

## Examination of the Benefits of Enhancing Chip Seal Surface Treatments with Paving Fabric Interlayers

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### ABSTRACT

Paving fabric interlayers have been used in the United States (U.S.) to mitigate reflective cracking in hot mix asphalt (HMA) overlays for decades. Chip seal surface treatments (or simply chip seals) have been used to seal roads for over a century. Combining paving fabric interlayers with chip seals is a hybrid system that has been successfully used in the U.S. and elsewhere abroad for reflective cracking control and extending pavement's service life for more than 25 years. Besides this application field, it has also been widely used in several other countries for reducing sub-grade moisture content and stabilizing roadways built on expansive clay sub-grades.

This paper will examine the exploding use of paving fabrics under chip seal systems in the U.S. through literature review, it will update the reader on the systems' current use and it will pay some emphasis on using the system to stabilize roadways over expansive clay subgrades.

### 1. INTRODUCTION

Geosynthetics are used to improve the performance and/or life cycle cost in many civil engineering applications. Geosynthetics are still relatively new when compared to materials like rock, asphalt, concrete, steel and lime. The acceptance and use of geosynthetics in civil engineering is most similar to the acceptance and use of reinforcing steel in concrete. Because geosynthetics are still relatively new, many federal, state and academic entities still separate designs with geosynthetics from standard design methodologies. For example, the Federal Highway Administration (FHWA) has recently incorporated geosynthetics into some of their standard design guides, but they still have a separate manual for designing with geosynthetics. FHWA also did not consider geosynthetics as a standard construction material in the Long Term Pavement Performance Project (LTPP) and in the development of the Mechanistic-Empirical Pavement Design Guide (MEPDG). They are currently integrating geosynthetics into the MEPDG. The United States Army Corps of Engineer's (USACE) manual Design and Construction of Levees (USACE, 2000) does not include design methods for geotextile-reinforced levees although geotextiles are commonly used in levee construction. USACE has a separate geosynthetics design manual, Engineering Use of Geotextiles (USACE et al., 2004), with a chapter dedicated to the design of geotextile-reinforced levees. Geosynthetics design is still taught as a separate and/or elective course at many universities instead of being incorporated as a regular part of basic design courses, despite the fact that many civil engineering professors are knowledgeable to varying degrees about geosynthetics design. The excellent multifaceted performance of geosynthetics has enabled engineers to build structures which were not possible prior to geosynthetics' existence. However, geosynthetics performance and manufacturing complexities may make the incorporation of geosynthetics into standard designs more difficult.

This complexity and struggle for acceptance is very apparent in the paving fabric market. Billions of dollars worth of paving fabrics have been successfully installed and numerous case studies have been published on performance and life-cycle benefits. Some cities even include paving fabric in every hot-mix asphalt (HMA) street they own. There have also been pavements with paving fabrics that have failed for different reasons, and there is good documentation on these failures. Most failures associated with installed paving fabric systems can be traced to the paving fabric being the wrong treatment for the problem at hand or an improper installation. Industry experts, good paving fabric installers and frequent end users of paving fabrics know that when utilizing paving fabrics is the right treatment for a certain pavement and when fabrics are installed properly and at the right time, their benefits are fully realized.

Most states, counties and cities in the U.S. can not afford to properly maintain the rapidly deteriorating transportation infrastructure system. Entities that do not have a pavement preservation or maintenance program have a large percentage of pavements that need to be seriously rehabilitated or completely replaced. It is now well known that every dollar spent on preservation, before rapid deterioration of the pavement structure begins, saves four to ten dollars in the future. FHWA is strongly encouraging states, counties and cities to focus on and spend a significant portion of their transportation budget on pavement preservation.

FHWA and other agencies are evaluating the use of paving fabrics under chip seals as a standard pavement preservation treatment option. It has been proven that the application of paving fabrics under chip seals can

significantly decrease the life-cycle cost of pavements when it is used in the right place at the right time. Agencies that have successfully incorporated paving fabrics into their chip seal program report considerable savings.

## 2. DESCRIPTION

### 2.1 Paving Fabric under Chip Seal System

The “paving fabric under chip seal” system is constructed by installing a paving fabric on a properly prepared existing pavement followed by a conventional single (Figure 1) or double chip seal over the fabric. Proper installation of a paving fabric for use under a chip seal is slightly different and more critical than proper installation of a paving fabric for use under an HMA overlay. Guidance on the proper installation of paving fabrics under a chip seal can be found in the recently published (Davis et al., 2008), in installation guidelines published by major U.S. manufacturers of paving fabrics, in Brown (2003) and Sprague et al. (1993).

