Evaluation of an airport pavement after almost 8 years of overlay rehabilitation with a polyester geogrid asphalt reinforcement

Monser, C.A.
STE SA, Canoas, Brazil

Montestruque, G.E.
Consultant, São José dos Campos, Brazi

Silva, A.E.F.
Huesker Ltda, São José dos Campos, Brazil

Keywords: polyester geogrid, asphalt reinforcement, overlay rehabilitation

ABSTRACT: Crack reflection for the new asphalt overlay have been a frequent problem in pavement maintenance jobs on roads and on airports. For prolonging the service life of a rehabilitated pavements, in January 2002, a new overlay was executed on an originally rigid access stretch known as Taxi Golf of the Salgado Filho International Airport in Porto Alegre, state of Rio Grande do Sul in Brazil.A polyester geogrid was used as an anti-reflective crack system and asphalt reinforcement for enlarging the service life of the restored pavement. After almost 8 years of the work done the comparison of the benefits of the reinforced overlay with of a simple overlay is possible, once two tracks were restored, one with geogrid and other without. The track without geogrid presents a severe condition of crack pattern. To evaluate the vertical and horizontal movements between existing crack walls a displacement measurement device called “Crack Activity Meter” was used. The adherence between asphalt layers is very important for the good behavior of the pavement. The stress distribution on the interface of asphalt layers may be deeply influenced by its adherence. A direct shear equipment called “Leutner Shear Test” was used for verifying the adherence between asphalt layers and the geogrid.

1 INTRODUCTION

The use of geogrids as anti-reflective crack system in overlay rehabilitation works is a technique that has been applied since the 70’s, and over these 40 years, a great amount of experience and knowledge was collected around the world. In airports, where stopping operation is a critical subject, it has an special interest once this technique allows for a quick effective intervention: the execution period is short and the lack of time between two consecutive maintenance projects is enlarged.

2 REINFORCING INTERLAYER SYSTEMS WITH POLYMERIC GRID

The high tensile stiffness geogrid acts as reinforcing component in the overlay system. In this application, the reinforcing grid takes a part of the traction stresses in the crack tip, reducing the horizontal and vertical relative movements of the crack walls, due to the combination of its tensile stiffness and adherence properties. The crack pattern changes from one dominating reflective crack to several microcracks, with less damage potential.

This behavior was also clearly identified in dynamic fatigue tests in asphalt concrete beams carried out in ITA, with and without polyester geogrids (Montestruque 2002). The aim of this research was to study the influence of the PET geogrid in the mechanism of crack propagation. The geogrid used in this research was combined to a very light nonwoven backing and coated with bitumen to improve the adherence to the underlying surface. Polyester is resistant to fatigue under dynamic loads, what is an important property of the material to be applied as pavement reinforcement element. On that set of tests, beams with polyester grid reinforcement presented a service life of up to 6 to 10 times the one without reinforcement on the same conditions of loading.

Numerical simulations were performed using the Finite Element Method (FEM) to interpret the results obtained at the dynamic fatigue tests, making use of 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.

Figure 1 presents a comparison of the loaded beam at laboratory and the respective numerical simulation graphic on a similar stage. The numerical simulation allowed a better understanding of the crack propagation mechanism observed in laboratory. Geogrid, as an asphalt concrete reinforcement, absorbs part of the applied load, interrupting the propagation of the reflective crack. Once the reflective crack problem is controlled, the durability of the overlay and the appearance of new cracks became function of the asphalt concrete fatigue characteristics.

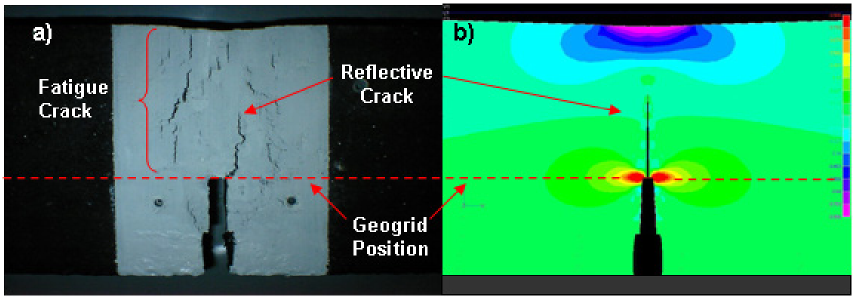

Figure 1. Comparison between the laboratory and the numerical simulation results (Montestruque 2004).

