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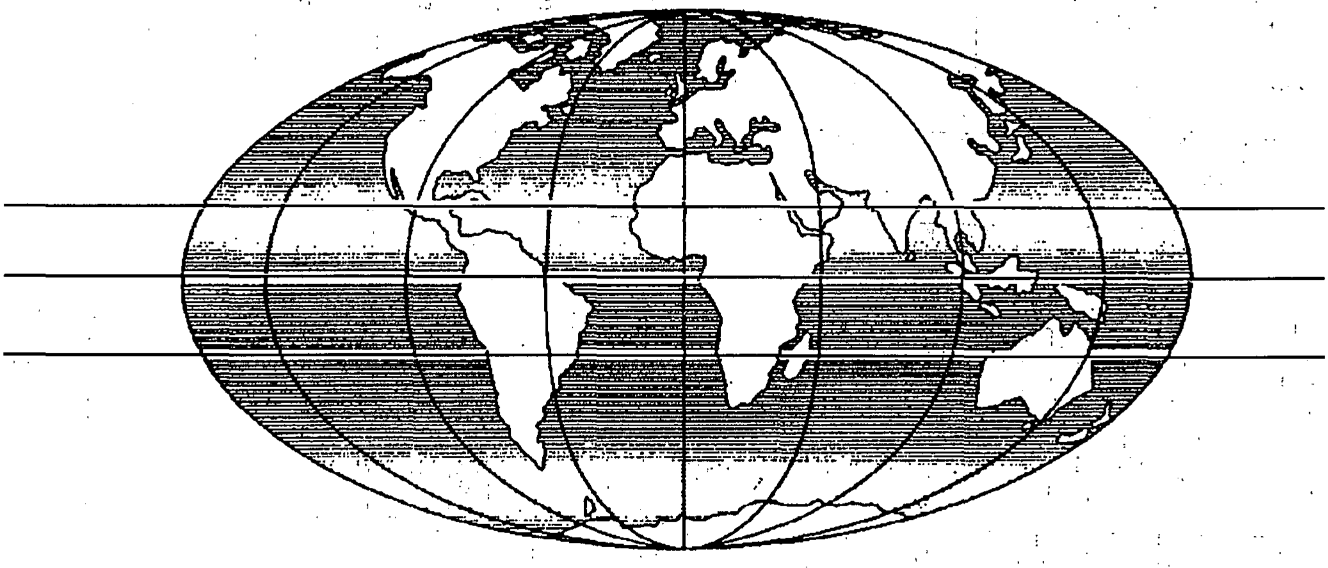
by J Emby, C Jones and M S Mustafa



Overseas Centre
Transport Research Laboratory
Crowthorne Berkshire United Kingdom

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THE USE OF HOT SURFACE TREATMENT TO REHABILITATE CRACKED ASPHALTIC CONCRETE SURFACINGS IN MALAYSIA

Johari Emby
Training and Research Institute,
JKR Malaysia

Colin Jones
Transport and Road Research Laboratory
UK

Ir. Mohamed Shafii Mustafa
Training and Research Institute,
JKR Malaysia

ABSTRACT

In tropical climates the binder in the top few millimetres of dense bituminous surfacings suffers from rapid age hardening causing the viscosity of the bitumen to increase. The material becomes brittle and this results in premature cracking starting at the surface caused by environmental or traffic induced strains. If left untreated these cracks will propagate down through the bituminous layer decreasing its effective modulus and allowing the ingress of water resulting in more serious pavement deterioration.

One method of arresting this type of cracking before more serious failure occurs is to heat the surfacing and then either remove or recycle the cracked layer before the cracks can reach any substantial depth.

This paper describes the first two years performance of a full-scale hot surface treatment trial on a heavily trafficked urban highway in Malaysia. The performance of the trial was monitored under a joint research programme between the Training and Research Institute of the Jabatan Kerja Raya (JKR), Malaysia and the Transport and Road Research Laboratory (TRRL) of the UK.

