Thin Surfacing Material Trials in the United Kingdom

JOHN MERCER, J. CLIFFORD NICHOLLS, AND JOHN F. POTTER

Thin surfacings have been developed in France that are considered a cross between conventional thin-wearing course surfaces and thick surface dressings. Two of these materials, Safepave (or Euroduit) and UL-M, are now being offered in the United Kingdom. A series of road trials are under way to assess their benefits and any possible negative aspects. The trials have two main objectives: to compare the performance of these thin surfacings with existing materials of known performance and to assess their effectiveness as resurfacing materials. To compare their performance, the first aim, the surfacings were laid in sections alongside sections of rolled asphalt wearing course, racked-in surface dressing, and slurry surfacing. To assess their effectiveness, the second aim, Safepave was laid over concrete highways using different treatments at the joints to delay reflective cracking. Trials were conducted on various types of road, including a motorway, major-trunk dual carriageway, rural-trunk and urban dual carriageway. Measurements made on the surfacings included visual assessment, skid resistance (Sideway-force Coefficient Routine Investigation Machine and rake-force trailer), texture depth (sand patch and sensor-measured), rutting, longitudinal profile, and noise. Use of thin surfacings in the United Kingdom is discussed and results of the trials to date are reported. Usefulness of these materials, as well as the conditions under which they should prove effective compared with other currently available materials surfacing is also considered.

As the volume and loading of road traffic has risen and the disruption costs of making repairs has increased, new surfacing materials are being developed in many parts of the world that enable roads to remain maintenance free longer or that can be applied to roads in a manner that minimizes traffic disruption. New materials include thin surfacings, several of which have been developed and approved in France through the Avis Technique system. Some of France's thin surfacings are being brought to the United Kingdom through licensing agreements with U.K. contractors.

Thin surfacings are classified as a single layer of material, laid and compacted using paving machines and rollers. Such surfacings are considered a cross between thin wearing courses and thick surface dressings. Their typical thicknesses range between 15 mm and 30 mm, and it is possible to apply greater thicknesses in localized areas. The advantages to using thin surfacings are that they provide the appropriate level of skid resistance and also regulate the profile (to a limited extent) while minimizing the loss of headroom at overbridges and the need to raise ironwork. As with veneer surfacings, such as surface dressing and slurry seals, thin surfacings should be used only where supporting pavement is structurally adequate. The surfacings have all the advantages of a surface dressing, without the disadvantage of the after-care service that is required for surface dressing. They also are able to make uneven surfaces regular and can be laid under weather conditions that surface dressing cannot.

J. Mercer, Highways Engineering Division, Department of Transport, St. Christopher House, Southwark Street, London, SE1 0TE, United Kingdom; J. C. Nicholls and J. F. Potter, Transport Research Laboratory, Old Wokingham Road, Crowthorne, Berkshire RG11 6AU, United Kingdom.

In France, thin-surfacing systems have been grouped into categories such as very thin surface layers (VTSL) (*1*) and ultra thin hot-mix asphalt layers (UTHMAL) (*1,2*). The thin surfacing systems currently available in the United Kingdom are the UTHMAL Safepave, and the VTSL UL-M. Safepave, the UTHMAL, was introduced first; there are now several U.K. sites where it has been used. Whereas UL-M, the VTSL, a later import, may have been laid on only one public road in the United Kingdom prior to 1993. Stone mastic asphalt (SMA) (*3*), developed in Germany, can also be laid in thin layers and is shortly to be evaluated for United Kingdom conditions as part of another research project at the Transport Research Laboratory (TRL).

MIX DESIGNS

UTHMAL's sprayed binder is a modified emulsion, containing approximately 70 percent solids, and it is sprayed at a rate of 1 L/m^2. The mixed material specification follows a French design; it is shown for the 10-mm grading in Table 1. The binder used in the mix is 100 penetration-grade bitumen. The aggregates used are of high quality and have a high PSV, in order to provide good skid resistance. The binder content is 4.9 $\pm$ 0.3 percent.

The 10-mm size aggregate for VTSL is in accordance with the U.K. standard BS 63 (Part 2: 1987), and the fine/filler proportion should be within the limits shown in Table 1. The total mix, excluding the binder, should be within the grading envelope also indicated in Table 1. The bitumen is either a 70 pen or 100 pen, modified with an ethylene vinyl acetate, for which the grade and dosage rate were not identified. The binder content is within the range of 4.5 to 7.0 percent, depending on the mix.