3 CONTEXT OF THE PROJECT

Salgado Filho International Airport is the 7th airport in Brazil in terms of airplanes movement. In January 2002, it was executed the maintenance of the so called Taxi Golf stretch, which is access for the maintenance dockyard of a commercial air company. The traffic volume was big on this stretch, composed by great port aircrafts, up to a Boeing 777, with a gross weight over 250 tons.

The pavement on this stretch, what was originally constructed on the 1940 decade, was composed by a granular base (CBR ~ 30) for concrete rectangular slabs 5,0m x 3,5m with a thickness of 25cm. Along the years, several overlays have been executed on top of the broken slabs, result of heavy traffic loads and thermal movements. In 2002, the surface on that stretch was severely cracked, after a long period without maintenance, what have allowed for water entrance, what has promoted an accelerated process of fines pumping and voids creation below the concrete slabs, resulting in high deflections.

For this intervention, the project evolved injection of cement on the voids, leveling the surface, laying down one layer of he polyester geogrid HaTelit C 40/17 (bituminous coated biaxial polyester geogrid with a light nonwoven attached) below a 5cm of a standard bituminous concrete mix.

4 JOB EXECUTION

Due to the fact it was a short stretch as well as it was impossible to stop operation during daylight, the available period for the work was one night only, from 1:00 to 5:00 am.

Because of a delay on the beginning of the work, there was no time for the complete installation of the geogrid, and only one of the two tracks was done according the project, with the reinforcement material. The geogrid was installed on the left side from the axle (from the terminal to the dockyard), and no geogrid was used on the right one. The shoulder tracks, on both sides, didn't take the geogrid as well. On the entire area, 5cm of asphalt concrete was executed above the geogrid.

5 EVALUATION PROGRAMME

5.1 *Introduction*

Recent evaluation work was done on the pavement, aiming to compare the results of both maintenance solutions, differed by the use of the polyester asphalt reinforcement geogrid. Both cases (both tracks) had the same pavement structure and conditions, were submitted to the same execution procedure, the same thickness of asphalt overlay and the same traffic load. The difference was only the presence of the geogrid in only one of them.

The evaluation was done by the following steps:

1st. Visual inspection with photo registration (November 2008);

2nd. Measurement of crack activity by the relative movements between exiting crack walls (August 2009);

3rd. Specimens extraction (August 2009);

4th. Shear strength on geogrid-asphalt interface (October 2009).

5.2 *Visual inspection*

During visual evaluation on a daylight time in November 2008, the difference of severities of the cracks on the two tracks under comparison was very clear, in special crack over the slabs joints.

Considering the 7 past years of the rehabilitation work at that time and the good condition of the reinforced track, it was considered a successful solution in this case. Only a few cracks, with small aperture size (less than 1mm in all the cases), and no sign of pumped fines could be observed. There was no remarkable reflective crack over the slabs joints on that track as well.

A different situation was observed on the non reinforced and on the shoulder track, without geogrid. Reflective cracks were more frequent and more opened (some with 10mm aperture), mainly over the slabs joints, from what the dimensions of the slabs could be clearly seen. Figure 2 presents an overview of the section. Figure 3 presents the visual situation of some inspected sections.

Figure 2. Overview of the studied section: view from the dockyards to the terminal.

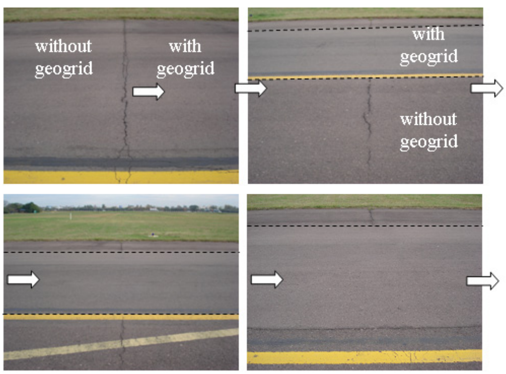

Figure 3. Sequence of pictures showing reflective cracks on the tracks (areas) without reinforcement, but no clear crack on the reinforced areas.

On the first pictures showed on Figure 3, the exact point of the beginning of reinforced stretch, where a remarkable reflective crack from a joint between two slabs may be seen upon the edge of the geogrid panel. The other pictures highlight the comparison between the two tracks, showing cracks on non reinforced tracks and no clear cracks on the reinforced one. The trace line marks the limit between track with and without reinforcement. The arrows indicate the direction from the terminal to the dockyards.

