Colombian experience using fiberglass geogrids as a reinforcement alternative for flexible and concrete pavements

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ABSTRACT: One of the variables that directly influences the lifetime of pavements is vehicular traffic, if it is not adequately estimated the pavement will be exposed to major repetitive load cycles. This excessive load acts over the asphalt concrete overlays creating fatigue of the bituminous material leading to cracking. These fissures promote water penetration into the pavement structure, which can diminish the support capacity of the granular materials; and as a result a progressive lost of mechanical properties and structure deterioration. Important points to consider when evaluating maintenance costs for pavements.
The latest world-wide advance in pavement technology for reinforcement of asphalt overlays, that takes into account minimizing maintenance costs, is the use of Fiberglass Geogrids. The main objective with this process is to reinforce the bituminous layers increasing resistance to fatigue and delaying the appearance of existing cracking in these bituminous materials.
The objective of this paper is to present to the Latin America Pavements Engineering sector the new Colombian experiences with Fiberglass Geogrids, as a reinforcement alternative for flexible pavements. At the same time, show the state of the art in Colombian installation of Fiberglass Geogrids Pavco R-100, which are ideal for asphalt pavement overlays, new and in reconstruction. The mechanic properties of these Geogrids such as high resistance to tension, high elasticity module and low elongation are optimal for controlling reflective cracking on asphalt pavements and airport tracks. In addition, these features require less maintenance costs in the long term and increase the lifetime of the pavements.

1 INTRODUCTION

Asphalt has been a durable and economical material for roadway construction. However, maintenance problems appear when cracking of previous structure fissures are reflected through the new asphalt overlays. This type of cracking is induced by thermal changes and pavement fatigue caused by vehicular traffic load. In addition, asphalt pavements are also affected by rutting and fatigue cracking (Huang, 1991). This paper will present a Colombian experience using fiberglass geogrids as a reinforcement alternative for flexible and concrete pavement.

Firstly the use of fiberglass geogrids to reinforce asphalt overlays will be discussed. Secondly, the difference between paving and repaving materials will be showed. Finally a Colombian case study using fiberglass geogrids and its positive results will be presented.

2 FIBERGLASS GEOGRIDS USED TO REINFORCE ASPHALT OVERLAYS

Before presenting the Geodgrid reinforcement technique, the problems that exist for asphalt overlays should be discussed. Usually, vehicular traffic exerts shear and tensile forces on pavements and when these forces generate strains greater than the yield strength of the overlays cracking starts (ibid). Asphalt overlays can also suffer fatigue cracking caused by tensile strength in the lower part of them. Another problem, known as rutting and caused by permanent deformations on the roadway surface as a result of continuous loads, material characteristics of individual overlays and interaction among pavement overlays also affects pavements (Checkmate Geosynthetics, 2007). Finally, reflective cracking which is crack propagation from an old pavement structure to new overlays that affects asphalt layers placed over concrete pavement also exist. It can be caused by individual movements of concrete slabs that expand and contract under temperature variations. These movements produce great stress under the asphalt overlay, directly on concrete joints, cracking the asphalt surface.

All the above failures lead to a reduction of the pavement service life as water enters through fissures penetrating the secondary layers and damaging the total surface course and as a result a reduction of the pavement structural capacity. However, all these problems might be solved by using reinforcement techniques such as asphalt overlays.

Restoration techniques can be successful as long as they are combined with the improvement of drainage systems, crack sealing, full depth asphalt restoration if required, sub-grade reinforcement and drainage, as well as appropriate asphalt thickness for the traffic load design. If an overlay is too thin or is placed over an inappropriate base, reflective cracking is likely to occur (Huang, 1991).

For many years, a lot of research has been conducted about the use of geosynthetics such as repaving geotextiles and reinforcement geogrids over asphalt overlays (Checkmate Geosynthetics, 2007). Uses vary depending on the geosynthetic function, from a waterproof barrier to a provision to reinforce pavement structures reducing reflective cracking effects.

Fiberglass geogrids are flexible geogrids used between asphalt overlays to control reflective and fatigue cracking; and plastic deformation between asphalt concrete liners. Liners used for high and low traffic volume roadways, highways, airports, platforms, and parking lots, among others (ibid).