TRIAL SITES

Thin surfacings have been laid at six sites; one of jointed concrete and the remaining five with asphalt surfacings. The sites are

- A47 Thorney, Cambridgeshire. An undulating two-lane single carriageway road built over marshy ground with transverse and longitudinal cracking and general deterioration of the original surface. UTHMAL was laid along a 3.6-km length on both sides of the road in September 1991; a racked-in surface dressing had been laid at one end of this section the previous week and rolled asphalt was laid adjacent to the other end about 3 months later during the winter. The surface dressing required remedial work the following season.
- A1 Eaton Socon, Cambridgeshire. Dual two-lane trunk road of jointed concrete with poor ride characteristics and a loss of texture. An overlay of UTHMAL was laid along a 1.2-km length of the

TABLE 1 Aggregate Gradings for 10-mm Nominal Mixes

BS Sieve	Per cent passing UTHMAL Combined aggregate	VTSL Fine aggregate	VTSL Combined aggregate
14 mm	100		100
10 mm	55 - 100		80 - 100
6.3 mm	30 - 65	100	25 - 60
5.0 mm	20 - 55	85 - 100	-
2.36 mm	15 - 45	55 - 100	20 - 40
1.18 mm	10 - 35	40 - 70	15 - 35
600 μm	7 - 30	-	10 - 30
300 μm	5 - 25	15 - 35	7 - 25
75 μm	0 - 15	0 - 20	6 - 13

southbound carriageway in September 1991. The trial also incorporated a proprietary reflective crack reduction treatment and saw-cut-and-seal joint treatments at the joints of the concrete.

- A1033 Hull. Four-lane, single carriageway, heavily trafficked road in poor repair leading to the docks. UTHMAL was laid along a 1.35-km length on all lanes, and a length with slurry surfacing was laid to the east in October 1991.
- A31 Romsey, Hampshire. Two-lane single carriageway the original surface of which had poor texture, with transverse cracking and general deterioration. UTHMAL was laid on both sides of the road for a length of 1.06 km in October 1991.
- A34 Stafford. Dual two-lane urban ring road for which the local authority was interested in potentially noise-reducing surfaces. To evaluate VTSL and UTHMAL's properties, 800 m of the northbound carriageway was surfaced with VTSL and the same distance along the southbound carriageway was surfaced with UTHMAL in September 1992.
- M5, Avon, Dual three-lane motorway whose existing surface-dressing was stripping. UTHMAL was laid on 2.8 km of the southbound carriageway in October 1992. Control sections of rolled asphalt were constructed to compare the rolled asphalt with the UTHMAL.

MONITORING

Unevenness

At Romsey, measurements were made with TRL's High-Speed Survey Vehicle (HSV) on the original surface and repeated immediately after the UTHMAL had been laid; measurements were taken again after various periods of trafficking. The results in Table 2 give average unevenness in terms of 3-m, 10-m and 30-m longitudinal profile variance values. The 3-m variance gives a good indication of overall evenness and ride quality. The initial reading on the new UTHMAL surface appears a little high, probably because of the laser pulses' absorption effect, which sometimes occurs on new, very black surfaces and results in a slight increase in the average variance value. Results clearly show, however, that evenness was significantly improved by applying UTHMAL, and evenness has been maintained at a good standard. The regulating effect of UTHMAL and the improvement in the longitudinal profile after resurfacing at Romsey is illustrated in Figure 1, which shows the 3-m profile on a section of the site.

At Thorney, UTHMAL's regulating ability could be observed during the laying operation, as undulations in the existing surface were effectively filled in. The thickness of the mat being laid varied from 20 to 45 mm in order to accommodate unevenness. The thickness provided a good even finish, in compliance with Department of Transport specifications. The surface regularity measured at the other sites also complied with the specification requirements.

Surface Texture

Initial Texture

Both sand-patch texture depth and sensor measured texture depth measurements were made at Thorney. The latter measurement was made using the Mini-Texture Meter (MTM), at locations on the surface dressing, and on the UTHMAL sections soon after they were laid. The results are shown in Table 3.

At Eaton Socon, the sand-patch texture depth of the UTHMAL measured before the road was reopened to traffic was between 1.20 and 3.83 mm, with a mean value of 2.1 mm in the lane carrying most heavy vehicles, and between 1.32 and 3.25 mm (with a mean value of 2.0 mm) in the overtaking lane.

