Use of Geosynthetics in Pavement Rehabilitation: Field Experience in Malaysia

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ABSTRACT: In Malaysia, it is a common practise to use a 40 mm thick Asphaltic Concrete overlays designed using Marshall procedures in pavement rehabilitation. However, field studies carried out by IKRAM on this practise showed that the overlays suffered from cracks very early in its service life. It has also been shown that these cracks were reflections of cracks found on the existing pavements. The reflection of the cracks occurred when the stresses created by the movements of the existing cracks created cracks in the new layer. Many methods have been tried by various researchers in trying to eliminate this occurrence, and the use of geosynthetic materials as interlayers can be a solution to mitigate the rate of formation of reflective cracks. The interlayer in theory could dissipate the crack-tip stresses therefore reducing the rate of crack propagation and the amount of damage done to the overlays.

Since 1988, IKRAM have carried out a number of trials using different types of geosynthetics materials as an interlayer between the existing pavements and the overlays. Altogether, three trials had been constructed and monitored. The first two trial uses a polypropylene geogrid; the third uses two types of geogrids and two types of geofabrics while the fourth and latest trial used one type of geogrid and geofabric.

Post construction measurements mainly focused on cracking and rutting in the overlay. Recent reviews of the trials have indicated some failures and some successes. Some had even failed early due to poor construction skills of the geosynthetic interlayers. The technique of laying the geosynthetic interlayer was found to be critical. In using the geofabric, the type and amount of tack coat was paramount. When the geosynthetic materials were placed correctly they show positive results in mitigating reflective cracks.

1 INTRODUCTION

In Malaysia, it is a common practice to use of bituminous overlays in rehabilitating pavements. However, large scale monitoring of this practice by Morosiuk and Mutalif (1) showed that these overlays suffered from reflection cracks early in their service life. The use of stress-absorbing interlayers between the existing pavement and the new overlays has been shown to be a solution in mitigating the occurrences of reflective cracks. The interlayer in theory could dissipate the crack-tip stresses therefore reducing the rate of crack propagation. In addition, the interlayer could also increase the fatigue resistance of the overlaying asphalt. Geosynthetic materials are said to have the potential to act as an interlayer for this purpose.

Laboratory tests had proven the advantages of using geosynthetic materials as interlayers. Button et al carried out laboratory tests on geosynthetic interlayers and concluded that improved properties of the overlaying asphalt could be achieved provided the geosynthetic material is installed correctly. The focus in this paper is given to the technique of installing the geosynthetic on the pavement to simulate the laboratory achievements.

2 FIELD TRIALS

2.1 TRIAL 1: Using Polypropylene Geogrid

The first field trial in Malaysia was carried out using a polypropylene geogrid as an interlayer. The geogrid used had a tensile strength of >50 kN/m^2 . The geogrid was laid on existing pavement according to the suppliers' specifications. This included the methodology for fixing the geogrid and the spray rate of the tack coat. The geogrid was first pinned to the pavement surface using nails before the tack coat was sprayed. A 50 mm hot Asphaltic Concrete was then laid on the geogrid.

After a few days, the overlay started to open up at the locations where there had been longitudinal and transverse joints of the geogrids. The cracks were attributed to the shrinkage of the polypropylene geogrid due to the heat.

From the deflection studies using Fallingweight Deflectometer (FWD) before and after construction, it was found that the geogrid was not improving the structural strength of the existing pavement. The premature failure occurred in the form of slippage and short transverse cracks. Wheel-path cracking and rutting occurred at a later stage. Hypotheses put forward for the failure are:

1. Delays during the paving process allows differential creep to take place in the geogrid thus breaking the bond during construction

2. Intense heat from the asphalt causing shrinkage in the polypropylene material

3. The stiff polypropylene material warps under the wheel load of the trucks and pavers, thus causing pumping in the new asphalt layer.

The above reasons necessitate improvements to the method of installing the polypropylene geogrid.

2.2 TRIAL 2: Retrial on Polypropylene Geogrid

The second trial was carried out using the same polypropylene geogrid as an interlayer, but this time, the geogrid was laid using a different approach. In this trial, after nailing the geogrid to the existing pavement surface and the tack coat applied, a layer of surface dressing was laid before laying the hot Asphaltic Concrete. The steps taken are as shown in Table 1.

Table 1. Summary of construction method

Construction Detail	Applied
Preparation of existing surface	As specified
Tension of the grid	750-800 kg
Fixing the grid	As specified
Application of tack coat	0.45 l/m^2
Thickness of dressing layer	< 20 mm
Compaction of dressing layer	No
Laying temperature of asphalt	100-190 °C

This trial was successfully constructed without failure occurring until today, 5 years later. The elimination of direct heat contact on the polypropylene geogrid proved to be the successful formula.

2.3 TRIAL 3: Using Various Types of Geosynthetic Materials as Interlayers

In this trial, four geosynthetic interlayers were tried. The geosynthetic materials used and their relevant properties are given in Table 2.

Table 2. Various types of geosynthetic material use as interlayer in Trial 3.