5.3 *Measurement of crack activity*

With the objective of evaluating the potential for crack reflection after a new rehabilitation work, measurement of vertical and horizontal relative movements of the crack walls against each others, was done by using an special device for that purpose, called “Crack Activity Meter” (Figure 4)

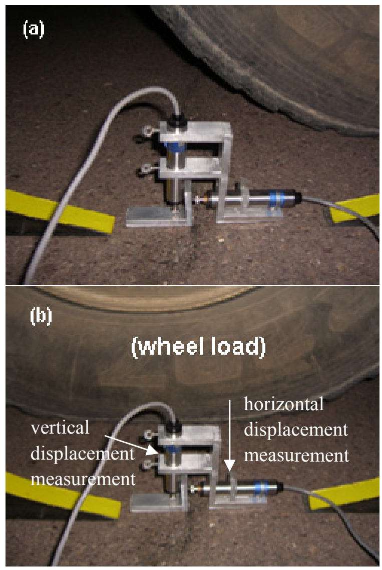

Figure 4. Crack Activity Meter and load position: (a) shearing mode, (b) bending mode.

Such device was developed by the National Transport Institute from South Africa, and allows the measurement of differential displacements of each side of one specific crack along the passage of a wheel (de Bondt 1999). Two displacement measuring devices type LVDT (Linear Variable Differential Transformer), one positioned horizontally and the other vertically register, respectively, the increment on the aperture of the crack and the relative vertical displacement (shearing displacement) of the crack walls. It must be placed and fixed in a location where the crack in study stays in between the two fixing plates.The truck used for the tests had double axle calibrated with 8,2 ton / axle. The data acquisition system was a dynamic type electronic equipment, able to register the complete curves of displacements.

On the stretch with geogrid, as already mentioned, only some small cracks could be observed, different from the area with no reinforcement, where thick cracks (up to 10mm) could be observed.

Figure 5 and Figure 6 present CAM data for two of the studied cracks, one on the reinforced zone, the other on the non reinforced zone, both over slabs joints, respectively vertical and horizontal relative displacements. Figure 7 presents a resume of all the measurements in terms of maximum measured displacement in each case.

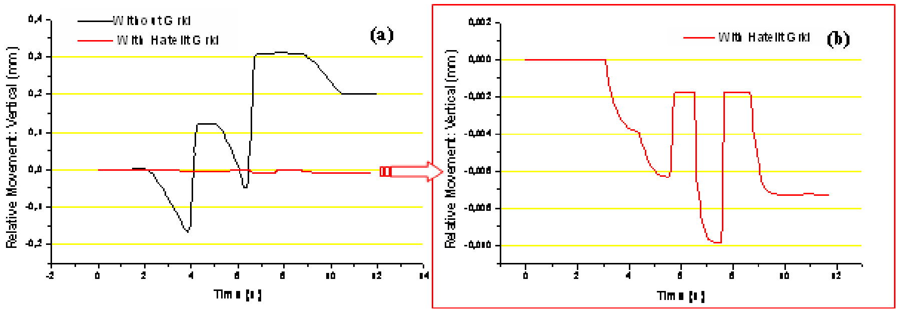

Figure 5. Vertical relative displacements between crack walls:
(a) cracks on areas with and without geogrid, (b) zoom of the results on the area with geogrid.

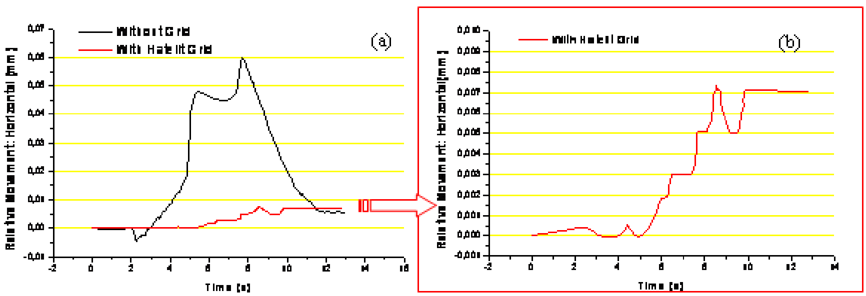

Figure 6. Horizontal relative displacements between crack walls:
(a) cracks on areas with and without geogrid, (b) zoom of the results on the area with geogrid.