Three different hot surface techniques were used in the trial and their performance compared to that of a control section. The results showed that although these techniques have been designed to treat only shallow surface cracking, minor modification to one of the methods may make it suitable for solving the more serious problem of reflection cracking in thin overlays.

1.0 INTRODUCTION

The primary cause of failure of thin asphaltic concrete overlays used to maintain flexible road pavements in Malaysia is the occurrence of reflection cracking which is initiated by cracks in the previous surfacing. These cracks can occur as soon as 2-3 months after the construction of 40mm thick overlays, their rate of propagation being dependent upon the severity of cracking before overlay, the pavement deflection and the commercial traffic volume.

Viljoen et al, 1987, have reported that the rate of propagation of reflection cracks in asphalt surfacings is dependent on the number of load repetitions and the movement of the crack due to the deflection of the road pavement under the load. As shown in Figure 1 the movement at the crack will impose a localised strain on a layer placed above, eventually causing the material to fracture and a crack to propagate upwards through the new overlay.

Rolt et al, 1986, have shown that another common mode of failure of both new asphaltic concrete surfacings and overlays in tropical environments is cracking which starts at the top of the surfacing and propagates downwards. This type of cracking is induced by the oxidation and consequent hardening of the bitumen in the top 2-3mm of the material (Smith et al, 1990) making it brittle and thus susceptible to 'top-down' cracking. This type of cracking, although exacerbated by the material properties of the top 2-3mm, can be caused by a variety of stresses.

Hot surface treatment, a technique recently introduced into Malaysia, can be used to rehabilitate road surfacings which suffer from this latter type of 'top-down' cracking.

This paper compares the first two years performance of three different forms of hot surface treatment with that of a control section on a heavily trafficked urban highway in Kuala Lumpur, Malaysia.

2.0 EXPERIMENTAL DESIGN

The four trial sections are located adjacent to one another in the slow lane of a three lane highway. Each section is approximately 180 metres long and all four were overlaid with a common thickness of 60mm of asphaltic concrete after the surface treatment was completed. The layout of the sections and the method of treatment prior to overlay are shown in Figure 2.

2.1 Surface Treatment

The different methods of surface treatment are described below:

Section 1:	Heat, scarify and recompact. In this section the road surface was heated to approximately 140°C, then scarified to a depth of 25mm and immediately recompacted.
Section 2:	Heat, remove and patch. In this section the road surface was heated to approximately 140°C, scarified and removed, and then a new 25mm layer of nominal 13mm asphaltic concrete was layed.
Section 3:	Control section. The surface of this section was untreated prior to overlay.
Section 4:	Heat and pave. In this section the surface was heated to approximately 140°C and immediately paved with a 20mm layer of a nominal 13mm asphaltic concrete.

3.0 PRECONSTRUCTION MEASUREMENT.

The site was marked out by 10 metre chainages and the measurement of rutting, deflection and cracking made with reference to these chainages.

3.1 Rutting

Rut depth measurements were taken using a 2 metre straight edge and calibrated wedge. The values given in Table 1 show that all four sections were structurally strong with only low values having developed, with the exception of one chainage in section 2, since its construction 15 years previously. The only exception to this was one chainage in section 2 which showed a rut depth of 19 mm.

3.2 Deflection

Deflection measurements were made with the Falling Weight Deflectometer (FWD) and the results corrected to a standard pressure of 700 N/m . The results given in Table 1 show that sections 1 and 4 had similar values to the control section (Section 3). Section 2 had slightly higher values.