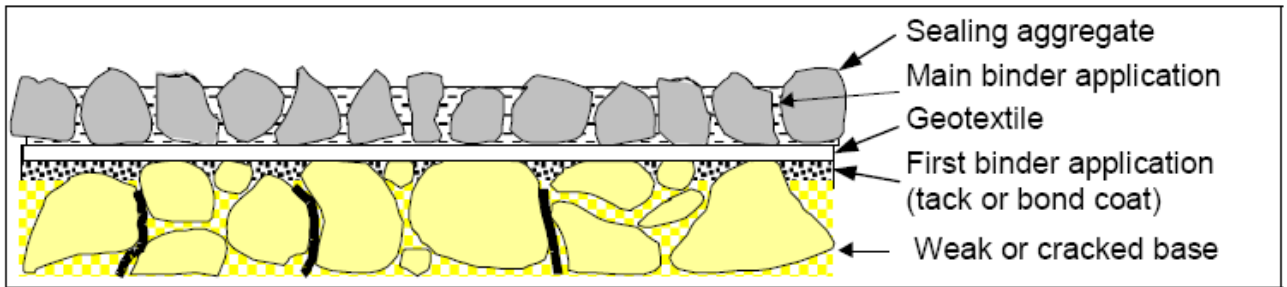


Figure 1 Paving Fabric Under Single Chip Seal (Alderson, 2006)

### 2.2 Benefits of Paving Fabric under Chip Seals

The benefits of using paving fabrics under chip seals are (Brown, 2003):

- Reflective cracking control: the saturated paving fabric bridges cracks and allows for the movement of the blocks of pavement beneath without directly affecting the chip seal matrix on the surface
- An extension of the pavement life that is directly attributable to the complete blockage of sunlight, air and water that typically age and cause deterioration of asphalt pavements
- Prevention of surface water infiltration,
- Stabilization of subgrade moisture content
- Allowing wet, weak subgrades to regain strength and load-carrying capacity

### 2.3 Successful Site Selection for Paving Fabric under Chip Seals

Paving fabrics are typically used under chip seals on low- to high-volume rural roads and low volume municipal roads. They are best suited for:

- Straight or gradually curving roads
- Sections of roadway with few driveways or intersections
- Vertical grades up to about eight percent
- Pavements that would have a sound structural section under optimum subgrade moisture conditions

For subgrade moisture control, the system has been successfully used as a surface treatment on existing asphalt pavements as well as directly on the clay subgrades of remote, light traffic roads.

For reflective cracking control, the “paving fabric under the chip seal” system performs well on pavements with extensive age-induced alligator or block cracking and oxidation.

Experienced users of the system have used paving fabric under chip seals in extreme conditions with outstanding results. However, it is highly recommended that new users be conservative with site selection to ensure success.

## 3. USE OF PAVING FABRICS UNDER CHIP SEALS

### 3.1 Current Use in the United States

In the U.S., the “paving fabric under the chip seal” system has been a standard treatment option in San Diego County’s, CA annual chip seal program for over 20 years. Successful applications of this system in Northern California have been reported in the literature (Brown, 2003). Some fabric under chip seal projects in the U.S. have resulted in maintenance-free pavement life-cycles of over 20 years with little to no reflective cracking. Figures 2 and 3 are two sections of the same pavement in northern California (Brown, 2003). The section in Figure 2 was treated with an HMA overlay. The section in Figure 3 was treated with a double chip seal over paving fabric. When these photographs were taken both sections were at least 20 years old and had received no maintenance.



Figure 2 Aerojet Facility, Northern California  
20-year old 2-inch hot mix asphalt overlay (Brown, 2003)



Figure 3 Aerojet Facility, North California  
20-year old double chip seal over fabric (Brown, 2003)

The County of San Diego, CA first started using paving fabric under chip seals as a standard treatment option in the 1980s after installing and evaluating different chip seal methods. By incorporating paving fabrics into their chip seal program they estimate annual savings of about \$100,000 a year. On pavements with fabric under a chip seal, maintenance costs are decreased and crack sealing is eliminated once the paving fabric is in place. Details of the San Diego County, CA program have been reported in a TRR Circular (Davis, 2005).

Currently, Texas DOT and FHWA, as well as several other transportation agencies throughout the U.S., have installed and continue monitoring and evaluating several paving fabric under chip seal test sections.

