Geotextiles in Road Rehabilitation and Maintenance - The African Experience

G. M. James
Kaytech Geotechnical & Industrial Fabrics, Johannesburg, South Africa

J. M. Botma
Kaytech Geotechnical & Industrial Fabrics, Cape Town, South Africa

ABSTRACT: Over the past ten years geotextile based methods of cracksealing, patching and resealing paved roads have increasingly gained acceptance as a cost effective solution to the problem of maintaining and rehabilitating South Africa's rapidly deteriorating road network. Trial sections, testing and monitoring programmes and actual case studies involving Sealmac are described and discussed. Many important lessons have been learnt from the various installations around Southern Africa to the extent that reliable guidelines are given in the paper to specifier's and users alike as to the approach to the design and construction of geotextile/bitumen systems in road surface maintenance and rehabilitation.

1 INTRODUCTION

Southern Africa has thousands of kilometres of paved roads which are rapidly deteriorating. The biggest problem facing road authorities and municipalities on the maintenance and rehabilitation of their roads is cost effectiveness and appropriate crack treatment and sealing.

In Southern Africa, over a period of 15 years, trials and tests have been performed to the extent that geotextile based methods of cracksealing, patching and resealing paved roads have increasingly gained acceptance as a cost effective solution. Geotextiles are used as alternatives to, or in conjunction with, stress absorbing membrane interlayers (SAMI), slurry seal coats and rubberized bitumen seals (SAM) in retarding reflective cracking and controlling surface water infiltration through the existing pavement.

The first trials in South Africa using paving fabric (nonwoven geotextile) impregnated with bitumen were installed in 1978 beneath chip and spray surfacings. These tests resulted in the first installation of paving fabric (9 500m^2) beneath a 35mm continuously graded asphalt overlay at Durbanville in April, 1980 (Dickson, 1989, and Van Zyl and Louw, 1989).

Although most of the earlier work done in Southern Africa was beneath asphalt overlays, recent trials and tests have been confined to maintenance and rehabilitation applications which are more pertinent to the current needs of the road network.

2 FUNCTIONS OF PAVING FABRIC

Successful application of paving fabrics is based on the complementary properties and characteristics of the geotextile and the bitumen, the former acting as a reservoir for the latter. The combination of these two elements enables the paving fabric to perform two functions: waterproofing and reinforcement.

The bitumen impregnated paving fabric provides a sufficiently thick, flexible, homogeneous waterproof layer and imparts a degree of reinforcement to a thin bituminous surfacing. In so doing the surfacing is better able to resist cracking due to rutting and will bridge shrinkage cracks. South African road experiments have shown that the geotextile remains relatively impermeable, even when the surfacing is cracked (Emery, 1990). By preventing surface water ingress the pavement moisture content is stabilized (Sutherland and Phillips, 1990). The paving fabric partially relieves the transfer of traffic induced stresses in the vicinity of the cracks, acting as a stress relieving layer. In so doing the base course is protected from shear stresses generated by traffic, and hence greater deflections are tolerated (Sutherland and Phillips, 1990).

3 AREAS OF APPLICATION FOR GEOTEXTILES

3.1 Cracksealing and Patching

Repair and maintenance operations are expensive if

related to the square metre area of surfacing being treated. Geotextile strips or patches are applied to cracks in the road surface as a necessary pre-treatment to "buy" time before a full scale reseal programme is carried out. The budgetry constraints are eased by extending the life of the deteriorating pavement with geotextile cracksealing. Depending on the volume of traffic and the type of surface treatment used the life of the paving fabric treatment may range from 6 months to over 5 years. As a maintenance tool the use of geotextile strips (generally 200 or 500mm wide) or geotextile patches (1,0m wide) is cost-effective due to :-

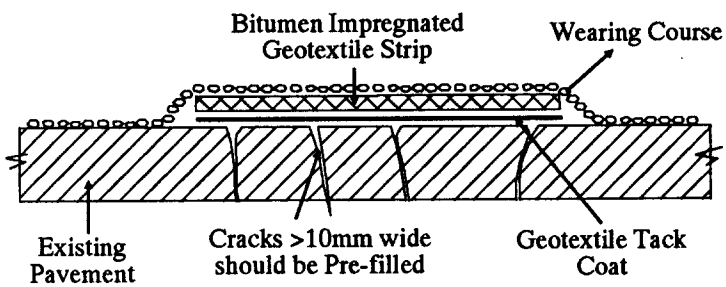
- Ease of handling and transport.
- No wastage of materials.
- Simply installed by a small labour force.
- Effective repair of cracks and patches to prolong the life of the pavement.

