Geotextiles and Geomembranes 43 (2015) 345–350

Contents lists available at ScienceDirect

Geotextiles and Geomembranes

journal homepage: www.elsevier.com/locate/geotexmem

Experimental study of the behaviour of different geosynthetics as anti-reflective cracking systems using a combined-load fatigue test

Irene Gonzalez-Torre [a], Miguel A. Calzada-Perez [b], Angel Vega-Zamanillo [b], Daniel Castro-Fresno [a,*]

[a] Construction Technology Applied Research Group (Giteco), University of Cantabria, Avda de Los Castros s/n, 39005, Santander, Spain
[b] Group of Roads (GCS), University of Cantabria, Avda de Los Castros s/n, 39005, Santander, Spain

ARTICLE INFO

Article history:
Received 16 July 2014
Received in revised form
12 February 2015
Accepted 13 February 2015
Available online 7 May 2015

Keywords:
Geosynthetics
Bituminous mixture
Anti-reflective cracking
Dynamic test
Secant modulus

ABSTRACT

A comparison between six different geosynthetics used to control reflective cracking is reported. The laboratory study involved a cyclic load test that combined two loads with different frequencies and amplitudes. Two characteristics are considered: the type of geosynthetic and the secant modulus. The results indicate that the type of the geosynthetic is critical to the long-term behaviour of the system.

1. Introduction

Reflective cracking is a very common failure mode in pavements. This process consists on the propagation of cracks from a deteriorated layer to the surface of an overlay layer that is placed as rehabilitation (Cleveland et al., 2002). One solution that is usually employed to fix cracked pavements is the placement of a new bituminous layer over the existing one, but in a short time cracks appear on the new layer surface. With the aim of minimizing this problem, several systems are used, and one of the most popular is the placement of geosynthetics under the rehabilitation layer. These products are composed in whole or in part of polymeric materials, and they are placed on the cracked surfaces before the spread of the overlay layer with the aim of acting as reinforcement or stress absorbing layer and thus, delaying the propagation of cracks (Button and Lytton, 2003). There are several geosynthetics specifically designed for this purpose which can be of different types and can be composed of different materials. Numerous field and laboratory studies have demonstrated the ability of geosynthetics as pavement reinforcement (De Bondt, 2006), but the selection criteria are still not clear (Zornberg, 2013).

Within the research carried out at laboratory scale, many authors have studied the performance of these systems using bi-layer bituminous specimens with a geosynthetic placed between them. Livneh et al. (1993) pointed out that the installation of a geotextile increases about 4 times the resistance to crack propagation, using a Wheel Tracking Test. Other laboratory studies like the presented by Prieto et al. (2007) developed a laboratory test that simultaneously applied a horizontal open-close movement and the passing of a wheel, for evaluating the effectiveness of fibreglass geotextiles, concluding that the best results were obtained with high strength geotextiles. Additionally, there are also numerous studies that use fatigue tests applying vertical loads. Khodaii et al. (2009) carried out an exhaustive study using a polyester geogrid. In this work, by using a cyclic load test it was concluded that the durability of the specimens with geosynthetics is greater than that of the reference samples, both for crack propagation and plastic deformations resistance. Other authors like Hosseini et al. (2009) performed the four point bending test on specimens with a geosynthetic, concluding that its presence increases stability and integrity of the specimens and that the crack opening was reduced compared with non-reinforced specimens. In addition, Virgili et al. (2009) and Ferrotti et al. (2012) using the same test (4PB) also found that geogrids increased the fatigue resistance of bi-layer specimens retarding crack propagation. Furthermore, Zamora-Barraza et al.

* Corresponding author. Tel.: +34 942 20 20 53; fax: +34 942 20 17 03.
E-mail address: daniel.castro@unican.es (D. Castro-Fresno).

http://dx.doi.org/10.1016/j.geotexmem.2015.04.001

(2011), apart from studying the increase on durability produced with geosynthetics, compared the behaviour of different anti-reflective cracking systems using a dynamic test. These authors found that all the geosynthetics delayed crack propagation, and that the geogrids with a higher modulus showed a better performance and provided higher resistance to deformations. Moreover, Vismara et al. (2012) studied the behaviour of glass-fibre reinforced geotextiles as anti-reflective cracking system, employing static and dynamic tests. In this case, the crack opening was reduced approximately 20% with the installation of geosynthetics in the specimens. In addition, they have also evaluated the reduction on the adherence between layers, as Zamora-Barraza et al. (2010) and others as Ferrotti et al. (2011, 2012), who also found a significant increase in the number of withstood cycles by a specimen when a glass-fibre geogrid was placed and that variables like coating of geogrids can influence their performance. More recently, Moreno-Navarro and Rubio-Gámez (2013) developed a new test which used a new laboratory device (UGR-FACT test) to study the effect of traffic loads and thermal contractions on the crack propagation in asphalt mixtures. This methodology has been used to study the behaviour of different anti-reflective cracking systems obtaining good results on the delaying of cracks propagation (Moreno-Navarro et al., 2014). Finally, Gonzalez-Torre et al. (2015) also developed a new dynamic test that combined vertical loads with different frequencies and amplitudes demonstrating that the presence of a geosynthetic retarded the propagation of cracks.