### 3.2 Current Use in Other Countries

Paving fabric under chip seal is a standard pavement preservation treatment option in France, South Africa, New Zealand and Australia. It is commonly described regionally as a geotextile-reinforced sprayed seal or GRS.

Australia is a strong proponent and user of GRSs and all Australian states have been using some form of GRS. Single chip seal GRSs are used as stress-absorbing membrane interlayers (SAMI) under other surface treatments. Australian practice seldom exposes a single chip seal over paving fabric to traffic. In Victoria, NSW, double chip seals over paving fabric are applied over a variety of surfaces, most of which are in poor condition. In some cases, the GRS yields 12 to 15 years of pavement life. VicRoads, the state road authority in Victoria, NSW also uses a GRS on some roadways in advanced states of deterioration. They aim in keeping the roadway in service until they can plan, design, arrange funding or relocate services for a more permanent pavement treatment. Used in this context, even 5 years of additional service life is considered a successful treatment as those additional 5 years of performance could not have been reasonably achieved by other means (Esnouf, 2008).

Vicroads uses GRS both in stress alleviating membrane (SAM) and SAMI applications as de facto rehabilitation treatments. GRSs are occasionally used as the sealed riding surface directly on formed but unpaved pavements in remote locations. In metropolitan regions, GRSs are increasingly used in composite treatments such as under ultra thin asphalts and as a waterproofing membrane under new asphalt overlays (Esnouf, 2008).

Vicroads and other Australian road agencies also use GRSs to control pavement shrinkage cracks built over expansive clay subgrades. Field studies and literature findings demonstrate that moisture contents in expansive clay subgrades below a GRS remain consistent and, as a result, the subgrade remains firm. Deutschbein et al. (1987) conclude that “the geotextile reinforced seal is effective as a moisture control tool.” Gordon et al. (1984) conclude that water ingress into the pavement occurs at the edge of the sealed section if vertical moisture barriers are not installed. Thus, the seal is extended well beyond the trafficked zone to maintain the desired stiffness of the pavement or vertical moisture barriers are installed.

#### 4. LITERATURE REVIEW

##### 4.1 Pavement Preservation Technology

FHWA and the National Cooperative Highway Research Program (NCHRP) jointly sponsored the Pavement Preservation International Scanning Study (FHWA, 2002). The objective of the scanning study was to review and document innovative techniques, materials, procedures and equipment used in the host countries (France, South Africa, and Australia) for pavement preservation and to evaluate these elements for potential application in the U.S. The scanning team traveled to the host countries and met with government agencies and private-sector organizations involved with pavement preservation. They also visited project sites to observe the results of successful pavement preservation techniques and strategies.

The scanning team reported that these countries emphasize pavement preservation, use only quality materials and have rigorous specifications that they firmly enforce.

Two of the scanning team's key findings are:

- All the countries visited have made a commitment to design and build long lasting structural pavement sections on their national roadway networks. This initiative has shifted focus of maintenance activities on surface courses in order to preserve the large investment made in the underlying layers. This, in turn, promotes the use of relatively low cost seals and thin overlays as the primary maintenance techniques, instead of more costly types of rehabilitation.
- By providing initial high structural capacity sections, emphasis is placed on maintaining the structure using relatively low cost seals and thin overlays on set, repeatable maintenance cycles. For the most part, rehabilitation is a minor portion of the agency maintenance programs. Consequently, pavement preservation techniques are emphasized.

The scanning team developed eleven recommendations with implementation potential in the U.S. One of these eleven recommendations was to “test and evaluate geotextile-reinforced chip seals in both freeze and no-freeze environments.”

The scanning team also recommends that individual entities partner with sponsor agencies to develop “research statements to evaluate the use of better aggregates, geotextiles, and binder application procedures in preventive maintenance treatments.”

##### 4.2 Chip Seal Best Practices

The most common pavement preservation treatment in use today is the chip seal. NCHRP Synthesis 342, “Chip Seal Best Practices,” (Gransberg et al., 2005) contains an international survey and summary of chip seal best practices. Ninety two entities responded to the survey. The survey revealed almost 610,000 lane miles of chip seals have been installed in Canada, Australia, New Zealand, South Africa and the United Kingdom while another 140,000 lane miles have been installed in the U.S.

