Asphalt Reinforcement with Polyester Grids: Practical Experience in Airfields

Zehra KAYA [1], Fabiana LEITE-GEMBUS [2]

1. *Huesker Australia, Brisbane, Australia*
2. *Huesker Synthetic GmbH, Gescher, Germany*

ABSTRACT

Construction of asphalt overlays is a conventional method used for rehabilitation of airfield pavements. However, cracks in an existing flexible or rigid pavement, and/or construction joints in the existing rigid pavement can rapidly propagate into the new asphalt overlay as a result of the aircraft loading combined with temperature changes. Widely known as reflective cracking, this phenomenon can be addressed by incorporating polyester (PET) asphalt reinforcing grids that have shown significant results in delaying the process of crack propagation. The reinforcement occurs through a mechanism whereby the polymer grid captures the peak stresses at the tip of the crack, distributes them over a larger area and therefore achieves a retardation of the crack propagation into the newly constructed asphalt overlay. Utilizing basic theory and practical experiences, this paper will demonstrate the success and extended pavement life that can be achieved by using polyester asphalt reinforcing technology in airfield pavements. Evaluation of long-term performance on site and the key factors associated with the effectiveness of the reinforcing material (e.g. the loss of tensile strength due to the paving procedure, and the importance of the bond-strength) have been highlighted in particular. Furthermore, based on 40 years' practical experience with asphalt reinforcement, this paper presents typical applications and also limitations associated with the use of asphalt reinforcement in rehabilitation of deteriorated runways, taxiways and aprons at airports. The paper concludes that the extended pavement life achieved by the use of this technology reduces both the construction disruption to airfield operations and the associated maintenance costs to asset owners.

Keywords: Asphalt reinforcement, Polyester (PET) polymer grid, Pavement rehabilitation, Airfields, Case study.

1. INTRODUCTION

For over 40 years, all around the world, geosynthetics have been used in order to delay or even prevent the development of reflective cracks into asphalt layers. Use of an appropriate asphalt reinforcement has been proven to clearly extend the pavement service life and therefore increase the maintenance intervals of rehabilitated asphalt pavements [1-2]. As a result, damaged roads and airfield pavements can be resurfaced more cost-effectively by incorporating reinforcement systems [3- 4].

Currently, there are a number of different products and systems made from different raw materials (e.g. polyester, glass fibre, polyvinyl alcohol, carbon fibre, polypropylene) available in the market. It is not disputed that each of these products has a positive effect in the battle against reflective cracking [5-6]. However, it must be noted that there are differences in the behaviour and the effectiveness of each system.

The objective of the paper is to provide the reader with sufficient information on effective asphalt reinforcement and introduce the concepts of using appropriate asphalt reinforcement geosynthetics in pavement rehabilitation or maintenance, with a particular focus on airfield pavements. To achieve this, the paper will address and present the following: Required properties for asphalt reinforcement products described in accordance with the European standards, proof of effectiveness by research using dynamic fatigue tests, example practical experiences from various airports, and finally, limitations to using asphalt reinforcement.

2. BASICS: REFLECTIVE CRACKING & ASPHALT REINFORCEMENT INTERLAYERS

The phenomenon known as reflective cracking is the result of the propagation of cracks from layers deeper in the pavement into the new overlay and is a major mode of failure in rehabilitated pavements [7]. It is well established that cracks occur due to external forces, such as traffic loads combined with temperature variations. High stresses at the bottom of the pavement caused by the external dynamic loads lead to cracks which then propagate from the bottom of the pavement to the top (bottom-up cracking). Cracking can also start at the top of the pavement and propagate down (top-down cracking). This can be caused by high surface stresses (tensile and thermal stresses), a low stiffness at the top due to high surface temperatures and bitumen aging (e.g. oxidation process). Contraction and curling of the old pavement caused by temperature changes can result in the formation of cracks and therefore thermal movements can also contribute to reflective cracking, especially when dealing with rehabilitated rigid pavements [8].

When a wheel load passes over a crack in the existing pavement, bending and shear stresses are induced on the existing crack, causing the crack to develop further [1-6]. The shear action occurs twice by each load application, while the bending action occurs only once (Figure 1).

Shear action (+) Bending action Shear action (-)

FIGURE 1 Critical Loading Cases in a Pavement Crack

Conventionally, rehabilitation of a cracked flexible pavement involves milling off the existing top layer and installing a new asphalt layer. However, in this instance, the cracks can still be present in the existing (old) asphalt layers. Consequently, with the influence of the high tensile stresses at the crack tip, caused by the dynamic loads combined with temperature changes, and the subsequent horizontal and vertical movements of the crack walls, the existing cracks can rapidly propagate to the top of the rehabilitated pavement [8].

Similarly, deteriorated concrete pavements are typically rehabilitated by installing new asphalt layers over the old concrete slabs. The temperature variations lead to a rapid crack propagation especially at the expansion joints into the new asphalt overlay.

