Transportation Geotechnics 1 (2014) 45–54

Contents lists available at ScienceDirect

Transportation Geotechnics

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

Influence of tack coat rate on the properties of paving geosynthetics

N.S. Correia [a,*], J.G. Zornberg [b,1]

[a] School of Engineering of the University of Sao Paulo at Sao Carlos, Geotechnical Engineering Department, Trabalhador Sao-carlense Avenue 400, Sao Carlos, SP 13.566-536, Brazil
[b] University of Texas at Austin, Civil Engineering Department – GEO, 1 University Station C1792, Austin, TX 78712-0280, USA

ARTICLE INFO

Article history:
Available online 7 February 2014

Keywords:
Geotextile
Geogrid composite
Tensile stiffness
Hydraulic conductivity
Asphalt emulsion

ABSTRACT

The use of geosynthetic reinforced asphalt overlay technique is becoming increasingly used to enhance the performance of cracked asphalt pavements. However, the compilation of design specifications for paving geosynthetics used as anti-reflective cracking systems has been a difficult task, leading to largely empirical procedures. Stiffness has been identified as the governing property to quantify the potential contribution of the interlayer to the asphalt overlay strength. Additionally, the asphalt binder forms a low hydraulic conductivity barrier that enhances bonding of the geosynthetic to the existing overlay. The type and rate of tack coat impregnation can significantly influence the reinforcement and waterproofing mechanism, potentially leading to early overlay failure. This paper presents the results of an experimental testing program conducted to quantify the influence of tack coating contents on the tensile strength and stiffness as well as the hydraulic conductivity of paving geosynthetics after emulsion asphalt impregnation. Both nonwoven geotextiles and composites involving geotextile and geogrid are considered in the study. Evaluation of the geosynthetics changes in tensile properties provides insight on the identification of an optimum bitumen dosage to enhance tensile strength and stiffness of impregnated geosynthetics. A tack coat rate equal to the asphalt retention capacity was specifically evaluated as baseline dosage, which was ultimately found to be an optimum dosage to enhance the mechanical properties for the effect of the tack coat rate on the tensile behavior of the geosynthetics. The use of asphalt emulsions were found to lead to a significant reduction in the hydraulic conductivity of paving geosynthetics.

Introduction

Paving geosynthetics such as nonwoven geotextiles and geotextile-geogrid have been used to minimize reflective cracking from an existing deteriorated pavement into new asphaltic overlay layers. Paving geotextiles have been reported to offer two main contributions to enhance the performance of asphalt overlays: a stress-relief layer and a hydraulic barrier (Khoddaii et al., 2009; Lytton, 1989). Geosynthetic reinforcement in asphalt concrete layers adds tensile strength to the resulting composite material by increasing its capacity to absorb energy during repeated

Abbreviations: AASHTO, American Association of State Highway and Transportation Office; ASTM, American Society for Testing and Materials; DER, Department of Highway of Sao Paulo State; GT, geotextile; GC, geogrid composite; PET, polyester; PP, polypropylene; UTS, ultimate tensile strength; XD, cross-machine direction.

* Corresponding author. Tel.: +55 16 3373 95 01; fax: +55 16 3373 95 09.

E-mail addresses: nataliacorreia@usp.br (N.S. Correia), zornberg@mail.utexas.edu (J.G. Zornberg).

[1] Tel.: +1 303 492 04 92; fax: +1 512 471 65 48.

http://dx.doi.org/10.1016/j.trgeo.2014.01.002

loading cycles (Mahrez et al., 2005). Geogrids and geocomposites incorporating geogrids have been reported to also contribute to the lateral restraining effect of pavements (Austin and Gilchrist, 1996; Tschegg et al., 2012). As reported by Pasquini et al. (2012), the mechanical properties of the asphaltic layers were reported to increase with increasing geosynthetic tensile strength.