Gransberg et al. (2005) gave special consideration “to the highly technical process used to design and build chip seals in Australia, South Africa and the United Kingdom”. As per Gransberg et al. (2005), “the average chip seal life-cycle in the U.S. is 5.75 years. The average chip seal life-cycle in Australia is 10 years, in South Africa is 12 years and in the United Kingdom is 10 years. Each of these countries “indicated that they consistently achieve chip sealing performance excellence on both low- and high-volume roads.” GSRs are also a standard treatment chip seal in all three countries. These “international respondents unanimously believe that geotextile-reinforced seals are effective for treating badly cracked, oxidized or structurally distressed pavements”. Gransberg et al. (2005) also report that these other countries have a standardized chip seal design method, they demand and they are willing to pay for higher quality materials and they have strictly-enforced installation procedures. San Diego County, CA and several state authorities in the U.S. have reported excellent chip seal performance. It is the opinion of the author that these states could easily incorporate paving fabrics into their chip seal programs.

Gransberg et al. (2005) also concluded that “it appears that the use of geotextile-reinforced chip seal is promising and should be considered for those roads that have more than normal surface distress and for which an overlay is not warranted.”

#### 4.3 FHWA, Texas DOT Research

In an effort to implement the findings of the Pavement Preservation Technology Study (FHWA, 2002), FHWA partnered with Texas DOT to evaluate the use of paving fabric under chip seals. The research was conducted from 2004 to 2008. “The project objective is to assess as to what extent non-woven geotextile fabric underneath chip seal surface treatments will reduce reflective cracking, reduce moisture penetration through the pavement structure, affect ride quality and increase the pavement life.” In 2004, TXDOT Waco District constructed single chip seals over paving fabric at six sites using different combinations of tack coat, seal coat binder and aggregate materials. Each test section was at least 0.5 miles long and covered at least two travel lanes. The traffic volumes at the sites varied from an average daily traffic (ADT) of 330 up to 31,000. (Rodriguez, 2007) Each section also had a control section consisting of just the chip seal treatment (no fabric) used in the “paving fabric under chip seal section”. A visual evaluation/survey and several standard pavement condition surveys of the test sites were completed annually and are now available from FHWA.

The following key observations are in FHWA's 2007 Annual Pavement Condition Survey (Rodriguez, 2007):

- The chip seal sections with geotextile fabric are doing a better job of controlling reflective cracking
- Most of the noted pavement surface problems in the chip seal over geotextile fabric sections are a result of poor geotextile fabric placement practices
- The rate of deterioration is higher in the control sections than in the ones including the geotextile fabric.

It is the opinion of the author that the benefits of using paving fabric under chip seals will be apparent at the end of the study. However, due to the fact that proper placement practices have not been meticulously implemented and documented and due to the wide variation in the asphalt and aggregate materials properties, the author also believes that the results of the study may not show the benefits of the system to the extent that it has been realized among users such as San Diego County, CA and the Australian transportation agencies.

#### 4.4 Vicroads Geotextile Reinforced Seals Technical Note (Vicroads, 2008)

Vicroads (2008) reports that “since being introduced into Australia in the 1970s, Geotextile-Reinforced Seals have found particular application in the rehabilitation of cracked and weak pavements by reducing the incidence of reflection cracking and provision of a high level of performance as a waterproofing membrane.” On SAM treatments, Vicroads (2008) states that “GRS treatments may be used to provide more robust waterproofing and resistance to reflection cracking on pavements that are cracked due to ageing of asphalt or sprayed seal surfaces, shrinkage of cemented base materials or high deflections on weak pavements.”

Australian road agencies use a double chip seal over paving fabric for SAMs. Vicroads (2008) recommends that “expert advice should be sought before using a single coat seal” over a paving fabric under direct traffic loading. Vicroads (2008) and Brown (2003) both assert that double chip seals over paving fabric provide a robust treatment with good resistance to turning traffic.

Vicroads uses a GRS as a SAMI where there is a risk of “reflection cracking from shrinkage of cemented base materials, or excessive embedment and/or high deflections on weak base materials” but a GRS may not be the preferred riding surface.

#### 4.5 Other Literature

Once Australia and other countries made long-term budget goals, they also placed heavy emphasis on pavement preservation and life-cycle cost instead of initial construction cost (FHWA, 2002). Austroads (2006), Vicroads (1995) and Austroads (2004b) refer to the system as a common treatment when a durable, highly waterproof seal is needed. The U.S. is still in the process of shifting care of infrastructure from rehabilitation and replacement to preservation. Some agencies that have made that paradigm shift are beginning to realize the benefits of incorporating paving fabrics into their chip seal programs.

The author recommends the following reference sources for detailed information on site selection, design, installation, performance and cost savings of the “paving fabric under chip seal” system: Davis et al., 2008; Brown, 2003; Sprague, 1993; Austroads, 2003, Austroads, 2004a, Austroads 2004b, Austroads, 2005 and Austroads, 2006.