Accordingly, in order for the overlay rehabilitation to become more cost effective, the speed of the propagation of the existing crack into the new surface must be reduced, considering the life cycle cost of the overlay [3].

To delay the propagation of cracks into the new asphalt layers, there are several techniques available for rehabilitation of cracked pavements, such as modification of the mechanical properties of the overlay or use of a stress-relieving system. However, use of interlayer systems between the old pavement and the new overlay, such as geosynthetics, is one of the most popular methods recommended amongst new techniques [9].

The main function of geosynthetic products used in the construction and rehabilitation of roads and pavements is to reduce the amount of cracking in a new pavement or asphalt overlay. This can be achieved by reinforcement, stress relief and/or interlayer barrier. Certain geosynthetics only perform a single function and others can perform several functions from a single product.

Basically, there are three types of geosynthetics designed for pavement rehabilitation: geotextiles (nonwovens), geogrids (grids) and geocomposites which are a combination of the former. While the stress relief function is associated with soft products (such as nonwovens) for dissipation of strain energy through deformation of the product itself, the reinforcement function requires products with tensile stiffness (such as grids) to compensate for the lack of tensile strength in Hot Mix Asphalt (HMA) [7].

The reinforcement occurs with the grid structurally strengthening the pavement by changing the pavement's response to loading [10]. The reinforcement grid increases the resistance of the overlay to high tensile stresses by absorbing and distributing these stresses over a larger area, and therefore reducing the peak shear stresses at the crack tip in the existing old pavement [1-2]. By doing so, the grid interrupts and retards the propagation of the existing cracks in the old pavement into the new overlay, and therefore extends the service life of the asphalt overlay as demonstrated in both laboratory and field evaluations [1-2]. As a result, the reinforcing grid increases the maintenance intervals of rehabilitated asphalt overlays, and thus, it can significantly reduce the maintenance costs per year.

It must be noted here that the established reinforcement process has been found to be linked closely with the asphalt grid's interface adhesion (bond) and tensile stiffness properties as well as it's resistance to fatigue under dynamic loads [1-2-3]. These properties are dependent on the mechanical and physical properties of the grid and the material from which the grid is made. Therefore, it is highly important that road engineers and designers consider the material characteristics required for effective asphalt reinforcement when using asphalt grids, based on the specific conditions and the application on site.

Additionally, several products have been promoted in the past as a reinforcement while in fact these products provide only a separation and moisture barrier function. Therefore, it is also important that the engineers have a clear understanding of the limitations different asphalt interlayer products offer in terms of their function, position and stress-strain characteristics within the pavement structure [11].

3. REQUIRED CHARACTERISTICS FOR EFFECTIVE ASPHALT REINFORCEMENT

In Europe, the standard BS EN 15381:2008 "Geotextiles and geotextile-related products - Characteristics required for use in pavements and asphalt overlays", specifies the relevant characteristics of a geosynthetic for the Declaration of Performance (DoP) and CE-marking [12]. Based on the function of the product, namely reinforcement, stress relief or interlayer barrier, specific characteristics must be declared. This standard can also be used by designers to define appropriate product properties and applications that should be considered on a specific project when using asphalt reinforcement grids.

3.1 Tensile Strength

Tensile strength has been well accepted as one of the important requirements for the reinforcement effect in asphalt [12-13]. This is because it contributes to the reinforcing mechanism by allowing the grid to be able to absorb and distribute the high tensile stresses at the crack tip in the existing (old) pavement. It must be added here that a good bond between the reinforcing grid and the surrounding asphalt layer is a prerequisite for absorbing such tensile stresses [3].

BS EN 15381 specifies that the tensile strength of asphalt reinforcement grids should be carried out according to the EN ISO 10319 “Geotextiles – Wide-width tensile test”. If this method is not suitable for a certain product type, it can be tested using a different standard. However, the tensile strength test shall always be performed on the finished (complete) product to ensure that the obtained (published) strength of the material corresponds with the actual strength of the reinforcing grid.

3.2 Resistance to Installation Damage

It has been established that resistance of geosynthetic asphalt reinforcing materials to deterioration and installation damage is the most decisive factor on their subsequent behaviour in the pavement rehabilitation [6].

Moreover, it is detailed in the BS EN 15381 that the damage during installation of an asphalt reinforcement geosynthetic is induced by the paving procedure and by the compaction of the asphalt. After an asphalt reinforcement product is placed, many asphalt delivery trucks may have to pass over the grid. Additionally, there is the compaction of the hot mix asphalt, during which the individual filaments or strands of the asphalt reinforcement are largely influenced by the movement of aggregates, of coarse and sharp-edged aggregates in particular. Subsequent to the reinforcement characteristics (flexible or brittle raw materials), the degree of installation damage by the roller compaction not only depends on the number of passes but also the type of compaction (e.g. rubber tired, static, dynamic). The degree of installation damage is additionally influenced by the weight of the compactor and the condition of the base layer (e.g. smooth, rough or milled).