In view of the above, the objective of this study was to evaluate and to compare the behaviour of different types of geosynthetics used as anti-reflective cracking systems in pavements. To do this, a fatigue test on bi-layer specimens has been carried out, following the procedure described by Gonzalez-Torre et al. (2015). The analysis of the results has been based on the type and the stiffness of the geosynthetics measured using the secant modulus, in order to determine what properties have more influence on their anti-cracking behaviour.

2. Methodology

2.1. Materials

Six different geosynthetics, an asphalt mixture and a bituminous emulsion have been employed in this study. All geosynthetics were characterized by using the wide-width tensile test according to UNE-EN ISO 10319:2008. Table 1 presents the mechanical and physical characteristics of the six geosynthetics. Additionally, morphology of geosynthetics can be described as follows:

G1: polypropylene non-woven geotextile with fibres randomly distributed.
G2: polypropylene non-woven geotextile reinforced with glass fibre filaments.
G3: polyester geogrid bonded to a polypropylene non-woven light geotextile.
G4: polypropylene stiff monolithic geogrid bonded to a polypropylene and polyester fabric.
G5: glass fibre geogrid covered with an epoxy resin bonded to a polyester non-woven light geotextile.
G6: glass-carbon fibre geogrid covered with bitumen.

Moreover, the asphalt mixture used to manufacture the specimens was an AC16 Surf 50/70 with a bitumen content of 5%, according to UNE-EN 13108-1:2008. Finally, the bituminous emulsion used as a tack coat was a C69 B3, as reflected in UNE-EN 13808-1:2005.

2.2. Specimen manufacturing

In this study, a total of 21 specimens were manufactured following the procedure described by Gonzalez-Torre et al. (2015). The specimens consisted of two layers of asphalt mixture. The lower layer simulated an existing bituminous layer that was cracked, and the upper layer represented the overlay layer placed as rehabilitation. Seven different types of specimens were tested: first, the reference specimens (R) which did not have any anti-reflective cracking system and second, the other six types are those that include the geosynthetics. Reference specimens (R) were used as the reference value in the study.

Therefore, all the specimens were manufactured using an asphalt mixture at a temperature of 150 °C. The first step to manufacture the specimens was the compaction of a bituminous layer so that it was 50 mm high. Then, the bituminous emulsion was spread over the layer as tack coat (see Fig. 1a). After placing the emulsion, the geosynthetics were placed (when used) (see Fig. 1b). After that, another 50 mm high bituminous layer was spread and compacted. The specimens were compacted following the rolling compaction procedure according to UNE-EN 12697-33:2003+A1:2007. The plan dimensions of each layer were 260 × 410 mm^2. Additionally, it is important to note that each geosynthetic needs a different amount of tack coat for its correct anti-reflective behaviour as shown in Table 2, and that the instructions from the manufacturers were followed during the installation. Moreover, to simulate a crack in the road, a cut was made in the lower layer of the specimens by sawing. The induced crack was 45 mm high and it was placed 5 mm below the interface. Thus, the crack propagation started locally in the centre of the specimen. Finally, a plaster layer was spread on the central zone of the specimens before testing them. In this way, the evolution of cracks could be visually perceived during the test.

2.3. Test description

The test consisted on the superposition of a sinusoidal load with a frequency of 10 Hz and amplitude of 5 kN, and a triangular load

Table 1
Mechanical and physical properties of the geosynthetics.

Geosynthetic	Tensile strength (kN/m)	Secant modulus[a] (kN/m)	Grid size (mm × mm)	Thickness (mm)	Unit weight (kg/m^2)
G1	10.1	37	n/a	1.2	140
G2	57.5	2811	40 × 40	1.8	430
G3	51.2	471	40 × 40	1.9	270
G4	27.2	472	65 × 65	4.1	220
G5	90.6	4200	40 × 40	1.4	400
G6	39.6[b]	2402[b]	20 × 20	1.0	460

n/a: not applicable.
[a] Secant modulus under a deformation of 2%.
[b] Values regarding the main direction (glass fibre).