Table 1: Rutting and Deflection Values Prior to Construction

Section No.	Rutting (mm)			Deflection (mm x 10^{-3})		
	No. of tests	Mean	Range	No. of tests	Mean	Range
1	12	7	4-11	12	389	283-494
2	22	7	3-19	22	526	288-866
3	18	5	3-8	18	408	253-577
4	16	5	3-6	16	417	339-529

3.3 Cracking

The cracking in each 10 metre length was assessed by its intensity and area. The intensity was assessed visually using the following classification:-

Intensity
0 - No cracking
1 - Single crack
2 - Two or more cracks - not connected
3 - Two or more cracks - interconnected
4 - Crocodile cracking
5 - Crocodile cracking with spalling

The longitudinal extent and the transverse location of the cracking was also recorded and from this its area calculated.

Table 2 gives the total area of pavement that was cracked prior to construction and its distribution by intensity.

Table 2: Cracking Prior to Construction

Section No	Area cracked (per cent)	Crack intensity distribution (per cent)				
		1	2	3	4	5
1	35.4	0	0	75	12.5	12.5
2	27.7	0	2.3	57.3	40.4	0
3	21.7	0	11.4	88.6	0	0
4	23.1	0	2.3	84.1	6.8	6.8

The results show that the majority of cracking at the site was intensity 3 and this was common throughout all four sections. It was also noted that by the time the cracks had progressed to intensity 3 they were becoming badly spalled.

3.4 Crack Depth

After recording the intensity and area of the cracking a series of 100mm cores were taken to establish the depth of the cracks. The results from these tests are shown in Figure 3. The Figure illustrates that although intensity 1 cracks were confined to the top 35mm of the surfacing, by the time they had progressed to intensity 3 they had propagated down through the surfacing to an average depth of 115mm.

3.5 Traffic

The site is situated in the slow lane of a particularly heavily trafficked three lane highway in Kuala Lumpur. A classified traffic count showed that the commercial vehicle flow in the slow lane was 6100 vehicles per day.

4.0 CONSTRUCTION

The heating of the road surface was by direct flame using propane burners. The average surface temperature achieved was 140°C decreasing to 65°C at a depth of 25mm.

The relevant construction details for each of the sections is given in Table 3.

Table 3: Construction Details

Section No	Surface temp. after heating (°C)	Temp. at rolling/ before paving (°C)	Pen. of recovered bitumen (mm x 10^{-1})	Depth of recompacted/patch layer (mm)	Thickness of overlay above road surface (mm)
1	136	110[1]	37[1]	25	60
2	-	-	-	25	60
3	-	-	-	-	60
4	144	78	-	-	20+40[2,3]

[1] Recompacted layer

[2] 20mm of 13mm nominal A.C. plus 40mm of 20mm nominal A.C.

[3] No tack coat was applied prior to the 20mm layer.

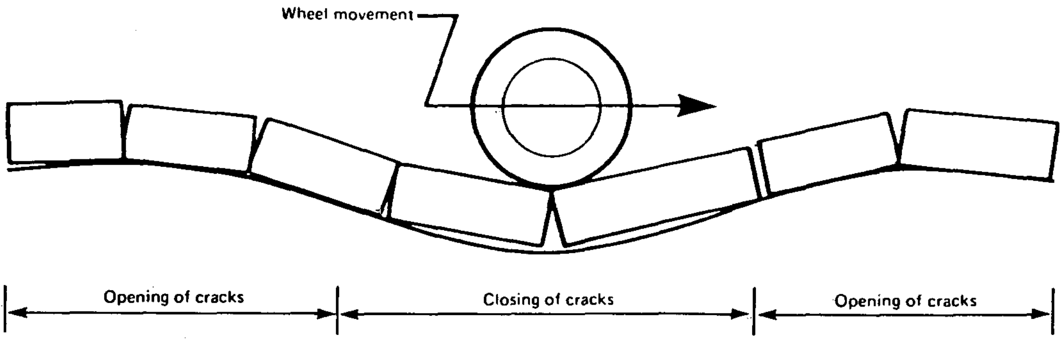

Fig.1 Crack movement caused by the position of the crack in the deflection bowl (after Viljoen et al, 1987)