In order to successfully counteract reflective cracking, placed reinforcement products must resist the installation influences without damage and as much as possible without serious loss of strength. This highlights the importance of the choice of material, from which the reinforcing geosynthetics are made. It must be noted that various materials have different mechanical properties that determine the end product’s ability to resist the installation damage. For example, polyester polymers, abbreviated as PET, are flexible and durable polymers, whereas glass fibres are known to be brittle.

3.2.1 Research into the Influence of Installation Damage on Asphalt Reinforcing Geosynthetics

A detailed research study was carried out by the RWTH Aachen University in Germany to analyse and quantify the residual tensile strength of asphalt reinforcement grids after the influence of installation damage [14]. Site tests were performed and two asphalt reinforcement products with different raw materials (polyester and glass fibre) were tested.

The results showed, that the potential of installation damage on asphalt reinforcement materials can vary depending upon the adopted product (Figure 2). The polyester grid lost max. 30% of its tensile strength after loading from truck passes and asphalt compaction. In contrast to this the glass fibre grid showed a loss of strength up to approx. 90%. This revealed that brittle raw materials can be damaged significantly more compared to a polymer grid reinforcement.

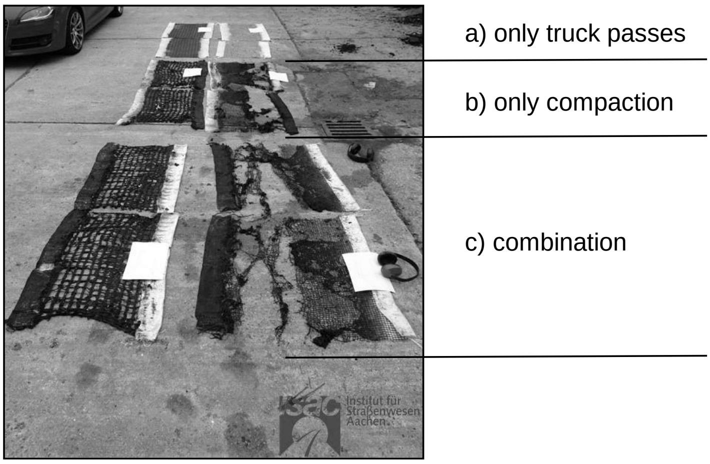


FIGURE 2 Results of Installation Damage Test (Left Polyester Grid, Right Glass Fibre Grid) [14]

Due to this good resistance to mechanical influences, polymer materials can be installed directly on milled surfaces. In contrast, fibre glass grid products usually require an asphalt levelling layer before the installation.

To summarize, all asphalt reinforcement undergoes installation damage caused by the combination of different activities during the pavement construction. This damage has the effect of reducing the available post-construction strength of the reinforcement and, therefore, it is important to know the residual strength of a product. Installation damage can be simulated using the testing procedure detailed in BS EN ISO 10722:2007 [15].

3.3 Bond Stiffness

De Bondt has found that the bonding of the material to the surrounding asphalt plays a critical role in the performance of an asphalt reinforcement [3]. If the reinforcement is not able to sufficiently adopt the high strains from the peak of a crack, the reinforcement cannot be effective. In his research, de Bondt determined an equivalent “bond stiffness” in reinforcement pull-out tests on asphalt cores taken from a trial road section. Of all the asphalt reinforcing geosynthetics examined, a bitumen-coated PET-grid was found to have, by far, the best equivalent bond stiffness.

3.4 Durability

The durability of an asphalt reinforcement grid, i.e. its resistance to chemical degradation, will depend mostly on the type of raw material that is used and on the environment conditions. BS EN 15381 specifies some important durability aspects, such as weathering, alkaline resistance and melting point, which should be considered when using asphalt reinforcement grids [12].

If a product is to be used in direct contact with an unprotected concrete or cement stabilized surface, alkaline resistance is needed. For example, grids made of polyvinyl alcohol (PVA) have a high strength and stiffness and a good resistance to alkalinity, lower concentrations of acids, and oils. Otherwise, glass fibre grids are sensitive to hydrolysis and when exposed to concrete, progressive loss of stiffness and weakening of the grid can be expected [16].

In relation to the material stability, polymer products must have a higher melting point than the temperature of the installed asphalt. For example, PET polymers are known for their heat resistance with a melting point of approximately 250°C.

4. WHY POLYESTER (PET) ASPHALT REINFORCEMENT ?

Polyester has been a preferred raw material because of the compatibility of its mechanical properties with the behaviour as well as the application of asphalt since the very early stages of using geosynthetics as an asphalt interlayer. For the reinforcement function from a geogrid interlayer, these properties become even more important.