Geosynthetic Material	Properties
A) Needlepunch, polypropylene fabric.	Tensile strength - 9.0 kn/m (ASTM D 4595), Bitumen retention - 0.9 l/m2 compressed (US FHTF 25)
B)Polypropylene Geogrid	Tensile strength >50 kn/m
C) Needlepunch polyester fabric	Tensile strength - 365 N, Bitumen saturation - 0.9 l/m^2, Melting point - 149 °C.
D) High-tenacity Polyester Geogrid	Tensile strength - 50 kn/m (DIN53857), Weight - 260 g/m^2, Rupture strain - 14 %

Each geosynthetic material was laid following the suppliers recommendation. Where tack coat was needed, the tack coat type and rate of spray was pre-determined by the supplier. All the tack coat used was emulsion based. The Polypropylene Needlepunch fabric used RS2K (a rapid setting, cationic emulsion with 60% bitumen); the Polypropylene grid and the Polyester Needlepunch fabric used RS3K (a rapid setting, cationic emulsion with 65% bitumen); while the Polyester geogrid used RS1K (rapid setting, cationic emulsion with 50% bitumen).

Shear tests were performed on cored samples to investigate the bond between the existing surface and the overlay with the geosynthetic materials in-placed. The shear test results are given in Table 3.

Table 3. Shear test results

Geosynthetic Material	Shear Strength (kn/m2)
A) Needlepunch fabric; RS2K Emulsion	142
B) Polypropylene Geogrid RS3K Emulsion	117
C) Needlepunch polyester fabric. RS3K emulsion	20
D) Polyester geogrid, RS2K Emulsion	170
E) Control (no geosynthetic)	250

The shear test results indicated poor bonding for the geosynthetic interlayers. The needlepunch fabrics indicate very weak bonding. The choice of tack coat and its rate of spray is suspected to influence the bonding quality and therefore is important in this case. The choice of the rapid setting cationic emulsion as tack coat may not suitable for geosynthetic applications. This is evidence from the strong bonding for the control section where there were no geosynthetic materials used. The use of specific type of tack coat for each geosynthetic material could solve this problem.

Subsequent inspection on the trial area shows that the poor bond resulted into pre-mature failure of the overlay in the form of rutting and slippage.

From this trial it can be concluded that the choice of tack coat and its rate of spray has a major role to play in order to avoid slippage of the overlaying asphalt. This is very important especially for the needlepunch fabrics.

2.4 TRIAL 4: Use of Geogrid and Geofabric in Mitigating Reflection Cracks

A more recent trial was carried out where only two types of geosynthetic material was specified, alongside other types of interlayers. Apart from the geosynthetic material, six other types of interlayer ranging from conventional surface dressing to thick dense bituminous macadam was constructed. The trial section is given in Table 4.

Table 4. Trial section for the study in mitigation of reflective cracks

Section	Description of Interlayer Used
A	Fibreglass Geogrid
B	Needlepunch Fabric
C	Cut and Patch
D	Surface Dressing - RSK
E	Surface Dressing - MC3000
F	Control
G	Binder Course
H	Pervious Macadam
I	Crushed Stone

The geogrid selected in this study was a glassfibre geogrid having a tensile strength of 50 kN/m^2 at 3 per cent strain. The geogrid is applied directly onto the existing cracked surface and was covered with a thin layer of fine aggregate mix before applying the 50 mm asphaltic concrete overlay. The manufacturers claim that the geogrid reinforces the overlay material above, thus 'substantially reducing reflection cracking'. The glassfibre geogrid was slightly coated with bitumen, and because of this the application of the tack coat was different from the previous trials. To ensure proper applicability, a trial lay was carried out. This method seemed to be a better option to ensure success of the project.

The needlepunch fabric selected was a polypropylene needlepunch fabric. It has a tensile strength of 9 kN/m^2 and a minimum extension at ultimate breaking strength of 50 per cent. The concept behind needlepunch fabrics is that the bitumen filled fabric will dissipate the crack tip strain thus reducing the strain induced to the new overlay and hence retarding the rate of propagation of reflection cracks. The supplier claimed that the 'deceleration factor' of reflection cracking is about 2-3. The needlepunch fabric was laid using a specially designed dispenser and a rubberised emulsion was used as tack coat.

After about a year in service, both sections are still in sound condition at the time this paper is written. There are no signs of pre-mature failure on the geosynthetic section indicating achievements in method of installing both the Needlepunch and the Geogrid.

A control section nearby those sections had already cracked, however at this control section, the deflection level is higher than the rest of the experimental sections.

3 CONCLUSIONS

Successful application of the geosynthetic material as an interlayer depends on factors such as,

1. Tack coat type and rate of spray
2. Laying technique to ensure that the geosynthetic material is fixed to the existing surface and do not warp under the paver load
3. Temperature susceptibility of the geosynthetic material

These are important factors to consider for the proper installation of the geosynthetic material. Simple and economical approach is needed since it will increase the total cost of the inclusion of the geosynthetic and the total cost of the rehabilitation system.

Although laboratory tests had shown improved properties of the asphalt with the inclusion of the geosynthetic interlayer, field applications is a challenging task to accomplish similar condition to that achieved in the laboratory. We had to take the hard way in learning how the geosynthetic materials should be applied to achieve the necessary results. Eventhough it took us five years four trials, we are satisfied with the results achieved so far. It is always better to ensure that the suppliers and contractors are very familiar in the laying and construction of geosynthetic materials as interlayers. It is our recommendation that trial lays should be carried out to determine compatibility of local tack coats with the geosynthetic materials being proposed. This is very important to ensure success.

4 REFERENCES

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