# Use of Geotextile-Reinforced Bituminous Seals To Improve Amenity and Environment of Remote Rural Roads

P. G. L. WOLFE

The recent development of geotextile-reinforced bituminous seals on clay pavements for use on remote rural roads to improve amenity and environmental conditions is described. The use of these seals allows substantial economies in the provision of all-weather roads in remote areas and improves access and road safety and reduces materials usage. The design and construction of these types of pavements and a trial using the accelerated loading facility to validate their structural adequacy are described.

Australia is a vast continent with more than 900 000 km of roads, with about 65 percent of these roads being unsurfaced. There are about 600 m of road per person in Australia compared with 300 m in the United States. Funds for provision of all-weather pavements in Australia are at a premium, particularly in the sparsely populated remote rural areas, where traffic volumes are typically less than 100 vehicles per day. In these remote areas, there are large tracts of expansive clay soils, which are particularly difficult to service with cost-effective all-weather pavements.

Most of these areas have average annual rainfalls of significantly less than 600 mm. However, precipitation as low as 3 mm makes these unsealed clay roads untraffickable for days. High summer temperatures, often exceeding 40°C, are common. Figure 1 shows the extent of these expansive clay areas throughout Australia.

Since 1985 the Roads and Traffic Authority New South Wales (RTA) has been developing the use of geotextile-reinforced bituminous seals for the provision of inexpensive all-weather pavements in remote areas with expansive clay subgrades. These types of pavements are capable of being constructed at between 30 and 40 percent of the cost of conventional pavements with comparable design lives. They also allow considerable improvement in amenity for remote rural communities, substantially reduce the use of local gravels (which are commonly of poor quality), eliminate dust problems, improve road safety, and reduce vehicle wear.

## HISTORY

Reinforcing of sprayed bituminous seals is not new. Field Marshal Sir William Slim, reporting in his book *Defeat into Victory* (Cassell London 1956) on the Burma campaign of World War II, recorded the use of hessian dipped in bitumen and laid on 100 mi of road formation (subgrade only) to support 1,000 army vehicles per day for a year, which included the monsoon season. With the advances in modern geotextiles, their use in this type of application has been tested by RTA since 1985.

## THE PROBLEM

The provision of all-weather pavements on expansive clay subgrades is a difficult problem. Clays with linear shrinkage values of 25 percent are not uncommon. Gravel in these areas is usually scarce and of poor quality. Failure modes for traditional unbound granular gravel pavements with a conventional sprayed bituminous chip seal are generally associated with environment rather than load. Failure usually relates to longitudinal cracking resulting from changes in moisture conditions of the expansive clay subgrades, which, in turn, results in surface deformations due to volume changes in the clay. This leads to increased moisture infiltration through the seal, which rapidly accelerates failure during wet periods. Seals under these conditions usually have only limited life, typically 5 to 8 years, because of oxidation of the bitumen from the high summer temperatures and low traffic volumes.

## DESIGN

The design of clay pavements with geotextile-reinforced seals comprises a number of considerations.

### Pavement Cross Section

The pavement cross section that has been adopted is shown in Figure 2. These types of pavements are generally built on very flat terrain, so the formation is raised above the natural surface using material won from borrow pits outside the road reserve. This is done to eliminate table drains so that water will not lie next to the pavement during the infrequent flooding that occurs in these areas.

### Height of Formation

The height that the formation is raised above the natural terrain is a compromise between gaining sufficient height to

Roads and Traffic Authority, 22–24 Campbell Street, Haymarket, New South Wales 2000, Australia.