At Hull, sand-patch measurements were made at 14 locations on UTHMAL, indicating a mean value of 1.5 mm for texture depth. At 10 locations, the slurry-surfacing section's texture depth had a mean value of 3.2 mm. Because roads with the slurry surfacing appeared to lose aggregate as soon as they were opened to traffic, measure-

TABLE 2 HSV Uneveness Measurements at Romsey

Age (months)	Unevenness - Profile variance (mm^2) East b/d 3 m	10 m	30 m	West b/d 3 m	10 m	30 m	Wheel-path rutting (mm) East b/d Average	West b/d Average
Original	1.82	19.94	697.45	1.22	5.93	23.69	-3.5	-2.6
1	1.10	16.50	666.61	0.61	3.51	18.05	-3.4	-1.8
9	0.72	15.62	673.39	0.50	3.31	17.72	-3.9	-2.1
12	0.77	16.05	666.59	0.45	3.31	18.20	-3.5	-2.5
16	0.73	16.04	670.34	0.46	3.35	17.89	-4.8	-3.7

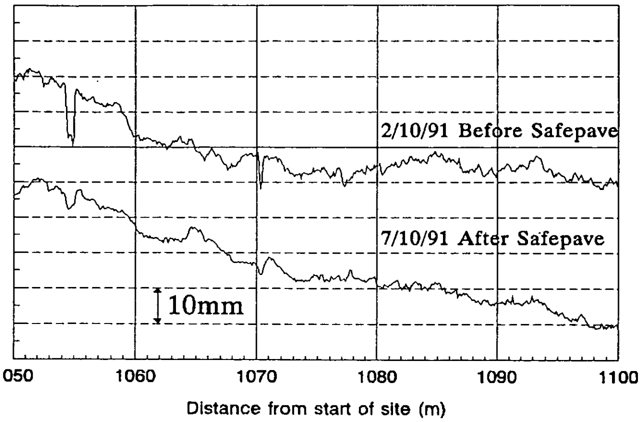

FIGURE 1 Improvement in longitudinal profile at Romsey.

ments were repeated after traffic had been on the surface for 1 hr. The texture depth, after trafficking, had decreased by 35 percent, down to 2.0 mm. However, this still is considered to be a relatively coarse texture.

At Stafford, a set of 10 sand-patch measurements were taken that indicated a mean of 1.4 mm on a 50-m length of VTSL that had not been opened to traffic. Measurements were made again in the inner wheel-track after 7 months of trafficking. By then the texture depth had to decreased slightly—to 1.3 mm.

Maintained Texture

The SMTD on all sites was monitored by the HSV soon after surfacing material had been laid. The absorption effect of the laser pulses was higher on the new UTHMAL surfacing than normally would be expected from conventional rolled asphalt surfacing. As a result, the SMTD for the new surfacing was slightly underestimated (by less than 10 percent). After a surface is trafficked for 3 to 4 months, the absorption effect decreases to levels comparable to those of conventional surfacings and does not affect the measured SMTD value. Results from all sites except Avon are given in Table 4. Average results for each surfacing material tested at Thorney are illustrated in Figure 2. The surface texture of UTHMAL is within current U.K. specification limits when laid but decreases with trafficking, much like surface dressings lose their thickness (Figure 2). Surface texture is more easily explained for surface dressing, for which design allows embedment of chippings into the substrate. The UTHMAL layer provides less point loads on the existing substrate. Assuming that secondary compaction occurs under traffic, this reduces the texture depth. There is less reduction in texture depth than occurs with surface dressing. The SMTD of UTHMAL decreases about 40 percent during the first year, at which time the compaction appears to be complete. Therefore, the as-laid specification limits may need to be increased to compensate for reduction. The results from Stafford on VTSL are, as yet, insufficient to determine whether a reduction in SMTD occurs. The VTSL was laid on a site which was not classified as a high-speed road and therefore it was not a requirement to have an initial 1.5 mm sand-patch texture depth.

For roads with bituminous surfacings, a texture depth of 1.5 mm is required; whereas for concrete roads, a lower texture depth of 0.65 mm is specified. On the site at Eaton Socon, the original brushed concrete had a lower SMTD, averaging about 0.4 mm. This was improved by the application of UTHMAL, increasing the SMTD to about 1.0 mm. However, the SMTD decreased with time; measured values now approach 0.7 mm, the level of macro-texture for in-service roads (4). The risk of accidents begins to increase significantly on roads with a lower SMTD than that.

Skid-Resistance

The sideway-force coefficient (SFC) of the various surfacings were measured at 50 km/h, using the Sideway-Force Coefficient Routine Investigation Machine (SCRIM). Results from all the sites are given in Table 5, and the mean values for Thorney and Hull shown in Figures 3 and 4.

Skid-resistance of all surfacing materials increases during the first few months, as the binder on the surface is worn off by traffic. The UTHMAL surfaces had the best skid-resistance of all the surfaces for vehicles accelerating at 50 km/h in the comparative trials at Thorney and Hull. On the basis of the Stafford results, the UTHMAL has a marginally higher SFC than does the VTSL.