The fiberglass geogrids main function is to increase the asphalt overlay tensile strength and also to ensure that, under a vertical load, the horizontal stresses are uniformly distributed over a larger surface. This means a roadway without cracks for several years (Instituto de Desarrollo Urbano, IDU, 2008). The main mechanical properties of the fiberglass geogrids are:

- High elastic modulus (70,000 MPa) and high tensile strength (normally 100 kN/m) according to reinforcement requirements.
- Shrinking and elongation: Shrinking below 0.5% at 200°C after 15 minutes and maximum elongation 2.5%.
- Creep: Excellent long term performance under sustained loads.
- Aging: Inert material with excellent UV protection and resistant to oxidation.
- Optimum opening size: 1" opening to ensure optimal asphalt overlays bonding and interlocking.
- Bituminous Coating: Optimizing chemical compatibility between fiberglass and reinforcement layers.

In addition, the main advantages and benefits of geogrids should be also mentioned (Checkmate Geosynthetics, 2007):

- Reduce reflective cracking caused by tensile stress and temperature changes in asphalt overlays.
- Reduce deflection of pavements that are exposed to high temperatures and intense sustained loads.
- Increase fatigue strength of bituminous coatings.
- Optimum bonding with asphalt overlays as a result of the bituminous coating.
- The fiberglass geogrid homogeneous thickness provides continuous support to asphalt emulsion; thus greater adhesion between the new overlay and the existing pavement.
- The original mechanical properties are maintained under cyclic loads as a result of the geogrid high fatigue strength.
- The geogrid low yield stress allows that under sustained loads and strength its deformations remain constant through time.
- Reduce regular maintenance for the flexible pavements.
- Provide cost benefits by increasing the pavement service life.
- Quick and easy installation.

3 ADVANTAJES OF GEOGRID AS A PAVING AND REPAVING MATERIAL

Figure 1 shows the stiffness influence on geogrids used for asphalt overlays. It can be observed that when geogrid is exposed to an increasing strain load, its stress or strength also increases (ibid). Analyzing the Fiberglass slope it can also be concluded that it has a higher tensile modulus than polyester; making it more efficient as reinforcement. According to the graph, polyester geogrid reinforcement will have a 12% deformation while fiberglass geogrid will have a 2.5% deformation for the same breaking load. This means that fiberglass reinforcement will be more efficient for asphalt overlays.

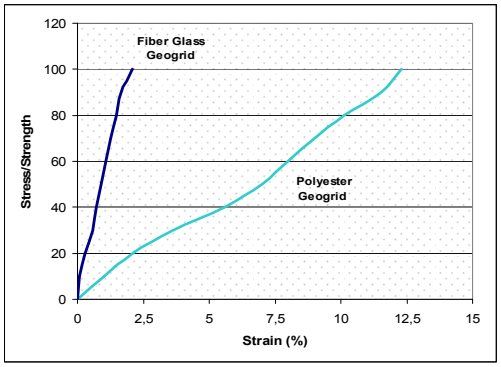

Figure 1
Stress/Strength Vs Strain of geogrids used for repaving works in Colombia

4 COLOMBIAN EXPERIENCE WITH FIBERGLASS GEOGRIDS

Fiberglass geogrids are used not only to restore asphalt and hydraulic pavements; but also to reinforce new asphalt pavements. This reduces construction and maintenance costs, extend the pavement lifetime, and prevent cracking on the wearing course (Instituto de Desarrollo Urbano, IDU, 2008).

Some reinforcement applications have been given to Fiberglass geogrids all over the world. For instance, some large international airports, such as Taipei, Suvarnabhumi and Kuala Lumpur, among others, used it as road reinforcement.

Fiberglass geogrids have been also used in Colombia since 2006 to reinforce asphalt overlays for different roads. These geogrids mechanical properties are shown on Table 1 (Instituto de Desarrollo Urbano, IDU, 2008):

Property	Test Method	Unit	PAVCO (R-100)
Ultimate Tensile Strength (MD/TD) (1)	ASTM D 6637	KN/m	108.3/108.3
Strain at Ultimate (MD/TD)	ASTM D 6637	%	2.5 / 2.4
Shrinkage Properties	CRDRG01	%	Less than 0.5% @ 200° C after 15 minutes
Aperture Size (MD/TD)	Nominal	mm	25.4/25.4
Heat Resistance	Minimum	C°	Up to 200
Melting Point	ASTM D 276	C°	>300
Roll Width		m	2
Roll Length		m	50
Grid Material	Fiber glass		
Coating	Bituminous		