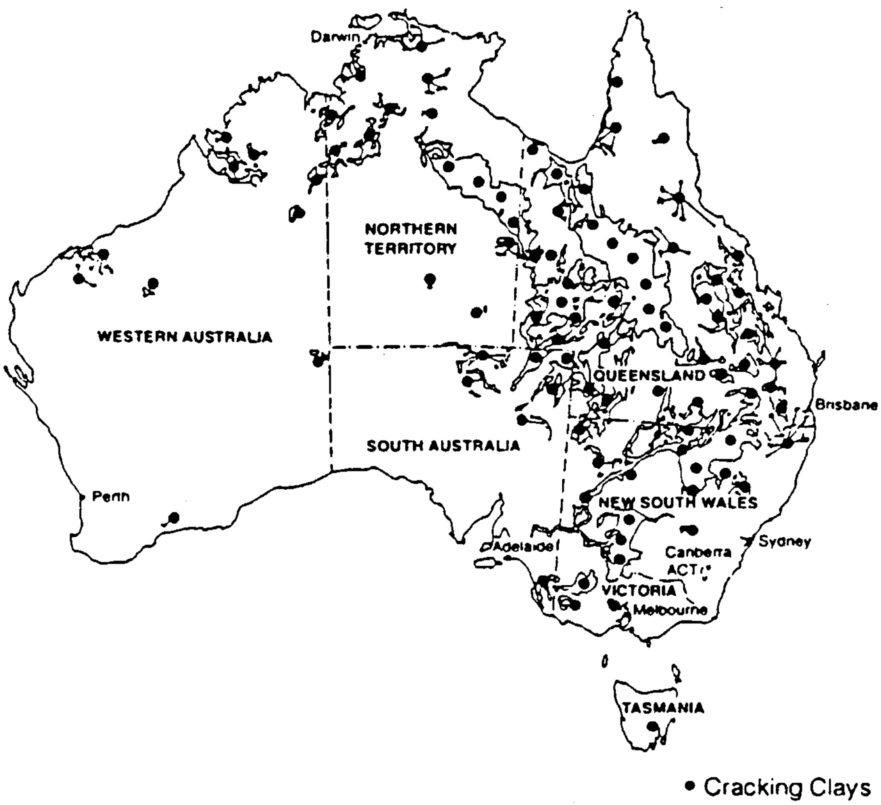


**FIGURE 1** Extent of expansive clay subgrades.

minimize moisture infiltration during floods and not having it so high that the formation will desiccate in drought periods. A height at the edge of the shoulder of 600 mm has been adopted in areas subject to intermittent flooding. A height of 300 mm may be suitable in other locations.

### Width of Geotextile Seal

A seal width of 8.2 m has been adopted. There are two reasons for this. First, 8.2 m can be subdivided into two 3.3-m-wide traffic lanes with 0.8-m shoulders that can be delineated by edgelines. Observations of unsealed clay pavements subject to edge saturation indicate that 0.8 m is close to the limit of infiltration of the wetting front. Second, the geotextiles used are supplied in 4.2-m-wide rolls allowing a 0.2-m overlap in the center of the pavement.

### Pavement Crossfall and Grade

A pavement crossfall of 4 percent has been adopted because (*a*) it tends to entice heavy vehicles to travel toward the center (and most moisture stable) area of the pavement and (*b*) if the clay embankment material swells near the edges as a result of moisture infiltration, adequate crossfall for drainage will still be maintained.

All the pavements built to date have been on very flat grades. Since the geotextile-reinforced seal generally does not bond to the clay pavement but lies on top of it like a heavy blanket, the use of these types of pavements where there is likely to be significant acceleration or deceleration of heavy vehicles must be questioned, because the seal may move.

### Batter Slopes

Batter slopes of 5:1 have been adopted as a compromise between a flat batter slope to minimize erosion of the formation due to rainfall runoff and the need to minimize earthworks volumes.

### Embankment Compaction

The embankment material consists of the in situ expansive clay compacted to a minimum level of 95 percent of standard

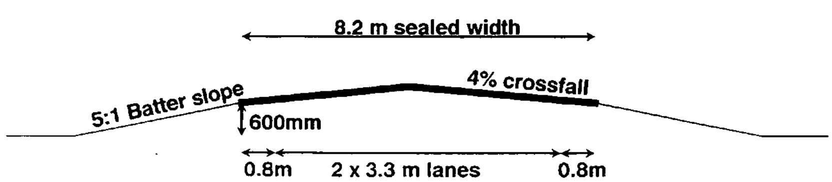


**FIGURE 2** Pavement cross section.

maximum dry density. The upper 300 mm of the clay embankment (the pavement) is compacted to a minimum density of 100 percent of standard Proctor maximum dry density (generally in two 150-mm layers). The compaction of the top 300 mm of the clay is critical to the performance of the pavement because it maximizes the bearing capacity of the pavement while reducing its permeability to a very low level. Compaction should be carried out at a moisture content near the long-term equilibrium moisture, generally between 15 and 20 percent for Australian conditions.