High-Speed Skid Resistance

In June 1992, a brake-force coefficient (BFC) trailer was used to measure high-speed skid resistance on the Thorney site at two speeds, 50 km/h and 130 km/h. Measurements were taken along a

TABLE 3 Initial Texture Depths at Thorney

	Surface dressing			UTHMAL			
	East b/d		West b/d	East b/d		West b/d	
	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7
Sand-patch							
Mean	3.2	3.4	3.0	3.2	1.6	1.5	2.3
Range	2.65-4.21	2.91-4.07	2.76-3.25	1.88-5.77	1.13-2.53	0.93-1.88	1.63-2.95
MTM*							
Mean	1.8	1.7	1.6	-#	0.7#	0.7#	0.9#
Range	1.75-1.76	1.68-1.74	1.59-1.65	0.00-1.10	0.73-0.73	0.70-0.73	0.93-0.96

* = '*Texture - Other Readings*' scale used
# = Results with high absorption of laser pulses
- = missing mean resulting from high absorption of laser pulses

TABLE 4 SMTD Results

THORNEY

Date	Surface dressing East b/d	Surface dressing West b/d	UTHMAL East b/d	UTHMAL West b/d	Rolled asphalt East b/d	Rolled asphalt West b/d
25/ 9/91	1.98	1.85	1.33	1.13	1.34*	1.10*
8/11/91	1.70	1.51	0.88	0.98	1.30*	1.06*
21/ 7/92	1.28	0.98	0.71	0.75	1.21	1.30
7/10/92	1.22†	0.87†	0.74	0.85	1.44	1.26
20/ 1/93‡	0.99†	0.84†	0.59	0.61	1.04	0.98
9/ 2/93	1.15†	0.90†	0.70	0.76	1.33	1.14
30/ 4/93	1.09†#	0.89†	0.62#	0.88	1.11#	1.21
20/ 7/93	1.07†	0.62†	0.72	0.83	1.24	1.17

EATON SOCON

Date	UTHMAL - Southbound S2	S3	S4	S5	S6	S7	S8
25/ 9/91*	0.41	0.40	0.48	0.74	0.42	0.38	0.43
3/10/91	0.88	1.03	0.96	1.18	0.91	0.73	0.78
8/11/91	0.83	0.96	0.85	1.07	0.80	0.68	0.66
20/ 7/92	0.81	0.92	0.92	0.85	0.78	0.60	0.57
8/10/92	0.77	0.88	0.94	0.82	0.76	0.60	0.57
9/ 2/93	0.65	0.75	0.80	0.73	0.70	0.59	0.58

HULL

Date	Slurry surfacing				UTHMAL				Existing rolled asphalt			
	East b/d		West b/d		East b/d		West b/d		East b/d		West b/d	
	n/s	o/s	o/s	n/s	n/s	o/s	o/s	n/s	n/s	o/s	o/s	n/s
27/ 6/93	0.37	0.55	0.61	0.39	0.91	1.07	1.05	0.87	0.48	0.65	0.48	0.49

ROMSEY

Date	UTHMAL Eastbound S1	UTHMAL Eastbound S2	UTHMAL Westbound S3	UTHMAL Westbound S4
2/10/91*	0.90	1.07	0.91	1.14
7/11/91	1.35	1.33	1.10	1.12
17/ 7/92	0.88	0.89	0.78	0.83
8/10/92	0.93	0.91	0.85	0.95
10/ 2/93	0.88	0.86	0.82	0.87

STAFFORD

Date	UTHMAL	VTSL
16/ 6/93	0.85#	0.85
12/ 7/93	1.04	0.95

† = after repairs * = prior to resurfacing
‡ = survey with 45° laser angle; other surveys with 60° angle giving 'deeper' readings
# = high absorption of laser pulses, tending to underestimate result

NOTE: Measurements are in millimeters.

70-m length at one location on the rolled asphalt section and at two locations on both the UTHMAL and surface-dressed sections. Three runs of the BFC trailer were made at each speed over the three sections, and a mean value of the BFC was calculated for each measurement location and test speed. The results are given in Table 6.

At Location 1 on the surface dressing section, the measured BFC was low at the higher speed, although there is no obvious explanation. It is possible that the test line at Location 1 might have a lower texture than the test line at Location 2, although this is not reflected by the sand-patch measurements shown in Table 3. Perhaps the line had been contaminated when the new test tire abraded away on an earlier run; however, the operator could not find any evidence of surface contamination.

Measurements of high-speed skid resistance at Thorney indicate that skid resistance drops with speed by slightly more on UTHMAL than on rolled asphalt or surface dressing between 50 km/h and 130 km/h. Nevertheless, the skid resistance at 130 km/h is still greater for the UTHMAL than the rolled asphalt, although not as great as that for the surface dressing (ignoring the result from location 1). Hence, the greater drop in BFC should be noted, although the UTHMAL material is still performing better than the rolled asphalt at these locations, that is, up to a speed above the legal limit for this type of road in the United Kingdom. The change in skid resistance with speed is being measured at other sites, and modifications to the UTHMAL material are being investigated in order to alleviate concerns.