High modulus PET is a flexible raw material with a maximum tensile strain less than 12%. Additionally, the coefficients of thermal expansion of polyester and asphalt (bitumen) are very similar. This leads to very small internal stresses and an excellent long-term interaction between the PET polymer fibres and the surrounding asphalt (similar to reinforced concrete). For this reason, PET does not act as an extrinsic material in the asphalt package, and as a result, an optimum load transfer is allowed between the asphalt and the installed PET reinforcing grid. However, at this point it should be mentioned that the aim of a PET-grid as asphalt reinforcement is not to reinforce asphalt in the same way as concrete is reinforced. The installation of a PET-grid as asphalt reinforcement improves the flexibility of the structure and protects the new overlay from the peak loads (stresses) in the existing cracked layer, and through this mechanism, it delays reflective cracking [1-2].

Moreover, with a melting point of approximately 250°C, PET is heat resistant, and therefore PET asphalt reinforcement is highly compatible with the application of HMA.

Crucially, PET is a robust polymer that has high resistance to fatigue under dynamic loads [2]. For this reason, PET is especially appropriate as an asphalt reinforcement interlayer, considering the dynamic loads induced not only during the installation of HMA directly over the installed reinforcing grid interlayer, but also throughout the service life of the asphalt overlay. Likewise, PET is not brittle, and is therefore suitable for applications directly over milled asphalt surfaces.

More importantly, as the paper has demonstrated above, studies have found the PET reinforcing grid to exhibit outstanding results in comparison to the other materials available in the market when examined against the key characteristics required for effective reinforcement, namely, high resistance to installation damage and optimum bond stiffness [3-14].

5. PROOF OF EFFECTIVENESS BY RESEARCH: DYNAMIC FATIGUE TESTS TO DETERMINE THE EFFECT OF A BITUMEN COATED PET POLYMER GRID REINFORCEMENT IN ANTI REFLECTIVE CRACKING APPLICATIONS IN ASPHALT OVERLAYS

5.1 Introduction

Following over 40 years of practical experience with the effectiveness of high modulus PET asphalt reinforcement, various laboratory test programs have been undertaken to examine the improvement of crack resistance in asphalt overlays when using the PET reinforcing grid.

Notably, the Aeronautic Technological Institute of Sao Paulo in Brazil carried out a full testing program that allowed a quantitative and qualitative evaluation of crack reflection behaviour with and without the PET geogrid reinforcement [1]. Details of this study are as follows:

5.2 Fatigue Tests

In order to determine the influence of the PET geogrid in anti-reflective cracking applications in the traditional rehabilitation technique of asphalt concrete overlay, dynamic fatigue tests were conducted on prismatic asphalt concrete beams made of the conventional HMA mixtures**,** with dimensions of 460 x 150 x 75 mm. Two asphalt concrete beams, representing the base layer and the overlay, resting on an elastic foundation were used for each test. The asphalt concrete beams used as the base layer were pre-cracked with openings of 3mm, 6mm and 9mm, in order to simulate a cracked pavement with an overlay rehabilitation. The PET geogrid was placed exactly over the pre-crack, between the two asphalt concrete beams, and both the bending mode and the shear mode were investigated under dynamic fatigue loading conditions [1].

The geogrid used in these tests was a high-modulus PET (polyester) geogrid incorporating an ultra-light nonwoven geotextile backing as an installation aid, with a bituminous coating for enhanced adhesion to the surrounding asphalt, a mesh size of 40 x 40 mm and a nominal tensile strength of 50 kN/m x 50kN/m at 12% strain (HaTelit® C40/17). Its resistance to fatigue under dynamic loads from the PET raw material, good bond as well as tensile stiffness properties are especially attributable to why it was chosen [1-2-3].

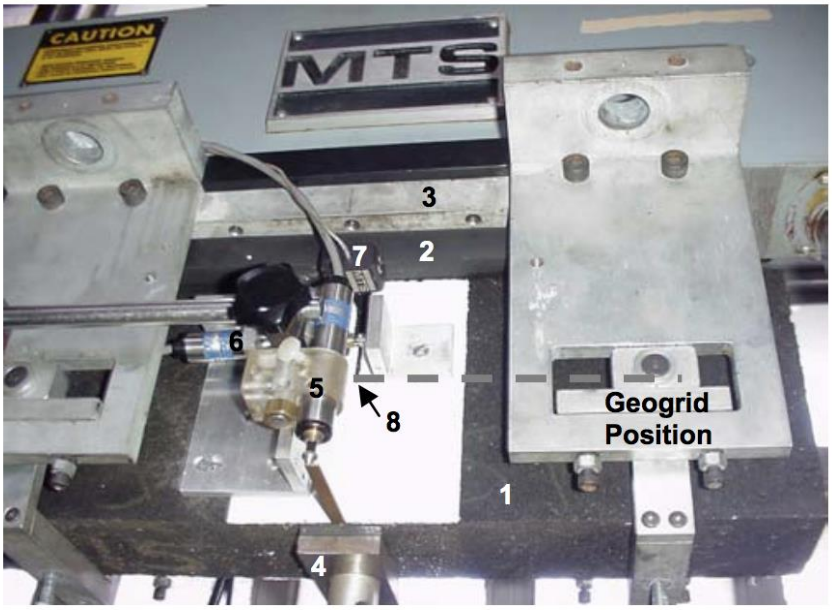
The type of loading was sinusoidal, applied by hydraulic equipment through a steel plate (MTS), with dimensions of 40mm x 75mm, generating pressures of 549kN/m^2 (higher pressure), 424.5kN/m^2 (average pressure) and 326.5kN/m^2 (lower pressure), at the two critical positions, on bending and on shearing.