## 5. PAVING FABRIC UNDER CHIP SEALS OVER EXPANSIVE CLAY SUBGRADES

As mentioned in previous sections, a specific use of the “paving fabric under chip seal” system is to control pavement cracks created by the shrinking and swelling of underlying (subgrade) expansive clay soils. Such subgrade conditions are encountered in many areas around the U.S. Most of the US research, technology and treatments addressing this issue involve modifying and stabilizing clay soils prior to building a pavement. Some significant research has also been reported on encapsulating expansive soils with impermeable membranes in order to stabilize the subgrade moisture content. Texas DOT and the Colorado Department of Transportation (CDOT) have invested significant resources in researching and looking for solutions to this problem. A significant drawback to the current practice for controlling surface cracking caused by expansive clay soils is the expense, time and effort of modifying or encapsulating the expansive clay subgrade soil. This may be a practical option for new roads, but rather a very expensive proposition for existing ones, where removing and replacing existing pavements is very expensive.

The use of a paving fabric under chip seal is a viable solution for many existing roads with shrinkage cracks and premature deterioration caused by expansive clay subgrades. Most of the surface water landing on a cracked asphalt pavement infiltrates into the pavement section. The paving fabric under the chip seal system prevents surface water from entering the subgrade through the pavement surface. This minimizes moisture fluctuations and reduces swelling and contracting potential of subgrade soils which cause shrinkage cracks in a pavement surface. A paving fabric under a chip seal will not eliminate surface cracking, but if it is designed and installed properly, it can reduce the size and movement of the surface cracks. Deutschbein et al. (1987) state that in clay underlain pavements sealed with a GRS, the role of the asphalt saturated geotextile is to bridge the cracks caused by shrinkage in the clay and prevent their reflection into the seal so that the clay is in turn protected from downward moisture ingress. Deutschbein et al. (1987) also conclude that the pavement beneath a GRS remains firm and well dry of optimum moisture. In comparison, the same material beneath the shoulder was spongy and well above optimum moisture.

Research and field studies, as early as 1965, have demonstrated the benefits of surface seals for controlling subgrade moisture content fluctuations (Gordon et al., 1984). The reader can also view the Austroads and Vicroads web sites ([www.austroads.com.au](http://www.austroads.com.au) and [www.vicroads.gov.au](http://www.vicroads.gov.au), respectively) for information on the use of GRS for controlling expansive clay subgrades.

## 6. INCORPORATING PAVING FABRIC UNDER CHIP SEALS INTO AN EXISTING PROGRAM

To successfully incorporate the “paving fabric under chip seal” system into a pavement preservation program, transportation agencies must:

- Understand the benefits and limitations of the system
- Understand the importance of proper site selection
- Use a rational design methodology, and
- Establish and enforce thorough material and installation specifications

It is the recommendation of the author that any agency interested in incorporating this system into their pavement preservation program must:

1. Study the site selection criteria, design methodologies and installation practices of the agencies and owners who have been successfully using this system
2. Partner with a paving fabric installer, chip seal contractor and/or paving fabric manufacturer experienced with the “paving fabric under chip seal” system
3. Perform and document field trials to determine the design methodology, specifications, materials and installation method most suited to their needs, location and available resources
4. Create guidance documents and specifications particular to their agency

## 7. CONCLUSIONS

Most of the work being performed on the U.S. transportation infrastructure is on existing pavements. Yet, due to budgetary constraints and rapid infrastructure deterioration, many agencies can not afford to rebuild, rehabilitate or sometimes even maintain their roads. FHWA is encouraging agencies at all levels to implement pavement preservation programs. As a result, larger portions of transportation budgets are being dedicated to pavement preservation.

Increased pavement life and decreased life-cycle costs are core elements of any pavement preservation effort. The keys to realize increased pavement life and decreased life-cycle cost with paving fabric under chip seals are the same as any other pavement preservation treatment; correctly installing the right treatment on the right pavement at the right time.

Australia, the United Kingdom, France, and San Diego County, CA have all reported successful applications of the “paving fabric under chip seal” system to increase average life-cycle and decrease life-cycle cost of pavements. There are detailed design methodologies for installing paving fabrics under chip seals. FHWA is encouraging agencies to research and test paving fabrics under chip seals. FHWA is also providing strong incentives for pavement preservation to qualifying agencies. The author strongly believes that US transportation agencies could increase the average life of their chip seals and pavements by properly incorporating paving fabrics into chip seal programs.

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