Hydraulic Conductivity

To examine claims that UTHMAL is able to reduce spray on wet roads similarly to porous asphalt, a series of hydraulic conductivity measurements were taken on the material laid at Hull. The values measured implied that UTHMAL possesses a capacity to remove water from the tire/road interface that might reduce spray. To confirm that the measurements reflected this capacity and were not influenced by the surface texture, the corrected outflow times *(5)* at each location were analyzed to see if there were any relationship

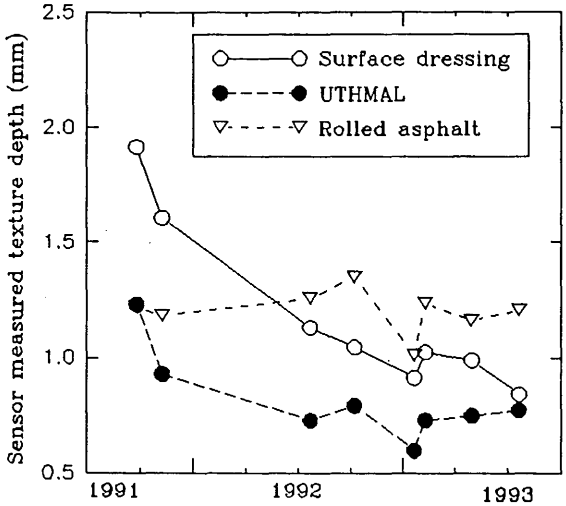

FIGURE 2 SMTD results from Thorney.

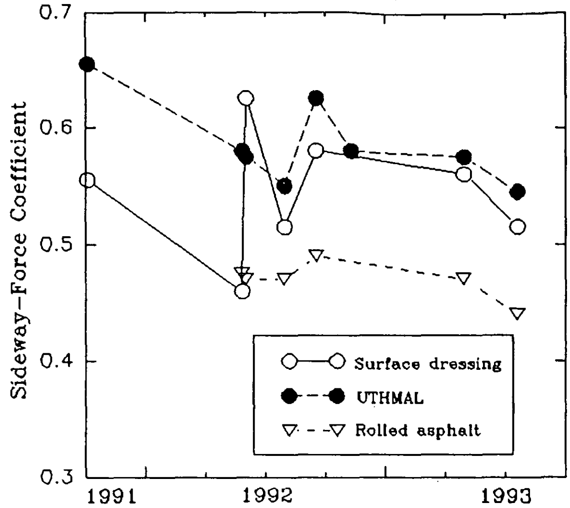

FIGURE 3 SFC results from Thorney.

TABLE 5 SFC Results

THORNEY

Date	Surface dressing East b/d	Surface dressing West b/d	UTHMAL East b/d	UTHMAL West b/d	Rolled asphalt East b/d	Rolled asphalt West b/d
4/10/91	0.55	0.56	0.67	0.64	-	-
27/ 5/92	0.52	0.40	0.60	0.56	0.47	0.48
2/ 6/92	0.65	0.60	0.58	0.57	0.48	0.46
30/ 7/92	0.53	0.50	0.56	0.54	0.48	0.46
18/ 9/92	0.57	0.59	0.65	0.60	0.50	0.48
11/ 2/93	-	-	0.58	0.58	-	-
30/ 4/93	0.57	0.55	0.58	0.57	0.47	0.47
20/ 7/93	0.54	0.49	0.55	0.54	0.44	0.44

EATON SOCON

Date	UTHMAL	Date	UTHMAL	Date	UTHMAL
8/10/91	0.69	6/ 7/92	0.55	10/ 2/93	0.59
1/ 6/92	0.61	7/ 9/92	0.56		

HULL

Date	Slurry surfacing East b/d n/s	Slurry surfacing East b/d o/s	Slurry surfacing West b/d o/s	Slurry surfacing West b/d n/s	UTHMAL East b/d n/s	UTHMAL East b/d o/s	UTHMAL West b/d o/s	UTHMAL West b/d n/s	Existing rolled asphalt East b/d n/s	Existing rolled asphalt East b/d o/s	Existing rolled asphalt West b/d o/s	Existing rolled asphalt West b/d n/s
16/ 7/92	0.39	-	-	0.38	0.53	-	-	0.48	0.39	-	-	0.34
27/ 8/92	0.49	-	-	0.52	0.56	-	-	0.58	0.44	-	-	0.48
16/ 5/93	0.44	0.46	0.47	0.44	0.57	0.57	0.58	0.57	0.41	0.45	0.42	0.37
27/ 6/93	0.41	0.43	0.43	0.38	0.56	0.57	0.57	0.55	0.38	0.45	0.42	0.36