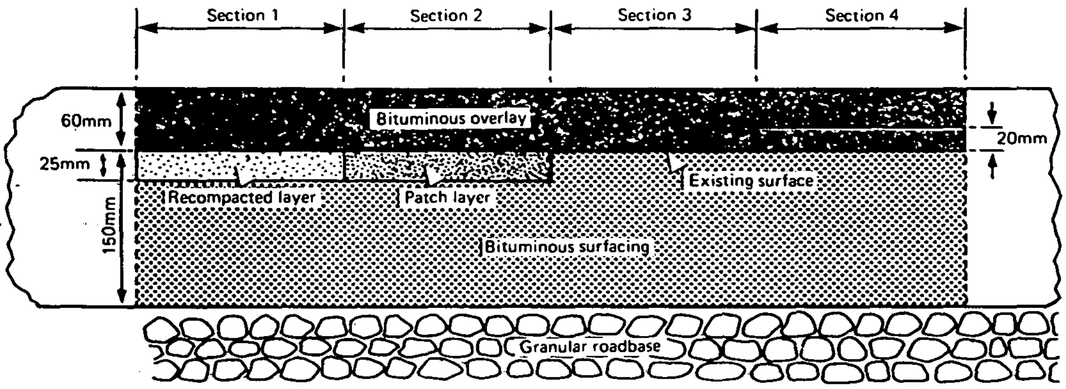

Fig.2 Schematic cross section of experimental site

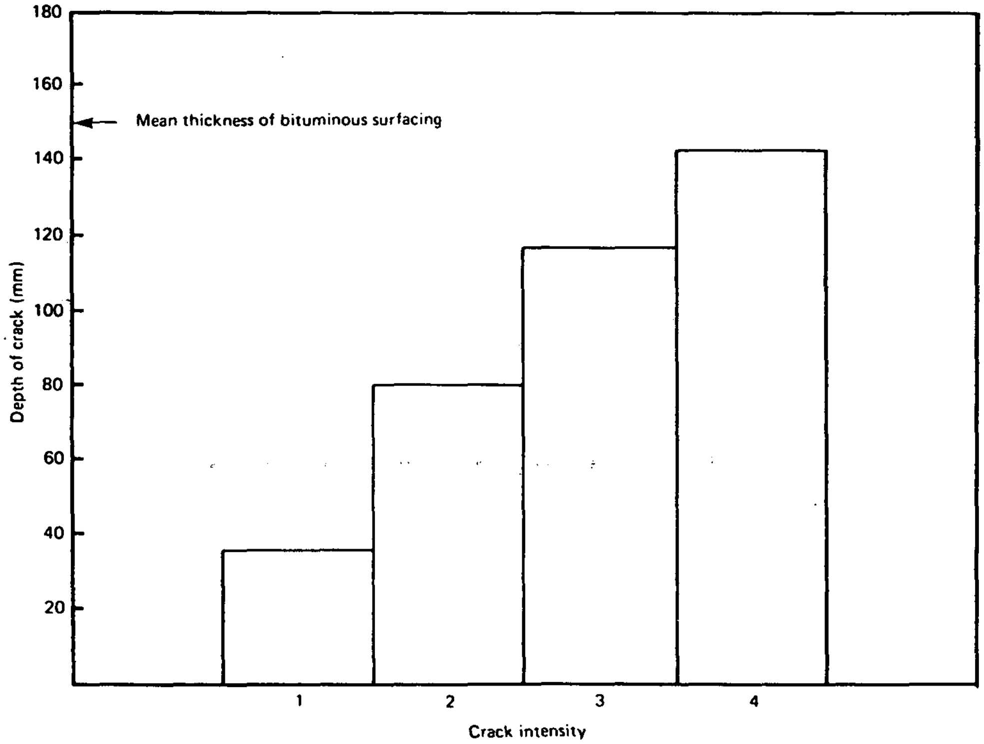

Fig.3 Relation between crack depth and intensity

5.0 PERFORMANCE

The rutting and cracking of the sections has now been monitored for a period of two years. The increase in rutting has been small with the mean values for the sections ranging between 2-4mm. There has however been a differential progression in the development of cracking.

