Application of moisture barriers for expansive soils

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ABSTRACT: Vertical moisture barriers are used to minimise the differential movement of pavements on expansive soil subgrades. This paper discusses two types of barrier: (1) the geomembrane barrier, developed for alluvial expansive soils, and (2) the lime and fly ash grout curtain, for residual expansive soils.

1 INTRODUCTION

Road pavements usually suffer considerable damage from expansive soil, since useful life of the pavement becomes significantly less than the design life due to the long wavelength roughness and longitudinal cracking caused by the seasonal moisture variation in the subgrade. A successful method of minimising differential movement of a road pavement constructed on an expansive clay subgrade, as well as preventing trees and shrubs from extending their roots under sealed pavements, is the installation of a vertical moisture barrier.

Two types of moisture barriers are discussed in this paper. The first is the geomembrane vertical moisture barrier which is primarily used for pavements constructed on alluvial expansive soils, and the second is the lime and fly ash injected grout curtain which has been used for pavements constructed on residual expansive soils.

2 GEOMEMBRANE MOISTURE BARRIER

An existing concept of moisture barriers, which has been used extensively in the United States and in various parts of Victoria, is the geomembrane barrier. Research into the application of geomembrane moisture barriers began in Victoria in 1985 when a length of the Sunraysia Hwy at Morton Plains was reconstructed due to pavement damage caused by expansive soils. Results from this trial (described in detail by Holden, 1992; Evans & Holden, 1994) provided strong evidence that the installation of vertical moisture barriers significantly increases the life of the pavement. This finding encouraged VicRoads to continue with the research into vertical moisture barriers and gave them the incentive to find a more cost effective method of installation.

2.1 *Installation of geomembrane vertical moisture barriers for alluvial soils in Victoria*

For the installation process to be cost effective, it was imperative that a new method of installing the geomembrane vertical moisture barrier be devised to fulfil certain requirements, including quicker construction time, reduced costs, and a barrier that can be easily applied to any existing pavement. These requirements were met as a result of the development of new equipment and procedures as follows (Evans et al. 1996):

- A slim-line boom and crumber bar used on a chain trencher (Fig. 1) were designed to produce an 80 mm wide trench, 2.0 m deep.
- A steel soil chute and conveyor belt were fitted to the trenching machine allowing the removed soil to be shifted to the verge, providing a clear working space (Fig. 2).
- In areas of wet clay, a lime dispenser (De Marco 1997), was used which sprinkled a lime powder on the teeth of the boom, thus preventing the wet sticky clay from clogging up the teeth.

• A membrane dispenser (Fig. 2) was developed that unrolled the membrane from a horizontal roll and placed it vertically, as a continuous sheet, into the trench.

Figure 1. Slimline boom

Figure 2. Train of equipment

• The double-layer membrane was placed on the shoulder side of the trench (Fig. 3) to allow the flowable fill to fill any cavities beneath the pavement caused by overbreak. The double-layer provides a low-friction shearing plane that protects the barrier from the seasonal vertical movements that occur in the unsealed shoulder.

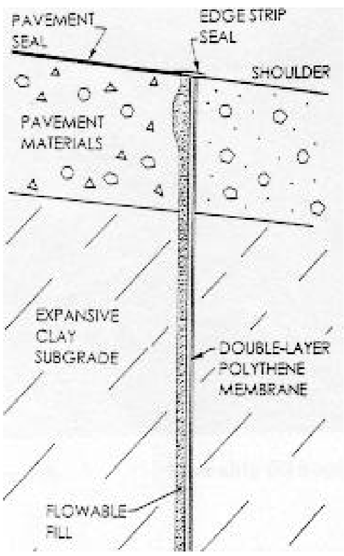

Figure 3. Cross section of barrier

• A mobile hopper was also developed (Fig. 2) which enabled the flowable fill to be easily poured into the trench. Polystyrene wedges were used to hold up the membrane in the trench while it was being backfilled.

2.2 *Types of backfill used*

Two types of backfill were used for the vertical moisture barriers. The first type of backfill, hereafter called "fly ash flowable fill", consisted of 87.5 kg cement, 1610 kg sand, 212.5 kg fly ash and 205 kg water to make up one cubic metre.

In October 1996, another type of flowable fill was tested which consisted of a mixture of 125 kg cement, 1800 kg sand and 275 L water. An aerating product called Darafill was added, increasing the flowability of the fill and increasing the volume of the stabilised sand by 15-35 %.

The virtues of using the Darafill flowable fill instead of the fly ash flowable fill are as follows:

• fly ash is not required; most concrete plants already have sand and cement, but fly ash needs to be specially purchased.

• Darafill flowable fill is quite porous and can absorb and transfer moisture (De Marco 1997). This eliminates any possible damming up of water in the sub-base of the pavement adjacent to the barrier, which can produce pavement distress.

• a better bond is achieved between the edge seal of pavement and the top surface of the barrier due to its hard porous surface as opposed to the dusty surface of the fly ash flowable fill, which allows the surface seal to be easily peeled off.

A cost analysis was conducted (De Marco 1997) to determine the maximum and minimum costs of installing the geomembrane vertical moisture barrier. The total cost for installing the geomembrane ranged from $12.30 to $25.90/lin m.

To test this new construction technique, field trials were conducted on the Henty Hwy at Dooen, located in the Wimmera region of North West Victoria. This trial is discussed in the accompanying paper (Pardo et al. 1998).