Between the steel plate and the asphalt concrete beam, a rubber was installed in order to minimize the concentration of stresses related to the stiffness of the steel plate (Figure 3a). The termination criterion of the test was considered when the first visible crack appeared at the surface.

Additionally, numerical simulations were performed using the Finite Element Method (FEM) to interpret the results obtained at the dynamic fatigue tests, using the software MacNeal-Schwendler Corporation, MSC. NASTRAN (Nasa Structural Analysis). The analysis was based on the global energy principle using the node release technique at finite element mesh, in order to simulate the crack propagation observed in laboratory.

5.3 Instrumentation and Test Set-up

To measure the horizontal movements of the reflection crack opening and the plastic deformation during the load application cycles, a displacement meter CAM (Crack Activity Meter) was installed in laboratory. CAM was secured using screws embedded within the asphalt concrete. To record the pre-crack opening during the test, a clip gage was utilised. To allow a more accurate visual observation of the crack propagation, the central part of the beam was painted in white. A scheme of the system instrumentation and the test set-up are shown below (Figure 3a and 3b).



(1) Asphalt concrete beam;
(2) Rubber base;
(3) Steel base;
(4) Cyclic load;
(5) LVDT-1 Plastic deformation meter;
(6) LVDT-2 Opening crack meter;
(7) Clip Gage-Opening pre-crack meter;
(8) Pré-crack with 3mm.

FIGURE 3a. Instrumentation [1]

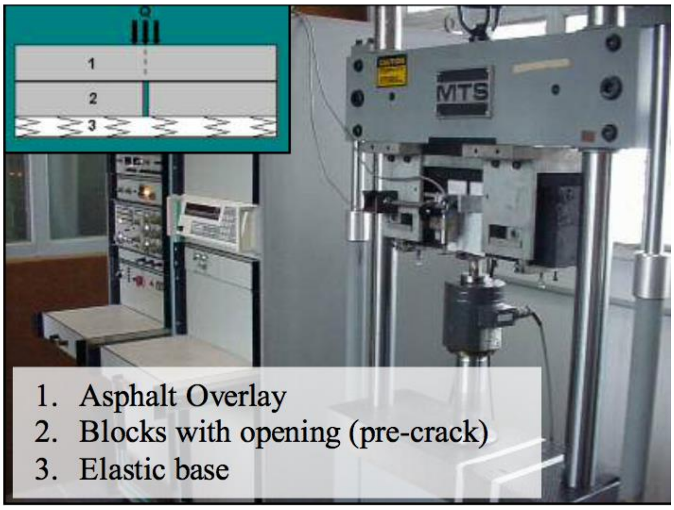


FIGURE 3b. Test Set-up [1]

5.4 Results

In asphalt beams without a geogrid, reflective cracking appeared after a few load cycles. The development of this crack, in bending and shearing mode, was fast and practically vertical, following the face of aggregates found on the way (Figure 3c). When the reflective crack reached the top of the 75mm thick asphalt beam, it ruptured and marked the end of the test.

In asphalt beams reinforced with the PET geogrid, this vertical growth occurred up to 2cm and 3cm, for the less severe case (pre-crack opening 3mm) and more severe case (pre-crack opening 9 mm) respectively. After more load cycles, micro cracks appeared becoming more and more visible, and interconnecting with each other, leading to the formation of new cracks of less severity spread over a greater volume of asphalt concrete (Figure 3c). This shows that the PET geogrid reinforcement interrupts the propagation of the reflective crack. This was observed for the bending load position as well as for the shearing load position. In beams with reinforcement, the test was concluded when only one crack of less severity reached the surface.

On the unreinforced specimen, with a pre-crack of 3mm, the crack reached the top of the beam after just 79,884 load cycles, whereas the reinforced specimen could resist 503,832 load cycles (Figure 3c). Based on the results, a factor of effectiveness was calculated. For the reinforced specimen with a 3mm pre-crack, this was calculated to be 6.1, while it was found to be 5.1 and 4.6 for the reinforced specimens with a 6mm and 9mm pre-crack.

Overall, the results demonstrate that the bitumen coated high modulus polyester grid considerably delayed the through-penetration of cracks generated due to shear stresses and bending stresses. Compared to the unreinforced material, the asphalt layer reinforced with the high modulus PET-grid was subjected to up to 6 times the number of dynamic loading cycles before a crack reached the surface in beams with a 3mm pre-crack (Figures 3c). The crack pattern clearly shows that the PET-grid reinforcement takes up and distributes the tensile forces (Figure 3c). The numerical simulation allowed a better understanding of the crack propagation mechanism observed in the laboratory (Figure 4). The asphalt reinforcement grid absorbs part of the applied load, interrupting the propagation of the reflective crack (Figure 4). Once the reflective crack problem is controlled, the durability of the overlay and the appearance of new cracks became a function of the asphalt concrete fatigue characteristics [1].

