system, the target binder content shall be determined by the binder drainage test in Clause 939, except that the range to be tested shall be amended to suit the grading of the aggregates proposed for use. The target binder content determined in the laboratory may be adjusted to suit the mixing plant and the aggregate type which is used, subject to plant trial and delivery distance. The adjusted binder content shall be notified to the Engineer prior to delivery and shall not be lower than that specified above. The tolerance on sampling and testing for binder content shall be ± 0.3 per cent.

Tack coat

13 Tack coat shall be a hot-applied cationic bitumen emulsion complying with BS 434: Part 1, with a minimum bitumen content of 38 per cent. To suit the particular system, it may be modified with a polymer. The choice of tack coat shall be notified to the Engineer before commencement of work.

Surface preparation

14 Existing surfaces shall be cleaned using steel brooms and suction sweeping or other appropriate means. The

surface may be moist but not wet; standing water shall not be present. All mud, dust, dirt and other debris and organic material shall be removed.

15 Where necessary or required by the Engineer, existing surfaces shall be regulated in accordance with the requirements of Clause 907, in advance of laying surfacing material to this clause.

16 Unless raised prior to surfacing, iron-work and reflecting road studs shall be located for lifting and relaying after completion of surfacing works. Gullies shall be covered prior to surfacing.

17 Where possible, existing road markings shall be removed.

Mixing

18 The material shall be mixed in accordance with the requirements of BS 4987: Part 1, such that an homogeneous mixture of aggregate, filler and bitumen is produced at a temperature of 150 - 180 degrees C.

Transportation

19 Mixed materials shall be protected from contamination and undue heat loss by being transported to site in sheeted lorries. To facilitate discharge of the materials, the floor of the lorry may be coated with the minimum of light vegetable oil or liquid soap or other non-solvent solution. When such coating is used, the lorry body shall be tipped to its fullest extent with the tailboard open to ensure drainage of any excess, prior to loading. The floor and sides of the lorry shall be free from adherent bituminous materials or other contaminants before loading the surfacing material.

Laying

20 Tack coat shall be spray-applied, in accordance with the requirements of the SHW Series 900, at a rate selected by the Contractor and notified to the Engineer before the commencement of work, to completely cover the surface where the material is to be placed. The particular spray rate shall be dependent on the proprietary system and the porosity of the surface being covered.

21 Bituminous materials shall be applied at a suitable temperature and compacted by at least two passes of a tandem roller, capable of vibration, and with the minimum deadweight of 6 tonnes, before the material cools below 80 degrees C, measured at mid-layer depth.

Surface texture

22 Where stated in Appendix 7/1, the texture depth of the surfacing shall be in accordance with the requirements of Clause 921 after compaction.

Details to be supplied

23 The Contractor shall supply all the details required in this Clause to the Engineer before commencement of work under this Clause and when requested during the work.

24 Checks shall be made at the end of each working day and records kept, to determine the quantities used of both tack coat and bituminous material.

25 The Contractor shall supply the Engineer with test certificates stating the properties of the materials used. Samples of emulsion tack coat, modified or unmodified bitumen or mixed bituminous materials from either the spray bar or storage tank or the pavement surface or other suitable sampling point shall also be supplied to the Engineer by the Contractor when so instructed by the Engineer.

Guarantee

26 The Contractor shall guarantee the surfacing materials and workmanship for a period of two years from the date of opening the surfacing to traffic. This guarantee shall exclude defects arising from damage caused by settlement, subsidence or failure of the carriageway on which the material has been laid, but shall include for fretting, stripping, loss of chippings and loss of texture to below 1 mm measured by the sand patch method described in BS 598: Part 105.

Appendix B: Highways Agency procedure for evaluating new materials

The procedure for evaluating new materials is carried out in 5 stages.

Stage 1 **Desk study**
Assess and evaluate existing information on the material.

Stage 2 **Laboratory study**
Test the mechanical properties of materials to allow theoretical predictions to be made of their performance.

Stage 3 **Pilot-scale trials**
Evaluation of construction and performance of materials in small scale trials.

Stage 4 **Full-scale trials**
Full-scale trial on a trunk road to establish whether the previous assessments obtained from Stages 2 and 3 are realised.

Stage 5 **HA specification trials**
This stage is necessary to carry out further evaluation of the material and to test the specification under contract conditions.

Notes

[1] Stages 1 to 4 are financed by the manufacturer of the material. For Stage 5 the additional cost, if any, of the material is borne by the manufacturer.

[2] Stages 1 to 4 can be carried out by the TRL or other independent organisation. In the latter case, the reports are appraised by the TRL.

[3] In all cases, the new materials are compared with conventional materials to obtain comparative

Abstract

Proprietary thin surfacings are being offered by materials suppliers in the United Kingdom, including MILLOM HITEX by Bardon Aggregates Limited. Information on MILLOM HITEX, with particular emphasis on the material laid in a trial by Doncaster Metropolitan Borough Council on the A635 together with a section laid at Bushey Arches, Watford, has been assessed and it has been found that MILLOM HITEX has complied with all stages of the *Highways Agency 5-Stage Procedure for Evaluating New Materials*. Based on this assessment, the Highways Agency has granted MILLOM HITEX Departmental type approval for use as a thin surfacing in accordance with Clause 942AR.

Related publications

TRL264 *Review of UK porous asphalt trials* by J C Nicholls. 1997 (price code H, £30)

TRL250 *Design of long-life flexible pavements for heavy traffic* by M E Nunn, A Brown, D Weston and J C Nicholls. 1997 (price code L, £40)

TRL234 *Highways: principles to practice,* edited by R Hosking. 1997 (price code P, £50)

TRL218 *Assessment of AXOFLEX, the Redland thin asphalt surface course* by J C Nicholls. 1997 (price code E, £20)

PR79 *Road trials of thin wearing course materials* by J C Nicholls, J F Potter, J Carswell and P Langdale. 1995 (price code H, £30)

PR65 *Evaluation of stone mastic asphalt (SMA): a high stability wearing course material* by M E Nunn. 1994 (price code E, £20)

Prices current at January 1998

For further details of these and all other TRL publications, telephone Publication Sales on 01344 770783 or 770784, or visit TRL on the Internet at http://www.trl.co.uk.