ROMSEY

Date	UTHMAL Eastbound S1	UTHMAL Eastbound S2	UTHMAL Westbound S3	UTHMAL Westbound S4
28/ 5/92	0.57	0.57	0.57	0.57
14/ 7/92	0.63	0.63	0.61	0.64
4/ 9/92	0.62	0.61	0.66	0.69
12/ 2/93	0.58	0.59	0.60	0.60

STAFFORD

Date	UTHMAL	VTSL
16/ 6/93	0.58	0.52
12/ 7/93	0.55	0.51

AVON

Date	Section 1 Surface dressing	Section 2 UTHMAL	Section 3 Surface dressing	Section 3 Rolled asphalt	Section 4 UTHMAL	Section 5 Surface dressing	Section 5 Rolled asphalt
11/11/92	0.48	0.61	0.47	n/a	0.60	0.49	n/a
5/ 3/93	0.44	0.55	n/a	0.51	0.57	n/a	0.52

- = Section not surveyed   n/a = Surface not existing for that survey

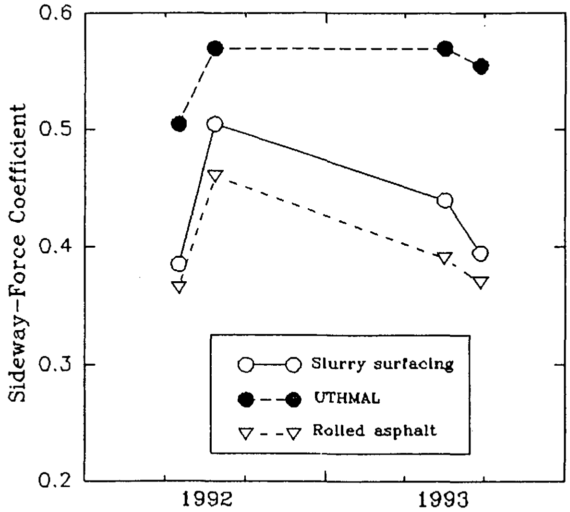

FIGURE 4 SFC results from Hull (north and south lanes).

between outflow time and texture, as indicated by sand-patch measurements.

Regression analysis showed that there was a relationship between texture depth and hydraulic conductivity, with a correlation coefficient of 0.85. The relationship, shown in Figure 5, suggests that water flow between interconnecting surface channels result from high texture levels and that texture is most likely a factor in the measured value of hydraulic conductivity. Locally, however, where the material had been laid thicker to even out the original surface, interconnecting voids within the material might have produced the increased levels of hydraulic conductivity, even though the voids were not sufficiently uniform to describe the material as genuinely porous. Because the basic structure of UTHMAL is a single aggregate layer, any interconnecting voids are likely to be open to the surface for much of their length rather than completely submerged. This assumption is consistent with the relationship found between texture depth and hydraulic conductivity.

Nevertheless, the surface texture and the ability to make it more even should help reduce ponding. Motorists have the perception that UTHMAL is a spray-reducing material. Compared with 20-mm porous asphalt, the hydraulic conductivity of UTHMAL is low, with only one point in Figure 5 attaining the minimum value (0.06 s^{-1}) specified in the U.K. standards for an individual measurement on porous asphalt. At 0.01 s^{-1}, the material can be considered to be closed up. However, if water is able to drain into the UTHMAL surfacing, then there is the likelihood of water being retained in the wheel ruts at the interface with the old underlying road surface, which in time, might cause problems within the new UTHMAL surfacing.

Noise

Vehicle noise was measured using the statistical pass-by method (*6*) on the UTHMAL and rolled asphalt sections at Thorney, and on the UTHMAL and brushed concrete sections at Eaton Socon. Results are given in Table 7.

For a broad range of conventional nonporous road surfaces, the maximum noise level relates to the skidding performance measure, or BFC, derived from the sand-patch texture depth. Recorded values of noise and BFC on the rolled asphalt and UTHMAL surfacings from Thorney lie below the "best-fit" line of the relationship determined from many measurements on conventional bituminous surfacings. The measurements taken at Eaton Socon are closer to the mean line of the relationship.

Although the results indicate that UTHMAL was quieter than either rolled asphalt or concrete surfacings at these sites, the noise levels from the UTHMAL surface were within the expected range for conventional surfaces for the same skid resistance, as derived from texture depth. However, the relationships between texture depth and BFC were derived from surfacings that differ from UTHMAL and so may not be valid.