### Choice of Geotextile

A vast range of geotextiles is now available. For use in sprayed bituminous seals the following characteristics are considered desirable:

- Nonwoven geotextiles are considered better than woven ones because they have more uniform elongation, resist tearing better, and have superior bitumen/fabric adhesion.
- Needle bonded are considered most suitable because heat- and resin-bonded joins may become unstable when in contact with hot bitumen.
- Polyamides absorb water, lose strength, and tend to become brittle; polyvinyls may be subject to bacterial attack; and polyolefines (polypropylene and polyethylene) burn easily (melting point typically 165°C), exhibit high creep, and are subject to ultraviolet light deterioration. Polyesters, which do not burn easily (melting point typically 250°C), absorb only small amounts of water, and are less sensitive to ultraviolet light, are the most suitable. Polypropylene can be used if bitumen emulsion is used in the sealing process.

Nonwoven needlepunched polyester is therefore the preferred material. Recommended properties are given in Table 1.

**TABLE 1 Recommended Geotextile Properties**

| Property | Recommended Minimum* |
|---|---|
| Mass | 140 g/m$^2$** |
| Thickness | 1.5mm |
| Elongation at ultimate strength | 50% |
| G Value (Robustness***) | 950 |
| Bitumen saturation | 0.9 L/m$^2$ |
| Melting Point | > 165$^\circ$C |

* AUSTROADS Guide to Geotextiles, Technical Report, January 1990.
** Suitable for 10mm aggregate. For larger aggregate sizes, heavier geotextiles should be used to minimise puncturing.
*** Robustness is a measure of resistance to stresses imposed during the construction stage.

## CONSTRUCTION

### Embankment

The embankment is constructed by conventional earthworks methods. Because typical expansive clays have optimum moisture contents (OMCs) of between 25 and 28 percent and are unworkable at these levels, compaction must be carried out at levels substantially less than OMC to try and minimize volume changes after compaction.

### Geotextile-Reinforced Seal

The application of the geotextile reinforced seal involves the following steps:

- A bitumen prime coat is applied to the clay surface, which has been swept and lightly watered. The binder is a Class 170 hot bitumen incorporating up to 3 percent cutter and is applied at a (cold) application rate of about 0.8 to 1.0 L/m$^2$, depending on the surface absorption characteristics of the pavement.
- The geotextile is then rolled out onto the primed surface using a mechanical applicator, which follows close behind the sprayer.
- A scatter coat of 7 mm aggregate is spread on top of the geotextile and rolled to bring the bitumen to the surface of the geotextile and to provide a tack-free surface for construction traffic.
- A hot bitumen seal (Class 170 bitumen), designed in accordance with RTA Seal Design Method (*1*), is then applied. [The usual (cold) application rate is about 1.3 L/m$^2$. If a polymer-modified binder is used, the usual application rate should be about 1.9 L/m$^2$.] The use of polymer-modified binders will obviously increase the initial cost but has the advantages of better aggregate retention and a reduced rate of binder oxidation. Cutter may be added to the binder in accordance with normal seal design procedures (*1*).
- Ten mm of cover aggregate is then spread and immediately rolled to cover the area sprayed.
- The behavior of the seal is dependent on the absorption of the binder into the pavement and the geotextile, which is often difficult to estimate. Allowances of between +0.5 and +0.8 L/m$^2$ are not uncommon. If the seal is deficient in binder, it may require an enrichment.

This provides a very substantial seal with a heavy application of binder, which is quite robust and resistant to oxidation resulting from high summer temperatures and low traffic volumes.

### Traffic Markings

Edgelines only are marked on the pavement to encourage travel away from the edges of the pavement, and guideposts are placed 800 mm in from the edge of the seal to stop wheels traveling on the outer edges of the sealed area.

### Pavement Maintenance

There is a need for a regular enrichment program to counter the effects of oxidation of the bitumen binder. If polymer-modified binders are used, this should decrease the frequency of the required enrichment.

Patching of the geotextile seal may be necessary and can be achieved by squaring any hole in the geotextile, cutting corner slits, placing a geotextile patch that "underlaps" the surrounding geotextile by about 150 mm, and then spraying the patch with bitumen emulsion and applying a 7-mm aggregate. Commercially available self-adhesive rubberized bitumen membranes may also be used.