If properly and timeously installed with an adequate surface treatment, paving fabric can be an effective preventive maintenance measure.

3.1.1 Installation Procedure (Figure 1)

- Sweep cracks or area to be sealed.
- Apply geotextile tack coat. 0,6 l/m^2 of residual bitumen.
- Lay geotextile strip/patch by hand. Allow emulsion to break before laying geotextile.
- Saturate geotextile with bitumen. 0,8 l/m^2 of residual bitumen.
- Spread suitable wearing course on bitumen impregnated geotextile.
- Roll to "bed in" wearing course.
- Open to traffic. Normal traffic speed restrictions should apply.

Fig. 1: Section through a Geotextile Crack Seal



3.2 Full Width Resealing

In many instances the frequency of cracks and/or potholes is so high that a full width geotextile surfacing seal may be considered necessary.

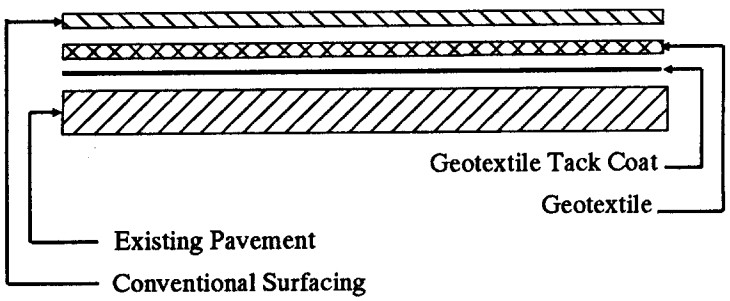
Regardless of the mechanisms of reinforcement and waterproofing, paving fabrics used under the right conditions and installed correctly will retard reflective cracking in flexible pavement systems and provide a moisture barrier. The right conditions refer to the condition of the bitumen, cause of the original distress and climatic conditions. Geotextiles have been found to be effective in controlling crocodile cracking, random cracking, block cracking and longitudinal joint cracks in flexible pavements (FHWA, 1990).

3.2.1 Installation Procedure. (Figure 2)

For full width resealing of a pavement with geotextiles to be successful, carefully controlled construction procedures must be followed.

- Pavement surface preparation. Potholes must be repaired and the road surface swept.
- Apply geotextile tack coat. 0,6 l/m^2 of residual bitumen is adequate.
- Lay down geotextile preferrably with a mechanical laydown device to reduce wrinkles and creases. Large wrinkles should be cut and overlapped.
- Roll the geotextile (2-3 passes) with a pneumatic tyred roller (PTR). This ensures adhesion of the geotextile to the road surface.
- Construct the conventional surfacing.
- Care must be taken not to open the road to traffic too soon. Exercise control over traffic speed to prevent chip loss.

Fig. 2: Section through a Full Width Geotextile Surfacing Seal



4 REVIEW OF PAVING FABRIC INTERLAYER EXPERIENCE

4.1 Cracksealing and Patching.

4.1.1 Road 1344—Beestekraal/Sun City (1991)

Cracksealing was carried out as a pre-treatment for later, full scale resealing on this road using geotextile strips, 200mm wide.

A geotextile tack coat of 65% cationic emulsion was applied at an application rate of 0,8 l/m^2. This rate did vary depending on the road surface and the consistency of the operator.

The geotextile strips were rolled out onto the wet tack coat and a saturation coat was then sprayed at an application rate of 1,2 l/m^2. Crusher dust was then applied. The road was then opened to traffic to fulfill the rolling/compaction function. The wearing coarse showed significant loss due to high speed traffic. The paving fabric strip, however, showed excellent performance as a waterproofing layer. Within a year a surface treatment was carried out over the geotextile strips.

4.1.2 Road P6/1—km 33.75. Bapsfontein—Bronkhorspruit (December 1992).

Experimental sections with different grades of nonwoven, needle-punched, polyester geotextiles were constructed. The existing surface was severely cracked, crocodile and longitudinal cracks prevailed. 500mm wide strips of a 115g/m^2; 120g/m^2; 150g/m^2; 180g/m^2 and 210g/m^2 geotextile were laid transverse to the direction of traffic.