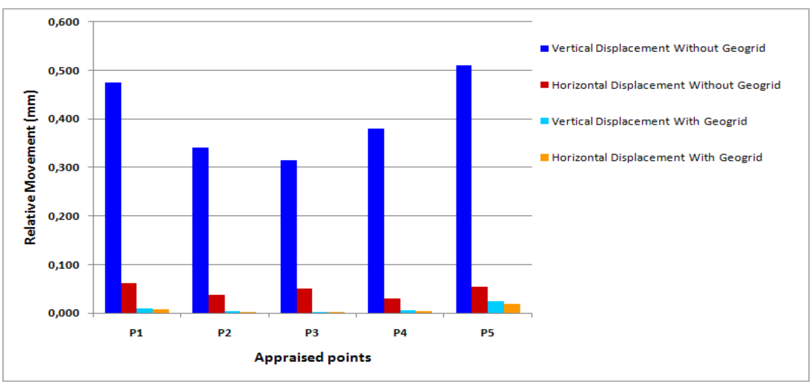

Figure 7. Maximum relative displacements measured in each case:
vertical and horizontal relative movements of crack walls on areas with and without geogrid.

5.4 *Specimens extraction*

While measuring cracks activity, some specimens were extracted from different areas. A 10cm diameter rotating drill lead was used for extracting at least 10cm thick specimens, either on areas with or without geogrid, including cracks and not including them as well.

By analyzing those specimens, it was clear the effect of interrupting the crack propagation on the geogrid level (Figure 8). This means that the reinforcement protected the new overlay from stress concentration on that zone on that level, avoiding the reflection of pre-existing crack, or, in the worst cases, producing considerably less aggressive cracks on the new asphalt layer along almost 8 years of traffic loading. It could be also observed good adherence between asphalt layers on the geogrid level.

In the case of specimens taken from non reinforced zones, when including cracks, it was not possible to extract an integrate element since the crack took the full thickness and separated at least in two parts these pieces (Figure 9). In some of those cases, adherence between the two asphalt layers was lost during extraction, what was not the case of specimens taken from non cracked areas.

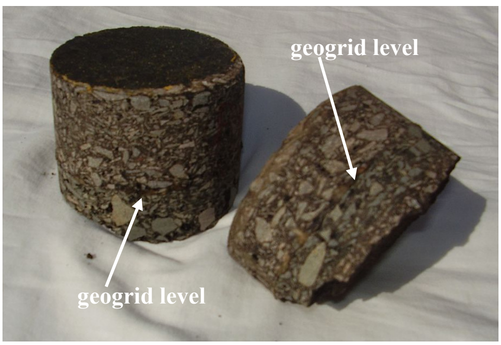

Figure 8. Specimens taken on reinforced areas: one non cracked (left) and another cracked (right).

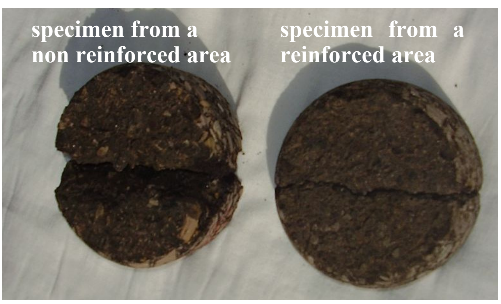

Figure 9. Specimens from areas with (right) and without (left) reinforcement.

5.5 *Geogrid-asphalt adherence*

For quantifying the adherence between the geogrid and the asphalt layers, direct shear tests were done on laboratory with some extracted specimens. The tests done are known as “Leutner Shear Tests” and were developed on Germany in 1970 resulting in a simple way of applying a shear stress exact on the interface of two layers (Raab 2004). The principle of this test is based on the application of a shear force that leads to a shear displacement on the interface on focus. The equipment itself consists of two peaces with a semicircular shape on the edge in contact with the specimen (Figure 10). Every specimen diameter demands an specific set. The velocity of the force increment on the test is equivalent of a displacement of 50mm / min in a controlled temperature.

According to the German Norm ZTV SIB 90, for specimens with 10cm diameter, the adherence may be considered satisfied for a shear stress greater than 0,85 MPa. Figure 11 shows the results of the direct shear stress test, with a maximum strength reaching 1,00 MPa, satisfying this reference.