3 LIME AND FLY ASH GROUT CURTAINS

The above method of installing the geomembrane vertical moisture barrier, developed by VicRoads, has been successful for alluvial expansive soils, but is not practical to apply in a cost effective manner for residual expansive soils (mainly found in the South West of Victoria) due to the presence of floaters. Another disadvantage, particularly for basaltic clays, is the development of oblique joint planes and slickensided surfaces, which are an extreme hazard to trenching operations (Dahlhaus & O'Rourke 1992), making the geomembrane barrier even less feasible to install.

Moisture takes an extremely long time to permeate the intact clay; however, when this clay is cracked, low resistance paths for moisture are created, thus greatly increasing its permeability. Therefore, an obvious solution to keep moisture from penetrating the cracks in a clay is to seal them. A method that seals the cracks has recently been introduced in Australia, that also provides a solution to the above problems with using the geomembrane barrier for residual soils. The Lime and Fly Ash (L/FA) Injection Method was originally developed in the United States for stabilising railways, earth embankments, river levees and active road subgrades (eg. Blacklock & Wright 1984). It was also used for grout curtains adjacent to sealed pavements (Gay & Lytton 1988; Steinberg 1992) and existing buildings (Petry 1992). In 1994, in Adelaide, Pavement Technology Ltd further developed the L/FA injection equipment to suit Australian conditions.

The L/FA slurry is injected to the depth of equilibrium moisture content, at fixed intervals, adjacent to the sealed pavement, with the intention of filling the cracks and fissures of the clay subgrade to form a continuous curtain. This grout curtain acts as a moisture barrier minimising lateral moisture flow beneath the pavement and thus maintains a stable moisture regime.

Ideally, tree roots extending into the subgrade of the pavement should be severed to eliminate their drying

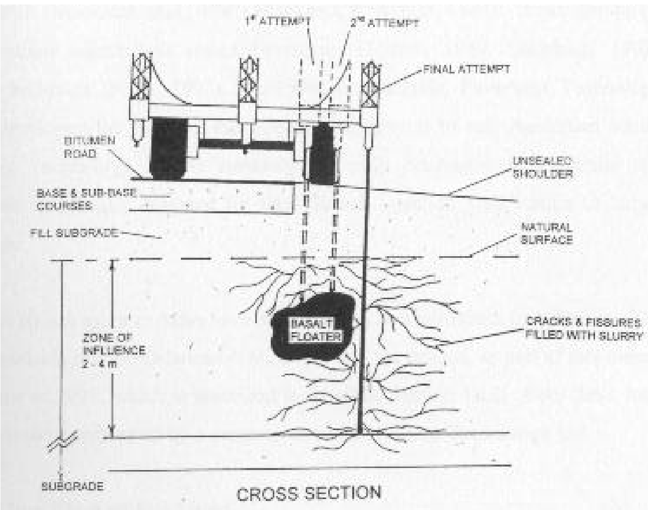

Figure 4. Basalt floater in L/FA grout curtain

effects; however, the high alkalinity of the slurry (pH 12-13) may deter and possibly terminate further growth of tree roots beneath the pavement (Mathias et al. 1996).

VicRoads discovered that the major virtue of using the L/FA injection method in a residual basaltic soil is that if a floater is hit, the injector is simply pulled out, moved across, and another injection attempt made (Fig. 4). Further attempts are made until the injector reaches the desired depth. The boulder then becomes encapsulated by the grout and a continuous curtain is formed.

3.1 *Installation of L/FA grout curtains for residual soils in Victoria*

The following description of equipment and procedures used by Pavement Technology Ltd applies to injecting a grout curtain adjacent to a sealed pavement (De Marco 1997). The injection rig consists of a 10 tonne reaction capacity rig and 3 injectors. For our purposes, injecting a grout curtain adjacent to the sealed pavement, only one injector was required. VicRoads designed a new injector tip (Fig. 5), which had a section of reduced diameter so that the slurry could remain under pressure in the resulting annular space, thus providing a greater ability to fill the intersecting cracks and fissures. This injector tip was used for the trial described in the accompanying paper (Pardo et al. 1998).

The injector was simply pushed into the unsealed shoulder adjacent to the sealed pavement at a constant rate using a chain drive. Grout injection was commenced from approximately 300 mm below the surface and was continuous to the pre-determined final depth.

Figure 5. VicRoads injector tip

For the lime and fly ash injected grout curtain to be effective, it must be installed to the depth of seasonal moisture change

3.2 *Timing of grout curtain installations*

Timing of the grout curtain installation is crucial in obtaining a successful moisture barrier. The ideal time of the year to seal all the possible cracks and fissures that can develop in the soil is at the end of the dry period of the year, when the soil is the most desiccated; however, a disadvantage of injecting at this time is that the grout will tend to flow out of large surface cracks, thus using excessive amounts of grout and making the technique less economical. Therefore, the best time to install a grout curtain may be after the first rains following the dry period. The moisture will partially close the cracks in the unsealed shoulder, yet may not reach the cracks in the subgrade of the pavement. This would allow the slurry to be guided beneath the pavement (where it is most needed) rather than breaking out of the cracks in the unsealed verges.

At this stage, VicRoads has only tested this method at one location (described in the accompanying paper, by Pardo et al. 1998). The overall cost was $39.10/lin m.

4 CONCLUSIONS

Two types of vertical moisture barrier have been developed: (1) the geomembrane barrier, for alluvial expansive soils, and (2) the lime fly ash grout curtain, for residual expansive soils.

At this stage, the injection method is more expensive than the geomembrane vertical moisture barrier; however, VicRoads was planning to continue with the refinement and thus cost reduction of the grout curtain.

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