Two 500mm strips of a pre-manufactured strip, comprising a 0,5mm thick polymer modified bitumen layer laminated to a 150g/m^2 nonwoven geotextile, were also laid in the wheel paths. Crushed sand was used to fill some of the wider cracks. (Inspection Notes, 1993).

A polymer modified emulsion was used for the tack and saturation coats at an application rate of 0,65 l/m^2 residual bitumen per coat. Crusher dust was applied as the wearing course. The traffic count was 4 245 EVU with 28% heavy vehicles. Visual inspections revealed that after six months the cracks did reflect to the surface but the integrity of the waterproofing layer was preserved.

Generally most of the wearing course was lost. The presence of water in unsealed cracks during the wet season and the sand filling of some of the cracks had an adverse effect on the geotextile adhesion to the existing surface. In places the fabric lifted and tore, exposing the old surface.

The test section became obsolete at the end of October 1993, with the opening of the new road, thus completing nearly 11 months of harsh exposure to traffic. The performance of the strips notwithstanding the problems encountered was considered as good.

4.1.3 N4—Witbank/Hondsrivier (1993)

This was a resurfacing contract which included surface treatments as well as some base failure repairs. A 200 mm wide strip of nonwoven geotextile was used for the cracksealing. Total emulsion used for the tack and saturation coat was 2,0 l/m^2. Where rutting occurred, a slurry was applied as a levelling course, with a bitumen rubber single seal as a surface treatment.

Numerous other projects have included geotextile cracksealing strips and are well documented by the authors. To date well over 1 000km of 200mm wide geotextile cracksealing strip has been successfully installed on Southern African roads.

4.1.4 Manzini—Big Bend, Swaziland (March—November, 1992)

The existing road surface exhibited extensive longitudinal and block cracking and prior to resurfacing the cracks were treated using 200, 500 and 1 000 mm wide paving fabric strips. Also in the areas of extensive cracking 2,5 m wide geotextile was used in a full-width application. As part of the rehabilitation programme the existing road was also widened and a 500 mm strip was laid along the joint between the new and old pavement to prevent ingress of water. In all instances a geotextile tack coat of 1,0 l/m^2 and a saturation coat of 1,0 l/m^2 of bitumen emulsion was applied. A single seal conventional surfacing treatment was then constructed.

4.1.5 Mombasa Road (at Athiriver), Kenya (February 1993)

A highly distressed section of this highway was patched using geotextile strips, 200 mm wide, with a total of 2,0 l/m2 of bitumen emulsion being used to saturate the geotextile. A crusher dust wearing course was then applied. The highway has an extremely high traffic volume. Performance to date has been good with stripping of the surfacing evident in places. Further deterioration of the road surface has been prevented.

4.2 Full Width Resealing

4.2.1. Zwelitsha, Ciskei (May 1990)

A 2 km section of a resealing contract incorporated a paving fabric laid on a 16 year old pavement, exhibiting severe potholing. The procedure was to repair all potholes and sweep; spray the geotextile tack coat, a 65% cationic emulsion at 0,6 - 0,8 l/m^2; lay the geotextile and then roll with a PTR (4 passes).

The conventional single seal was then applied and rolled. An inspection in April 1993 revealed that the section was generally preforming well. In two areas, where heavy vehicles turn off the road, there was fairly extensive damage to the surfacing. The geotextile, however, did not appear to be ripped or damaged. There was also localised surface cracking which did not appear to have affected the performance of the geotextile seal. Having undergone regular maintenance repairs

in the past the road section is now relatively maintenance free.

4.2.2 Road 681 - Brits/Dikololo (October 1991).
This road has severe cracking and rutting problems. Due to a lack of funds it was decided to do a surface rehabilitation until total reconstruction is possible.

In October 1991, three different methods of cracksealing were applied on Road 681 at km 4,6 + 0,38 from Brits as part of an official Transvaal Roads Branch Test Section:

- Full width geotextile seal comprising of a geotextile tack coat of 150/200 penetration grade bitumen sprayed at 0,6 l/m^2, geotextile laid down by hand and rolled with a PTR (very little geotextile pick-up occured) followed by a conventional seal of 150/200 penetration grade bitumen and 13,2mm pre-coated stone.
- Lancing method of cracksealing and 13,2mm single seal with bitumen rubber.
- Geotextile strip sealing of individual cracks and 13,2mm single seal with bitumen rubber.