5.1 Cracking

Cracking was noted in the new overlay as early as 6 months after construction and cores taken at that time showed them to be reflection cracks caused by cracks in the underlying layer. Figure 4 illustrates the increase in the area of cracking of the different sections since construction. The analysis has been restricted to those areas which had an initial crack intensity 3 because this type of cracking was the most extensive and common to all the four sections (see Table 2).

The Figure shows that in Section 2, 92 per cent of the area of intensity 3 cracking had reflected through after 2 years trafficking in comparison to Section 1 where only 24 per cent was recorded. The control section and Section 4 had levels of cracking midway between these extremes.

6.0 DISCUSSION

In the following discussion the performance of each section is compared to that of the control (Section 3).

Section 1

The improved performance of this section (see Figure 4) is believed to be due to the fact that the 25mm recompacted layer has a high void content. These voids effectively dissipate the strain above the crack in the lower layer and thus prevent the cracks propagating through the recompacted layer and into the new overlay. This is shown diagrammatically in Figure 5. This hypothesis is supported by the fact that cores taken from this section after two years showed that the recompacted layer had a void content over three per cent higher than the equivalent material prior to scarification and recompaction, sampled from the untreated surface in the control section.

Section 2

The performance of this section is significantly inferior than the control section, despite having a greater thickness of new material (see Figures 4 & 5). This is believed to be because the removal of the top 25mm of the original surfacing decreases the effective width of intensity 3 cracks by the removal of the spalled area at the top of the cracks, as indicated in Figure 5. Thus for the same horizontal movement across the cracks, dx, caused by the deflection of the road pavement under traffic, the strain at the top of treated crack, dx/L_2 is significantly greater than that at the top of a spalled crack, dx/L_1. It is this increased strain, compared to that in the control section that is believed to have caused the differential performance.

Section 4

As shown in Table 2 the temperature of the surface prior to laying the first layer of overlay had decreased from a maximum of 144°C after heating to 78°C on paving. As there was also no visual evidence that the preheating of the surface had changed the nature of the cracks there is no apparent reason why this section should perform significantly differently from the control section. This is substantiated by the crack progression illustrated in Figure 4 which shows the performance of this section to be slightly worse than the control.