## PAVEMENT PERFORMANCE

The long-term performance of clay pavements with geotextile seals depends on

- The structural capacity of the pavement to withstand the traffic loading,
- The environmental degradation of the seal and the pavement as a result of the temperature and moisture regime in which the pavement must perform, and
- The amount of accelerating and braking of heavy vehicles.

Because of the very fine nature of the clay, the geotextile-reinforced seal does not bond to the clay but sits on top of it. If there is heavy braking or acceleration, there may be local movements of the seal. If these areas can be identified during design, the use of a thin layer of gravel over the clay will ensure bonding of the seal.

The first trials of clay pavements with geotextile-reinforced seals were carried out on the Cobb Highway in western New South Wales in 1985. These trial sections are still in use and have suffered imperceptible structural damage to date and have only received routine maintenance treatment. However, there has been insufficient traffic to determine the structural adequacy over a design life of 20 years.

## BREWARRINA ACCELERATED LOADING FACILITY TRIAL

With the popularity of clay pavements with geotextile seals increasing, it was decided to conduct an accelerated loading test using the accelerated loading facility (ALF). The ALF is a relocatable road-testing machine that applies full-scale rolling wheel loads to a test pavement. The ALF was designed and manufactured by RTA and is owned and operated by the Australian Road Research Board in cooperation with AUSTROADS, the national road authority coordinating group. ALF has been used continuously since 1984 in a series of nationally coordinated pavement trials (*2*).

The trial was conducted on a remote arterial road in the northwest of New South Wales near the town of Brewarrina. The aims of the Brewarrina ALF trial were (*a*) to determine the structural adequacy of pavements consisting of geotextile-reinforced seals over prepared clay subgrades and (*b*) to gain knowledge of how distance of the traffic loading from the edge of the geotextile seal and the presence of water adjacent to the edge of the pavement affect the performance of these pavements.

The trial was carried out between July and December 1991, and detailed reporting is presented by Walter (*3*), Sharp and Johnson-Clarke (*4*), and Sharp and Walter (*5*).

For most expansive clay pavements in remote areas of New South Wales, the design traffic for a 20-year design life would be less than 200,000 equivalent standard axles (ESAs). A standard axle in Australia is 8.2 tonnes on a single axle with dual wheels. To test the worst possible case, with water adjacent to the edge of the seal, dams were built adjacent to some of the test pavements as shown in Figure 3.

The results of the tests on the clay pavement sections are summarized in Table 2.