Control sections comprising a 13,2mm single seal with bitumen rubber and 150/200 penetration grade bitumen without cracksealing were included in the test section. Five different combinations are available for evaluation via crack activity measurement and close visual inspection.

These test sections are the subjects of reports for the Transvaal Roads Branch, Directorate Materials (Inspection Notes, 1993 and Bester and Van Zyl Report, 1992). The last visual inspection was carried out in November 1993 and the following observations were made :-

- no pumping was visible on any of the sections
- cracks have reflected to the surface but the geotextile seal was intact.
- very little aggregate loss was evident
- bleeding was evident in the wheel tracks on all sections but more extensively so on the full width geotextile section. The latter being due to high binder application rates (total of 2,8 l/m^2 of 150/200 penetration grade bitumen)
- riding quality and skid resistance was assessed as fair to good
- the condition of the old pavement is very likely due to age rather than pavement deformation and movement
- no conclusions can be drawn at this stage on the performance of the different cracksealing methods.

Further full width seal applications using paving fabrics have been constructed in the Orange Free State on Provincial roads between Reitz and Tweeling, and Dealesville and Boshoff where the latest assessments have proved favourable. Also a full width reseal has been constructed in Witbank, Transvaal, to combat a recurring and severe rutting and cracking problem. The results have shown the system to be a successful rehabilitation measure for the problem

5 GUIDELINES FOR GEOTEXTILE REHABILITATION AND MAINTENANCE PROCEDURES

5.1 Geotextile Selection.

In all the South African applications to date in cracksealing, patching and full width resealing a relatively lightweight nonwoven, needlepunched, polyester geotextile has proven suitable. See Table 1.

Table 1: Properties of Paving Fabric

Property (Average Values)	Units	Value	Test Method
Weight	g/m^2	150	SABS 0221-88
Thickness under 2kN/m^2	mm	1,4	SABS 0221-88
Tensile Strength	kN/m	9	SABS 0221-88
Elongation at break	%	50	
Grab Strength	N	390	ASTM D-4632
Bitumen Absorption	l/m^2	1,0	T.P.A.
Bitumen Retention (Unloaded)	l/m^2	1,4	Task Force 25
Melting Point	°C	260	ASTM D-276

Worldwide experience indicates that needlepunched nonwoven geotextiles are the preferred type of geotextiles in this application. They saturate well with bitumen and their low modulus behaviour permits them to remain flexible within the surfacing seal.

Van Zyl and Louw, 1989, showed that an optimum binder application rate of 0,6 l/m^2 of residual bitumen established a maximum bonding of 110 Nm (torque force) for the geotextile shown in Table 1. This test procedure could also be applied to the actual road surface.

The geotextile used complies with the "Specification for Paving Fabrics" as prepared by the AASHTO - AGC - ARTBA Task Force 25 (1987) (FHWA, 1990).

5.2 Choice of Bitumen

All bitumens are compatible with polyester geotextiles. Experience in South Africa has confirmed the compatability of polyester nonwoven geotextiles with all types of bitumens.

5.2.1 Cracksealing

Generally cracksealing and patching with geotextiles has been installed using polymer modified emulsions, cationic and anionic emulsions. No doubt the best results achieved have been with polymer modified emulsions.

The residual binder content must be sufficient to totally saturate the geotextile and provide additional binder for the wearing coarse.

The Federal Highway Administration concludes, that best results are achieved on fatigue type crocodile cracking 3mm wide or less in relatively mild climates (Koerner, 1990). The Southern African experience has shown that cracks up to 10mm wide can be sealed without filling prior to strip placement. Success has even been achieved with 75 mm wide cracks pre-filled with a slurry mix.

5.2.2 Full Width Reseal

In this application most bitumen types have been used. Greatest success has been achieved using penetration grade bitumens and modified bitumens. Emulsion tack coats can and have been used successfully, but should be allowed sufficient time to break before laydown and rolling of the geotextile.