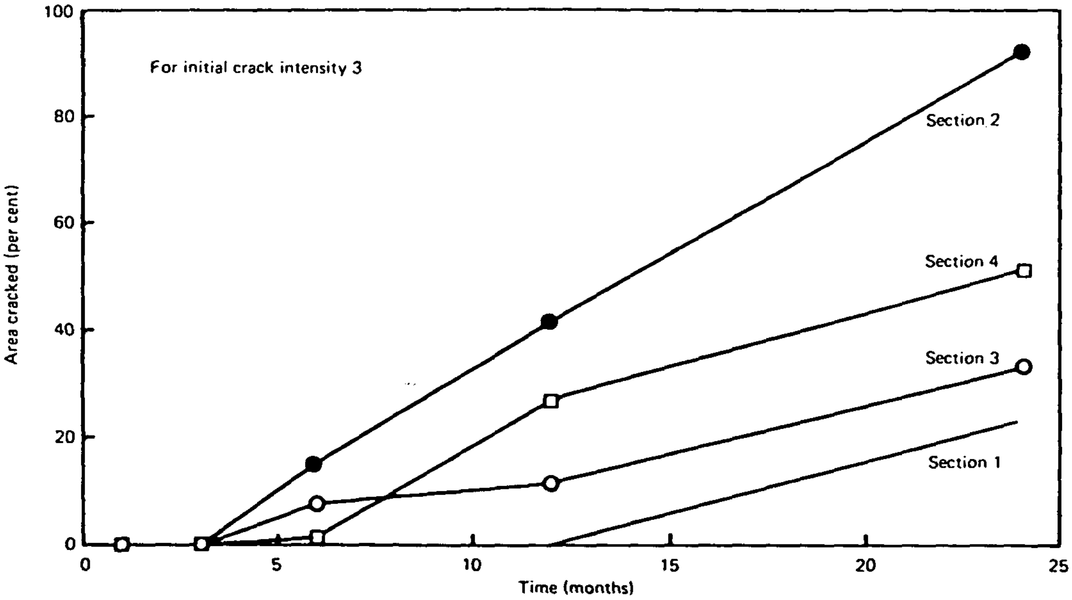

Fig.4 Relation between cracking and time

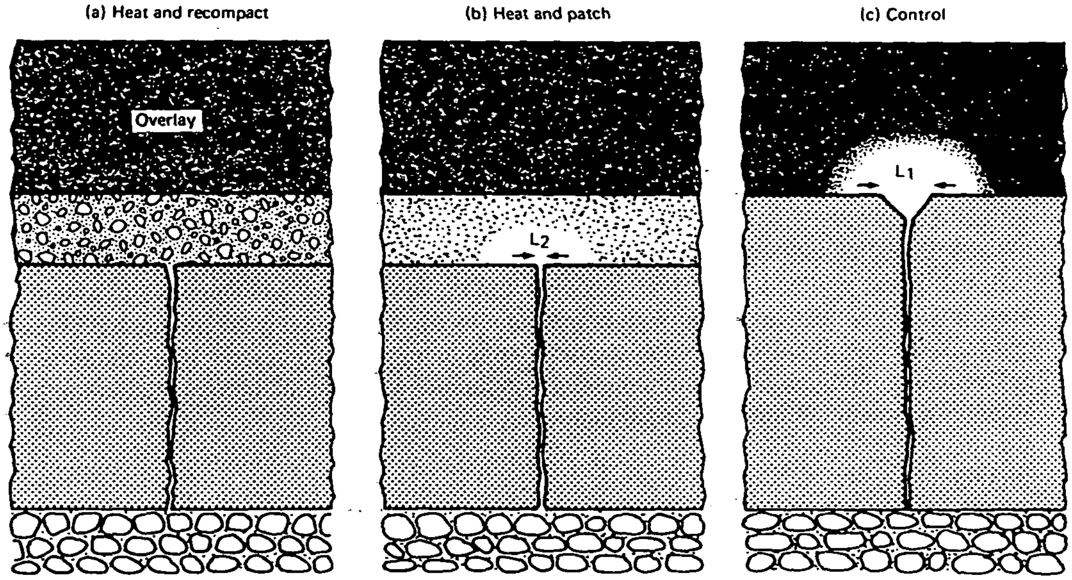

Fig.5 Crack propagation

7.0 CONCLUSIONS

1. The heat, remove and patch technique used on Section 2 has not been successful in preventing the propagation of reflection cracks at deflection levels of 500 x 10^{-3}mm and daily commercial vehicle flows of over 6000 vehicles. Removing the top layer of a cracked asphalt surface prior to patching can only be recommended when the cracks are confined to the top 20-25mm of the existing surfacing.

2. Heating the surface prior to paving was shown to be ineffective and is not recommended for further use.

3. The creation of an interlayer having a high void content, in this case by heating the surface, scarifying and recompacting, has been shown to be effective in reducing the rate of propagation of reflection cracking. The successful compaction of this layer depends upon the viscosity of the binder in the surfacing and a rejuvenating agent may have to be used with some materials to obtain a 'tight' surface.

4. The use of alternative 'high void' interlayers to prevent reflection cracking is being considered by the Training and Research Institute. At present interlayers of crushed stone, porous macadam and large stone surface dressings are being investigated. These methods would enable a more predictable void content to be obtained and avoid processing of the existing surfacing.

8.0 ACKNOWLEDGEMENTS

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