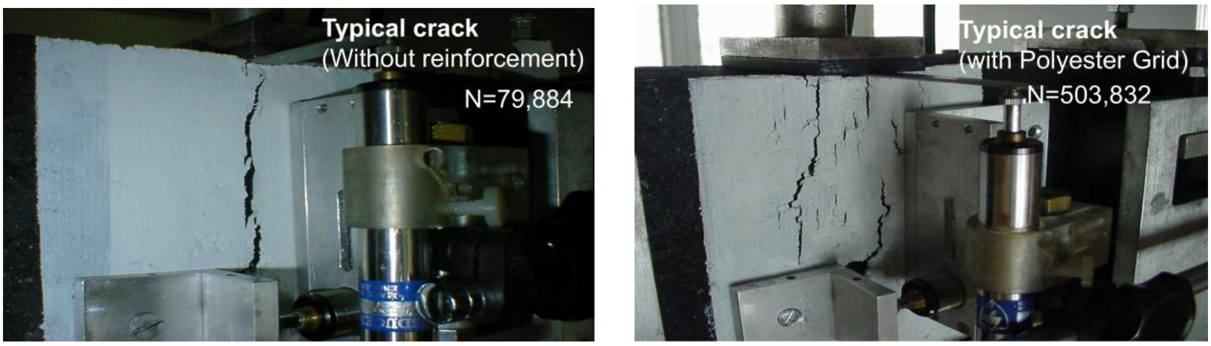


FIGURE 3c. Comparison of Beams with and without PET grid: Typical Cracking Patterns and the Number of Cycles Conducted Before the Cracks Reached the Surface (Bending and Shear mode) [1]

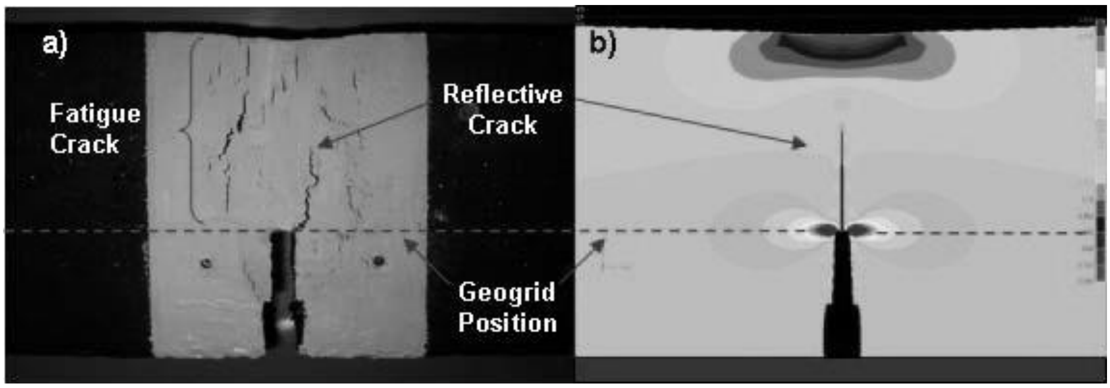


FIGURE 4. Comparison between Laboratory and Numerical Simulation Results [1]

6. PRACTICAL EXPERIENCES

The following projects are examples of the successful application of polyester asphalt reinforcement of airfield pavements.

6.1 Salgado Filho Airport, Porto Alegre, Brazil

In 2001 the existing access to an aircraft maintenance hangar used by aircraft as large as the Boeing 777 (empty weight over 250 tons) had to be resurfaced after more than 40 years of use. The existing pavement was made of 5.0 × 3.5m concrete slabs, 250mm thick. The slabs were resting on a layer of gravel.

The rehabilitation design involved the installation of an asphalt levelling layer first. In order to prevent the propagation of the expansion joints from the concrete slabs into the new surface, an asphalt reinforcing grid made from high modulus polyester was installed over the levelling layer, prior to the construction of a 50mm asphalt wearing course.

Because it was not possible to block the access for an extended period of time, the rehabilitation work had to be completed in one night. In order to stay within this very tight time frame, a decision was made on site to only reinforce the heavily loaded centre section of the pavement. The outer sections, which are not subjected to heavy loading by aircraft traffic, were left unreinforced.

What initially was considered to be a purely practical solution resulted in an ideal demonstration of the effectiveness of the polyester asphalt reinforcement grid. By only reinforcing a portion of the pavement and leaving the remainder unreinforced, a direct side-by-side comparison of the performance of the reinforced and unreinforced sections was made possible.