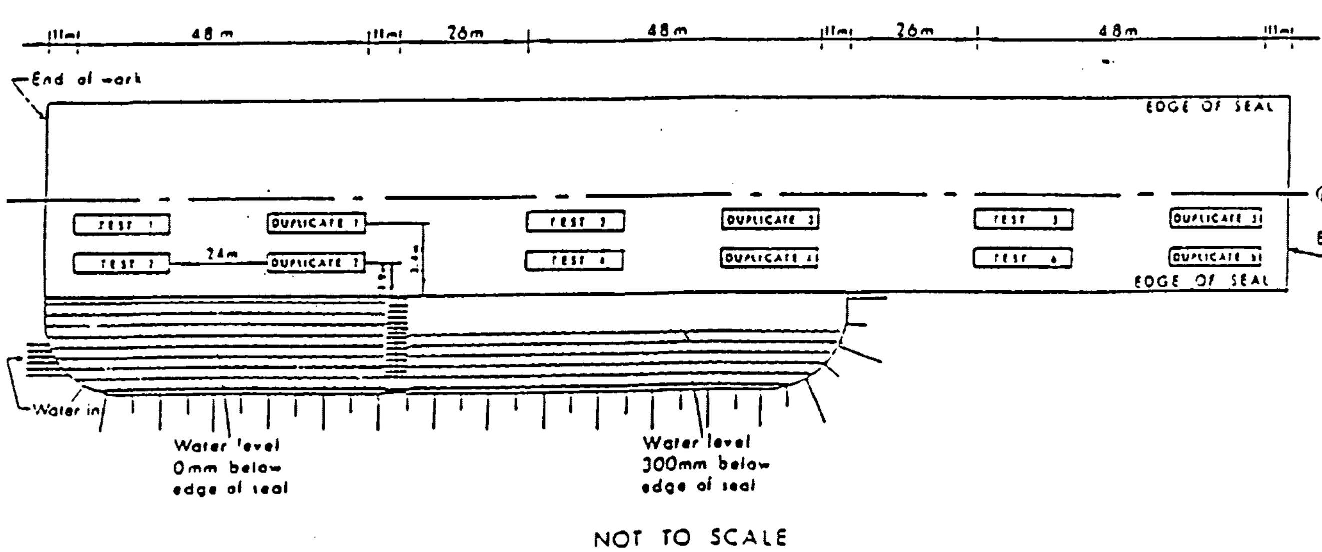


**FIGURE 3 Brewarrina ALF test pavement layout.**

**TABLE 2 Summary of Brewarrina ALF Trial Results**

| Position of Loaded Wheel | Rut depth | ESAs |
|---|---|---|
| Centre of dry pavement | 7mm<br>12 mm | 20,000<br>180,000* |
| 1.9m from pavement edge with water at edge of seal. | 9.4mm<br>22mm<br>35mm | 13,800<br>174,000<br>220,000* |

* Indicates end of testing.

A further trial was carried out with the ALF at an angle to the longitudinal direction of the pavement and with water at the edge of the pavement, to try and get the loaded wheel closer to the edge of the pavement. This resulted in substantial deformations on the outer 1 m of the pavement after only 150 load cycles. This illustrates the sensitivity of the clay pavement to moisture increases and indicates that these types of pavements would not be applicable in areas subject to inundation during flood times. However, from Table 2, the substantial structural capacity of the clay pavements was demonstrated by the ALF.

The transverse distribution applied by the ALF was a normal distribution of width 1.4 m. This is applicable to normal lane widths of about 3.5 m on reasonably heavily trafficked roads. Recent preliminary measurements on remote rural roads where there is little oncoming traffic and very good sight distances (*6*) indicate that transverse distribution of wheel loads on low-trafficked roads is substantially wider than 1.4 m. This means that the design ESAs used for this type of road may be decreased significantly.

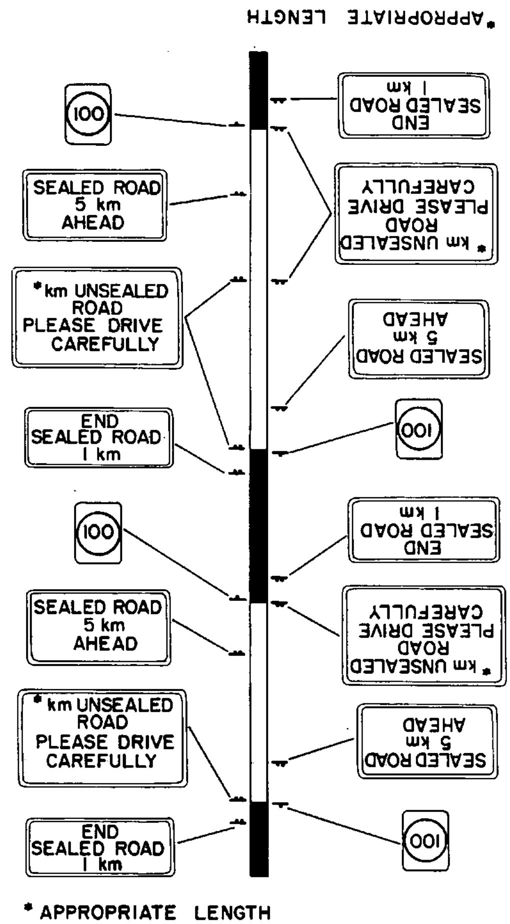


**FIGURE 4 Signposting scheme for improved overtaking safety.**

## SAFETY CONSIDERATIONS

Where there are long lengths of unsealed pavements that create safety problems as a result of dust hazards making overtaking maneuvers dangerous during dry periods, geotextile-reinforced seals have been used in short lengths to provide safe overtaking opportunities. In these situations, appropriate signs are erected to enable motorists to maximize the safety of overtaking maneuvers. A typical signposting scheme is shown in Figure 4.

This type of scheme has been implemented in remote areas of western New South Wales and is a cost-effective means of improving road safety on remote roads, particularly where tourist and commercial (e.g., stock haulage) traffic are mixed.

## CONCLUSION

The cost of providing an all-weather pavement using clay pavements and geotextile-reinforced seals is approximately 30 to 40 percent of a conventional pavement with 300 mm of gravel and a normal bituminous seal.

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