Use of UTHMAL on Jointed Concrete

To examine ways of minimizing reflective cracking above joints, a number of joint treatments were applied before resurfacing with UTHMAL. The trial used a proprietary rubberized anticracking treatment, as an inlay and an overlay. The saw-cut-and-seal technique was also used. Sealing grooves were sawn in the final running surface directly above the transverse joints in the concrete to control the reflective cracking that resulted from thermal movements of the underlying slabs. For comparison, a length with no joint treatments was included as a control.

Anticracking treatments (ACT) were associated with bleeding through into the UTHMAL. Why the two materials were incompatible is unclear, but the result was that smooth bands appeared in the UTHMAL surface, giving it a patchy appearance—both at the joints and where longitudinal cracks were treated similarly. When used as an overlay treatment, in which the ACT was not recessed into the concrete, the bleed-through was more pronounced, and cracking reappeared in the UTHMAL above the joints in the concrete at both edges of the treatment. The inlay treatment/UTHMAL combination produced a better result, but the surface texture was still poor because of the bleeding. Therefore, this type of ACT is not considered suitable for use with UTHMAL.

TABLE 6 BFC Trailer Results (Thorney)

	Surface dressing		UTHMAL		Rolled
	1	2	1	2	asphalt
50 km/h	55.2	52.3	54.0	52.8	41.3
130 km/h	17.0*	41.0*	36.0	35.0	29.3
ΔBFC #	-	22 %	33 %	32 %	29 %

Drop in BFC from 50 km/h to 130 km/h
* Shredded tire on first run (of three)
\- = Result not given as 130 km/h value suspect

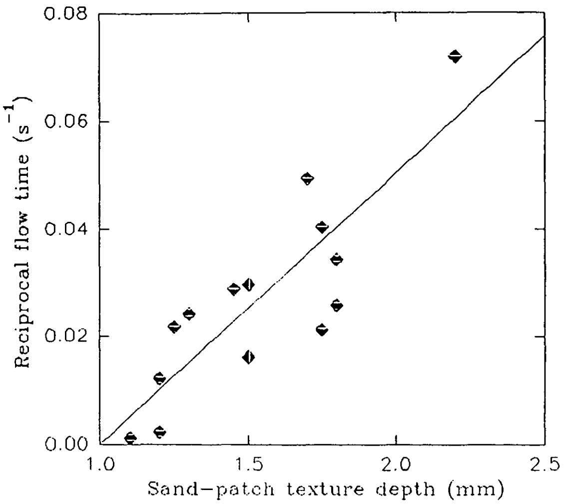

FIGURE 5 Relationship between hydraulic conductivity and texture depth.

On the control section, with no joint treatments, cracks reappeared at all expansion joints but not at contraction joints, indicating that only expansion joints may need to be treated. The majority of the saw-cut-and-seal joints are in very good condition, with seals intact. One or two seals have a fine parallel crack running alongside, probably caused by lack of precision when joint grooves were sawn. Accurate joint location, together with thorough cleansing before application of sealant, should ensure the effectiveness of this technique. Saw-cut-and-seal joints appear to be the best option if jointed concrete is to be resurfaced with UTHMAL.

General Condition

UTHMAL provides a visually acceptable surface when new, including no loose chippings and an even finish of good-riding quality. After the surface is trafficked for a few months, however, secondary compaction in the wheel-paths is noticeable, as is some closing-up of the surface texture, which might be caused by embedment of the aggregate, "fatting-up" of the binder-rich material, or a combination of both. Reasons for the closing up are being investigated.

A certain amount of wheel-path rutting is also evident at each site and, although not severe, is noticeable under wet conditions. Table 2 shows the average depth of rutting at Romsey to be about 2 to 5 mm, as measured by the HSV. However, as well as having an adverse effect on texture and skidding resistance, the combination of compaction/consolidation and wheel-path rutting could cause increased noise and spray.

Visual condition surveys were carried out before the application of UTHMAL and periodically for 16 months. The UTHMAL is generally in good condition at the first 3 sites to be treated and shows good integrity and adhesion, although a little scuffing and loss of material has been caused by vehicles turning at junctions at the Thorney and Hull sites. Where heavy vehicles turned on the control sections at Hull, similar scuffing and loss of aggregate occurred. Elsewhere at these sites, there are only a few localized areas of material loss. Reflective cracking has occurred at Thorney and Romsey where cracks and other defects were not pretreated. At Thorney, the majority of the transverse cracks in the original surface reappeared during the first 12 months, and, at Romsey, the more severe cracks observed in the original surface have now reappeared. This indicates that the behavior of UTHMAL is similar to that of other conventional bituminous materials in terms of minimizing reflective cracking, that is, cracks that would be expected to reappear within a year in an overlay thickness of 20 mm.