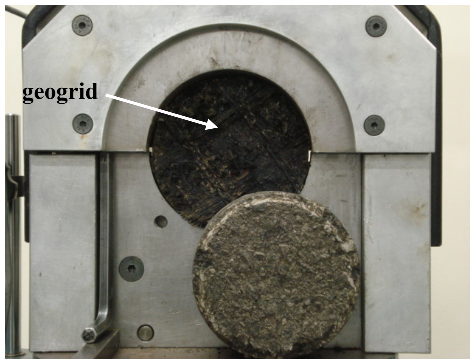

Figure 10. Front view of the equipment for direct shear test (interface adherence).

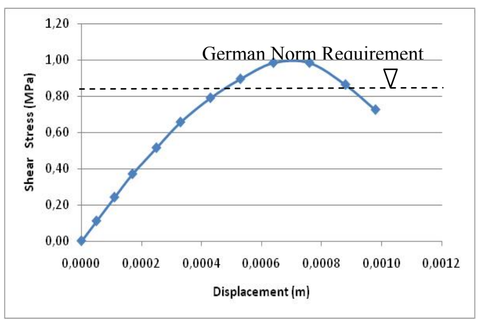

Figure 11. Direct shear test result.

6 CONCLUSIONS

The use of the geogrid as asphalt overlay reinforcement on the last intervention proved to be very effective. Only a few reflective cracks appeared after almost 8 years of heavy aircraft traffic on that area. In all these cases, a visual inspection leaded to the conclusion that the geogrid was responsible for keeping some “residual integrity” of the reflective cracks, avoiding important water infiltration and visual fine pumping effect. The same way, in all these cases, the surface cracks are not severe and still keep shearing resistance, what was observed by the crack activity measurements done.

By analyzing the results present on Figure 7, it is clear that vertical displacements are dominant in the studied case. It is an important information at the time of studying a new maintenance project. Residual shearing strength on the cracks, promoted by the geogrids, allow for a remarkable decrease of vertical displacements on the cracks on the reinforced zones, what implies on much less severe condition in terms of potential for crack reflection on those areas.

It is different the situation on the non reinforced area. On these areas, reflective cracks are thick and extremely opened. A new maintenance intervention should be forecasted. At least a sealing work over these cracks for avoiding water infiltration and fines pumping effect should be done.

It is also remarkable the good adherence of the geogrid on the asphalt pavement depicted from the direct shear tests performed on lab with some extracted cores. The obtained results are greater than the minimum required by German regulations. The good adherence is mainly due to the bituminous coating of the geogrid used in this.

It is clear that, based on the present situation of the evaluated area, a new overlay rehabilitation (simple repaving by an homogeneous thickness of asphalt concrete) would lead to different results on each track. Due to the considerably less severe condition of the reinforced area surface, it would be expected a much longer service life of this track compared to the one without reinforcement. From this observation, it may be concluded that the use of a proper asphalt reinforcement material (polyester geogrid) on overlay rehabilitation works, not only prolongs the service life of the intervention in question, but also the service life of all the other future works on the same pavement.

ACKNOWLEDGEMENT

The authors thank Infraero in the person of Eng. Edson Richter for allowing for the field stages of this investigation.

REFERENCES

German Testing Specification ZTV-SIB 90.

de Bondt A. H. 1999. Anti-Reflective Cracking Design of (Reinforced) Asphaltic Overlays – *Doctor’s Thesis*, Technische Universiteit Delft, pp. 291-305.

Montestruque, G. E. 2002. Contribuição para a Elaboração de Método de Projeto de Restauração de Pavimentos Asfálticos Utilizando Geossintéticos em Sistemas Anti-Reflexão de Trincas (Contribution to the preparation of a method of a project for rehabilitation of asphaltic pavements using geosynthetics on anti-reflective crack systems). *Doctor’s Thesis*., Technological Institute of Aeronautics. São José dos Campos, Brazil.

Montestruque, G. E. 2004. Stop of reflective crack propagation with the use of PET geogrid as asphalt overlay reinforcement. *Fifth RILEM International Conference Cracking in Pavement, Mitigation, Risk Assessment and Prevention*. Limoges, France, pp. 231-238.

Raab C, Partl, M.N 2004. Interlayer shear performance: experience with different pavement structures. *Third Eurasphalt & Eurobitume Congress*. Vienna, Book 1, pp. 535-545.