In October 2007, approximately 7 years after the rehabilitation, the first assessment of the pavement took place. At that time the Designer, the Airport Technical Manager, and a Representative of the reinforcement manufacturer were present. The expansion joints in the concrete below the unreinforced pavement sections were found to have propagated to the top of the surfacing aggressively. The vegetation, visible in the developed cracks, led to the conclusion that these cracks had existed for some time. In contrast, the areas reinforced with the PET-grid did not show cracking (Figures 5 and 6).

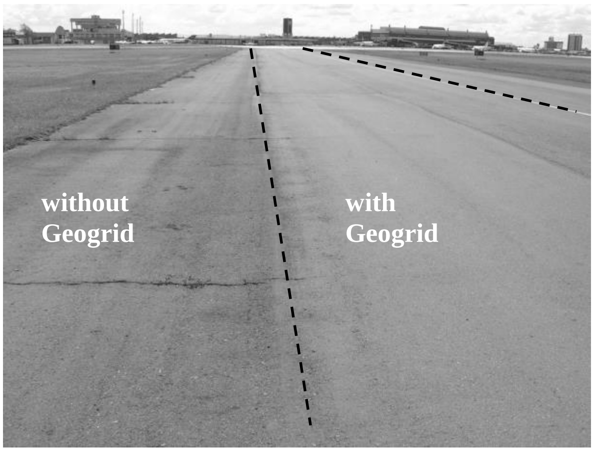


FIGURE 5 Overview of the Studied Section: View of the Taxiway to the Maintenance Hangar

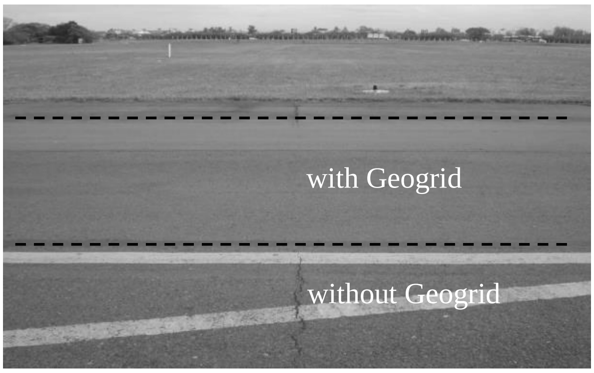


FIGURE 6 Joints of the Concrete Slabs Reflect in the Area Where No Reinforcement Was Used

This first visual assessment was followed by a detailed evaluation of the pavement to examine and confirm the effect of the high modulus PET-grid reinforcement in significantly delaying the crack propagation as seen in Figure 5 and 6.

6.1.1 Detailed Evaluation of the Airport Pavement

Approximately 8 years after the rehabilitation (a year after the first visual assessment), a detailed evaluation was also undertaken, incorporating crack activity measurement as well as extraction and examination of specimens from both PET-grid reinforced and unreinforced sections of the rehabilitated pavement [2].

The evaluation revealed that, in comparison to the section rehabilitated using only the 50mm overlay without the PET-grid, the crack propagation was interrupted at the PET-grid level below the 50mm overlay due to the geogrid being able to reduce the horizontal and vertical relative movements of the crack walls based on crack measurement and the extracted specimens [2].

Moreover, it was concluded that the PET-grid avoided the reflection of the cracks existing in the layer below, and in the worst case, it produced significantly less aggressive cracks (less than 1mm) compared to the unreinforced sections (with up to 10mm cracks) in the new 50mm asphalt layer, after almost 8 years of heavy traffic loading [2].

Additionally, based on the geogrid interface adhesion test (direct shear test) carried out on the extracted specimens, the significant crack retardation effect achieved by the PET-grid through stress distribution was closely linked with the strong bond strength achieved in the interface [2]. The achieved bond strength was attributed to the bituminous coating of the high modulus PET-grid that was used (HaTelit® C40/17) [2].

Because the unreinforced section was not subjected to heavy aircraft traffic, the propagation of the expansion joints in these areas can be largely attributed to the horizontal stresses that resulted from changes in temperature. The areas reinforced with the polyester grid were subjected to both temperature-induced and aircraft traffic-induced stresses. For more information the reader is referred to a detailed paper by Monser et al [2].

6.2 Albany International Airport, New York

In 2000, the asphalt runway 10/28 of Albany International Airport in New York was severely cracked, and required resurfacing. To prevent the cracks from the old asphalt layers propagating through to the new surface, the airport´s consulting engineer decided to use an asphalt reinforcement made of high modulus polyester.

The project specification required milling of the existing pavement, applying the asphalt reinforcement over the milled surface, and constructing a new asphalt overlay. Because of its flexibility and exceptional resistance against shear stresses, it was possible to install the polyester grid directly over the milled asphalt surface without a levelling course (Figure 7). This was extremely important to the project due to time limitations on site, with construction access to the runway between 10 p.m. and 6 a.m. only. Nightly repairs to the runway, including line painting, had to be completed by 6 a.m. each night. As the extra process of constructing a corrector layer was not required, works could be completed more efficiently on site, with larger areas being paved each night.