At Stafford, the UTHMAL was replaced before it was in service one year, because of of severe fretting. A noticeable loss of material occurred on the M5 Avon motorway site, in some areas, after only 6 months of trafficking. The contractor suggested the deterioration was due to the cold, wet weather conditions at the time the UTHMAL was laid at both sites. Poor bonding to the original surface was thought to be a contributing factor to the deterioration. At the M5 Avon site, the original surface dressing was in poor condition; there was severe stripping in some areas which was the reason for its resurfacing. Removal of this stripped surface dressing before application of UTHMAL, while adding to cost, might have been the better long-term solution.

The limited use of VTSL means that any conclusions about it have to be tentative. Using it to replace the UTHMAL at Stafford illustrates that it has its limitations, as have other materials, demonstrated by the need for repairs on the surface dressing section at Thorney.

COSTS

The cost per square meter of these thin surfacing ranges between £2.30 and £3.50, depending on the site and other local considera-

TABLE 7 Vehicle Noise and Surface Parameters

		THORNEY UTHMAL	Rolled asphalt	EATON SOCON UTHMAL 1	2	Brushed concrete
Vehicle Noise* (dB(A))	Light	79.8	81.0	81.1	81.8	82.9
	Heavy	85.5	85.5	85.5	86.2	87.9
SP† (mm)		1.42	2.05	1.37	1.71	0.52
ΔBFC‡ (per cent)		+1.0	-11.6	-12.6	-5.8	-23.2

* Vehicle noise at 7.5 m and vehicle speed of 90 km/h
† Sand-patch texture depth
‡ Estimated change in skidding resistance calculated from:

$$\Delta BFC = (20 \times SP - 40)\% \quad \text{for bituminous surfacings;}$$

and

$$\Delta BFC = (90 \times SP - 70)\% \quad \text{for concrete surfacings}$$

tions. The average cost for 10-mm of nominal size UTHMAL is about £2.60. For the sake of comparison, a 40-mm-thick layer of rolled asphalt costs between £3.50 and £4.00/m^2, whereas surface dressing can vary from 70p/m^2 for some unmodified single dressings to £3.00/m^2 for some modified racked-in systems.

CONCLUSIONS

The conclusions that can be drawn to date from this study are as follows:

- UTHMAL and VTSL materials are less expensive than conventional rolled asphalt but more expensive than surface dressing. They can be laid at a faster rate than rolled asphalt and do not require the high degree of aftercare needed for conventional surface dressing. Use of the materials is also less disruptive to traffic because the new surface can be put into service soon after it is laid down.
- Surfacings are laid using different application techniques, but no major problems occurred during laying, even when the job was done by contractors who had little experience with UTHMAL materials.
- Although the thin surfacing materials have not been in service for sufficient time to fully assess their durability and hence their life-cycle costs, nevertheless, when new, UTHMAL provides an effective regulating layer, improves evenness, and provides a good surface finish and standard of riding quality. At three of the five sites studied, UTHMAL generally is in good condition after 16 months, except at junctions where turning vehicles have caused scuffing and some loss of material. Poor weather conditions during construction appear to have caused loss of material from the surface during the initial months of trafficking at one site, resulting in the need to replace the new surface.
- Skid resistance, as measured by SCRIM, is good for UTHMAL materials; however, there is some concern about the reduction in skid resistance with increasing speed.
- Initial texture depth of UTHMAL is above the 1.5-mm sand-patch value required for high-speed roads within the United Kingdom, but the SMTD fell by about 40 percent during the first year of trafficking; after that texture depth maintained a steady level. The initial texture depth on the one VTSL test section (not a high-speed location) gave a sand-patch value of 1.4 mm.
- Spray- and noise-reducing properties of UTHMAL are at least as good as those of conventional rolled asphalt and surface-dressing surfacings.
- Where UTHMAL has been used over jointed concrete, the most effective solution for minimizing reflective cracking at transverse joints appears to be the technique of saw-cut-and-seal. However, the degree of success with this method relies on the accurate positioning of the sawn groove above the transverse joint in the concrete slabs. Observations also suggest that saw-cut-and-seal may only be necessary above expansion joints in the concrete and not at construction joints. A combination method, that is, using a proprietary anticrack treatment and UTHMAL for minimizing reflective cracking over concrete joints, was not satisfactory.

ACKNOWLEDGMENTS

The work described in this paper forms part of a Highways Engineering Division funded research program conducted by TRL. The paper is published by permission of the Deputy Secretary, Safety Highways and Traffic of the Department of Transport and the Chief Executive of TRL.

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The views expressed in this publication are not necessarily those of the Department of Transport.

Publication of this paper sponsored by committee on Characteristics of Bituminous-Aggregate Combinations To Meet Surface Requirements.