Depending on the texture and porosity of the cracked road surface the geotextile tack coat may vary between 0,6 and 1,0 l/m^2 residual bitumen to assure full saturation of the fabric and an optimum bond between the old surfacing and the paving fabric. The penetration coat should ensure enough free binder is available for chip retention after absorbtion by the fabric (0,3 - 0,4 l/m^2).

5.3 Choice of Reseal

Paving fabrics must not be considered in isolation as a remedial measure for failures in flexible pavements. They are intended to enhance the performance of conventional remedial measures e.g. slurry seals, single or double seals and asphalt overlays. The choice of seal type is based on which one will perform best in a specific situation most cost effectively. Standard procedures are used to make this decision.

The condition of the existing road pavement should be evaluated prior to the choice of reseal (CSRA TRH3, 1989).

A point worth stressing is that surface symptons indicate progressive failure due not only to surface water ingress but subsurface drainage problems. Remedial measures should include subsoil drainage as a supplementary consideration.

5.4. Performance

It must be borne in mind that a geotextile reinforced surfacing seal cannot make up for any structural deficiency or inadequacy of the pavement.

The objective of geotextile reinforcement is to enchance the principal functions of conventional surfacings and to extend the field of application of the conventional seals. This should open up the scope for road engineers to surface roads which may not otherwise be surfaced by traditional methods. There is also the potential for reduced subsequent maintenance.

Experience in the last 10 or more years in the United States suggests that a bitumen impregnated geotextile is equivalent in it's performance to 40mm of bituminous material (Walsh, 1989). Experience in Southern Africa, where the geotextile seal has been used both experimentally and in full scale application, has proved the effectiveness of nonwoven geotextiles in waterproofing cracked pavements.

An encouraging aspect has been the excellent adhesion of the geotextile to the road surface. The presence of water within the upper pavement layers during installation of the geotextile (especially the strips) has been known to affect the geotextile adhesion to the existing surface. Of concern with the strip cracksealing is the general loss of the wearing course once the system is opened to traffic. Comparison to successful applications revealed that too high a fine fraction in the crusher dust takes up too much bitumen leaving little for the coarser fraction to adhere to, thus more effort on rolling the system is required before opening to traffic. Normal speed restrictions should be imposed. A substantial wearing course more compatible with the expected traffic conditions should be considered.

Tight control on site and rigid adherence to proper installation procedures during bitumen application and paving fabric placement will produce an effective system. Obviously to ensure the continued excellent performance record for paving fabrics the most important factor will be the enforcement of stringent installation specifications and guidelines. The more than 7 year life attained out of the strips and patches installed in the Transvaal by the T.P.A. Roads Department bears testimony to good site control and installation practice.

15 years of good performance of a paving fabric interlayer beneath a 35mm asphalt overlay in Durbanville, Cape, is a strong indication that, provided the area of application is right and installation is correct, performance is excellent.

6 CONCLUSIONS

The results of test sections and actual installations in South Africa over the last 15 years have shown that :-

6.1 The paving fabric effectively prevents water penetration through the new surfacing into the underlying pavement layers.

6.2 Reflective cracking is retarded. If cracks appear in the new surfacing, the waterproofing function of the paving fabric layer is maintained.

6.3. Nonwoven, needle-punched polyester geotextiles have successfully prevailed as a component of the paving fabric interlayer system in Southern Africa.

6.4 Optimum binder application rate for the tack coat is 0,6 l/m^2 of residual bitumen. Depending on the state of the road pavement, additional binder must be allowed for in the conventional seal to fully saturate the geotextile.

6.5 Most bitumens have been used successfully especially with polymer modified bitumen emulsions in cracksealing and the hot mix penetration and/or modified bitumens in full width resealing.

6.6 Stringent specification and design guidelines are imperative.

6.7 Proper installation procedures are critical for optimum performance.

6.8 Mechanised fabric placement is faster and more effective on large scale contracts. The smaller projects are ideally suited to hand placement.

6.9 The paving fabric interlayer enhances the performance of the surfacing seal while providing benefits such as lower construction costs (e.g. compared to reconstruction) while prolonging the fatigue life of the pavement.

6.10 Paving fabric helps stretch available construction budgets via low maintenance requirements, pretreatment of roads prior to rehabilitation and extending the life of the deteriorating road pavement.

6.11 Long term evaluation of existing installations in comparison to conventional practices will continue and are necessary to assess overall cost effectiveness. Short term indications, however, remain promising.

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