However, Zamora-Barraza et al. (2010) report that the geosynthetic stiffness obtained from tensile tests is a more relevant property than the maximum tensile strength. Sprague et al. (1998) also states that stiffness constitutes the most critical property for the potential contribution of the geosynthetic to the strength of the overlay system. While these studies have shown the potential contributions of geosynthetics as anti-reflective cracking systems, the specifications for paving geosynthetics has been largely empirical. Accordingly, specifically, it is recognized that the relative conditions of cracked asphalt pavements should be better quantified and that the geosynthetic reinforcement properties that govern the enhanced performance should be identified and quantified. The geosynthetic must be able to absorb and retain the asphalt tack coat in order to effectively adhere to the underlying road surface (Maurer and Malasheskie, 1989). In addition, the amount of tack coat and the rate of application used to bond the geosynthetic to the underlying layer plays an important role. Indeed, use of tack coat of inadequate characteristics and/or rate may lead to early failure of the overlay (Lytton, 1989). Based on 65 field studies reported by Baker (1997), it was concluded that an inadequate tack coat was responsible for 75% of failures reported in identified case studies. As stated by Lytton (1989), the tack coat rate is recommended to be somewhat above the level as defined by the method for determining it, but not significantly above this level as this may cause shear strength losses at the interface of the underlying layer with the paving geosynthetic. A slight excess of tack coat may facilitate waterproofing if cracks end up reflecting to the surface. By minimizing water infiltration, the system becomes an efficient moisture barrier that enhances the pavement performance. FHWA (1984) reported a field hydraulic conductivity test in typical nonwoven geotextiles with tack coat rates ranging from 0.9 to 1.4 l/m^2, showing that in 33 out of 36 tests, the use of impregnated geotextiles allowed less water flow than in cases that did not use geotextiles as intermediate layers. In studies conducted by Marienfeld et al. (1999), results from modified permittivity test showed the tack coat rate ranging between 1.04 and 1.09 l/m^2 led to hydraulic conductivity values below of 10^{-6} cm/s. However, the actual values depended on the properties of geotextile and the applied tack coat.

According to AASHTO M 288-05 (2001), the specified rate of asphalt tack coat application should satisfy the asphalt retention capacity of the paving geosynthetic, and be able to bond the paving fabric and overlay to the old pavement. ASTM D 6140 (2005) provides a test method to estimate the asphalt retention capacity of paving geosynthetics. This standard defines asphalt retention as the volume of asphalt cement that is retained per unit surface area of geosynthetic. Koerner (2005) states that the rate of asphalt binder is a function of the geosynthetic saturation (ASTM D 6140 2005) and provides a correction based on the cracking level of the asphalt surface. In addition, Alvarez (2008) reports an on-site asphalt binder test conducted to determine the optimum amount of asphalt binder to be used in a project depending on the pavement conditions. This test should be performed on site with different tack coat rates until achieving complete material saturation. Castro and Ballester (2006) conducted a study on the influence of the types of asphalt binder on the asphalt retention capacity of paving geotextiles, showing that significant variations in retention values may result depending on the type of asphalt binder used. Accordingly, both the quantity and type of asphalt binder affect the geosynthetic asphalt retention capacity. Finally, Correia and Bueno (2011) conducted a preliminary evaluation on the effect of different rates of asphalt emulsion on the tensile properties of the geosynthetics. The results of tensile strength tests on impregnated geosynthetics revealed that increasing tack coat rates leads to increasing material stiffness, possibly enhancing the reinforcement mechanism of paving geosynthetics.

Based on the evaluation of the available technical literature, a systematic evaluation is needed of the possible changes after bitumen impregnation of the properties of mechanical and hydraulic paving geosynthetics. For example, the reinforcement benefit of paving geosynthetics has been typically neglected, at least when compared to benefits expected from stress relief and waterproofing. Accordingly, a thorough experimental study involving tensile tests was conducted in this investigation using paving nonwoven geotextiles and a geocomposite impregnated with asphalt emulsion at different rates. An important parameter to be defined in this study is the optimum tack coat dosage recommended for a given geosynthetic type. Specifically, the influence of tack coat contents on the tensile strength and stiffness of these geosynthetics is investigated. A tack coat rate equal to the asphalt retention capacity is specifically evaluated as a baseline tack coat rate. In addition, water vapor transmission tests were conducted to investigate the hydraulic conductivity of the impregnated geosynthetics.

Experimental procedures

Materials

A total of seven paving geosynthetics were used to investigate changes in tensile and hydraulic conductivity properties after impregnation with asphalt emulsion. A cationic aqueous rapid setting emulsion (CRS) was used in this research as the tack coat for geosynthetics impregnation, in accordance with DER-SP ET-DE-P00/043 (2006) specifications. The characteristics of the tack coat emulsion used in this study are shown in Table 1. The geosynthetic materials used in this study include: four needle-punched 100% polyester (PET) nonwoven geotextiles with different masses per unit area; two 100% polypropylene (PP) nonwoven geotextiles with different masses per unit area; a geocomposite involving fiber glass geogrid and a 100% polypropylene nonwoven geotextile. Fig. 1 illustrates the