1. Minimun Average roll value
MD= Machine direction (longitudinal to the roll). TD= transverse direction (across roll width)

Table 1
Technical Specifications - PAVCO Fiberglass Geogrid R100

A series of projects in which geogrids have had an outstanding performance are shown below:

4.1 *Devisab Concession; Cota-Cundinamarca (November, 2008)*

Background: Devisab is the maintenance firm for a 20 years period of the Chía to Giradot Roadway, which is about 150km. As part of the maintenance roadwork some repaving of the asphalt overlays was required. One of the contract's greatest challenges and also part of the problem was the need to perform a long lasting maintenance that would also represent less future intervention and a relevant cost-benefit relationship for the operation.

The original 12 cm thick course of the pavement structure for repaving in Cota was milled. After that a 5 cm leveling layer was installed and then the fiberglass geogrid was laid on the leveling layer as reinforcement (See Picture 1). The pavement structure was finally completed by placing a 10 cm asphalt mixture, for a total asphalt overlay thickness of 15 cm.

Picture 1. Roadwork after fiberglass application.

Due to the fiberglass properties, increasing resistance to fatigue of the bituminous materials and avoiding fissure possibly caused for the reflection of the milled bituminous layer, the objectives could be met. As a result of the reinforcement the lifetime of the superficial asphalt layer will increase and the required maintenance will decrease.

4.2 *Reinforcement of the asphalt layers for rigid pavements reconstruction.*

Background: When a blacktopping (reinforcement of bituminous layers over a pavement of hydraulic concrete) is required, refection fissures of the new asphalt over layer on the transversal and longitudinal joints are likely to happen. Also, when the geometric section of the roadway is increased to build a new pavement structure, due to the changes of the two rigid pavements, a reflection of he longitudinal joint could also happen.

Industrials Avenue, Medellín Antioquia (August, 2009): This avenue was concrete built during the 70's and by 2009 it presented concrete fissures and staggering of the transversal joints. The reconstruction program included a blacktopping that at the same time avoided the transversal and longitudinal joints of the rigid pavement. As a solution a 5cm leveling asphalt dense hot layer was installed and over this a 100Kn/m resistance tension fiberglass (See Picture 2) followed by a 10 cm asphalt overlayer. The fiberglass reinforces the bituminous layer and delays the joints reflection of the hydraulic concrete increasing the lifetime of the roads and decreasing its maintenance period.

Picture 2. Roadwork after fiberglass application

4.3 *Calle 127 with Cra 46ª Intersection, Bogotá D.C (May, 2008)*

Background: Considering that a lot of pipes are under this area and as a consequence a lot of humidity exists at the above intersection, it was necessary to consider the use of a reinforcement to prevent the concrete protection reflection in the new asphalt overlay.

As a solution, a fiberglass geogrid was used with the purpose of increasing the asphalt overlay tensile strength and reducing the concrete possible reflection. For this a 4cm leveling layer was placed together with a dense and hot asphaltic mix. After this the fiberglass reinforcement geogrid was installed (See Picture 3). Finally, a 5cm asphalt concrete layer was installed over the geogrid.

Picture 3. Roadwork after fiberglass application

5 CONCLUSIONS

After the knowledge of the fiberglass geogrids and the practical and positive results of its uses it can be summarize that:

- Fiberglass geogrids are ideal for the construction of new roadway infrastructure projects as they reduce long term maintenance costs and increase the pavement service life.
- The main technical benefit of fiberglass geogrids is to reinforce the bituminous coatings in highways, airports, and main and secondary roadways. Fatigue strength is increased and permanent deformations for this type of layers are also reduced.
- Fiberglass geogrids allow a 3% deformation, 9% less than a polyester geogrid with the same breaking load, which makes fiberglass geogrids more efficient for asphalt overlays.
- An ideal alternative for pavement structures reinforcement to reduce water penetration into the asphalt overlays is to combine a nonwoven geotextile that works as a waterproofing layer with a fiberglass geogrid that works as reinforcement.
- Currently, there is no design approach to reduce the asphalt overlay thickness by using fiberglass geogrids. However, in theory, a thickness reduction model could be made, but it will depend on the particular features of each project. These characteristics are mainly type of materials, soil and weather conditions, traffic load, etc.

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