FIGURE 7 Installation of the Polyester Reinforcement Grid In 2000

An inspection of the runway held in 2007 showed the pavement to be in a very good condition despite the increase in the amount of traffic and the size of the aircraft using the international airport (Figure 8). Airport officials were highly pleased with the condition of the reinforced runway pavement seven years after its installation.

FIGURE 8 Condition of the Pavement in 2007

6.3 Sydney Airport, Australia

In 1994, as part of Sydney Airport Parallel Runway project, at junctions between new and existing (active) runway pavements, 500mm thick unreinforced mass concrete pavements were constructed using a 100mm thick asphalt surfacing that was reinforced using a high modulus polyester asphalt reinforcement.

The polyester asphalt reinforcement was incorporated within the asphalt layer in order to delay the reflection of the cracks and joints in the underlying concrete slabs through the new surface and extend the lifetime of the pavement. This is because the joints and cracks in the underlying pavement layer typically reflect through the new overlay due to dynamic / traffic loads and thermal stresses. As required, an asphalt levelling course was first placed over the concrete slabs prior to installation of the polyester asphalt reinforcement which was then covered with a minimum of 40mm asphalt overlay to complete the works.

In 2010, assessing authorities reported that the Sydney Airport Parallel Runway expedient pavements had been in service for in excess of 15 years and that no cracks or joints from the underlying concrete had reflected to the given date at Australia’s busiest airport (Figures 9 and 10) [17].

FIGURE 9 and FIGURE 10 View Looking South-West Across Runway 16R-34L From Hold Point at Taxiway Lima

6.4 Melbourne Airport, Australia

In 2012, due to existing pavement failures, the 40 year old Taxiway Alfa north of Runway 27 (the only taxiway to holding point Bravo) required a maintenance treatment that could achieve 5 to 10 years usable service life with allowance for some ongoing maintenance.

The existing pavement consisted of 7.5 m x 7.5 m concrete slabs, which were 430mm thick. The pavement under the concrete slabs was a crushed rock base variable in depth, placed over improved subgrade. Since concrete slab replacement was not feasible at this point, 100mm asphalt overlay was proposed as part of the maintenance treatment to alleviate FOD risk and extend the lifetime of the pavement. The overlay rehabilitation design involved construction of two 50 mm asphalt layers.

Additionally, in order to mitigate the propagation of the existing concrete pavement failures into the new asphalt surface, an asphalt reinforcement made from high modulus polyester was installed between the two 50mm asphalt layers as seen in Figure 11. Works were completed overnight, between 10 p.m. and 6 a.m. The treatment area was 100m in length across the full taxiway width.

In 2016, approximately 4 years after the rehabilitation, the Airport Manager verbally reported that a good mitigation performance by the polyester asphalt reinforcement had been achieved with a substantial reduction rate in pavement failure, despite the increased amount of traffic, and the types of aircraft using the airport. The taxiway pavement currently continues to serve, and a future capital decision on this project is yet to be made.

FIGURE 11 Laying Asphalt Over the Polyester Asphalt Reinforcement

7. LIMITS IN USING A REINFORCEMENT GRID

There are limits in using asphalt reinforcement, with no system available in the market that can increase the bearing capacity. In most cases, the expectation of strength or bearing capacity improvements from the use of these materials is unrealistic [11]. The pavement structure must have sufficient bearing capacity to carry the future traffic loading, alternatively it has to be replaced or strengthened. When having a poor quality subgrade, it is necessary to carry out other procedures, e.g. base reinforcement or increasing the pavement thickness. Moreover, the integrity of the surfacing must be adequate to support the asphalt reinforcement without disintegrating.

It is generally difficult to prevent crack propagation resulting from large vertical movements (e.g. concrete slabs which are not stable in their position, frost heave), even when using an asphalt reinforcement system. In such cases, it is necessary to eliminate, or minimize, the movements prior the installation of a reinforcement grid and the new asphalt layers (e.g. undertake injection below the slabs, or “crack and seat” the slabs to achieve a stress relief).

Although there are a number of laboratory tests, research modelling and trials showing the effectiveness of asphalt reinforcement grids, it is important to understand the possible causes of existing cracks and other pavement distress. Maintenance or rehabilitation should only be instituted once the correct mechanisms that lead to failure / distress have been identified.

8. CONCLUSIONS

The presented laboratory tests as well as case studies have shown that asphalt reinforcement grid made from high modulus polyester can be a highly effective solution against reflective cracking in asphalt overlays.

The paper has demonstrated that, in addition to a good interface adhesion (interlayer bond), polyester’s high resistance against both installation damage and fatigue under dynamic loads is a key factor for successful stress distribution and effective crack retardation.

Based on the observed performance under site and laboratory conditions, it can be concluded that the service life of the rehabilitated pavement can be extended considerably by using a high modulus polyester asphalt reinforcing grid. As a result, significant advantages in reducing maintenance costs as well as construction disruption to airfield operations can also be achieved.

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