Use of geosynthetics for the strengthening of road pavement structure in Lithuania

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ABSTRACT: Last decade in Lithuania asphalt reinforcement with geosynthetics was often used for reconstruction of road pavement structures. The initial asphalt reinforcement with geosynthetics was carried out in 1996, during reconstruction of road pavement works in main road which is IXB TEN corridor. In this case a nonwoven geotextile was used. After it, several years nonwoven geotextile was widely used for asphalt reinforcement. But, after the latter research of these reconstructed road sections and some experimental tests, inefficiency of asphalt reinforcement with nonwoven geotextiles was determined. So, after it, the use of woven geogrids became more and more intensive. In 1998 Lithuanian Road Administration adopted the temporary regulations on Using Geotextiles and Geogrids for Road Construction, which are still being used by road designers and suppliers of geosynthetics. The regulations are based on the German experience and their specifications for the use of geotextiles on roads. However, when adapting these regulations no experimental research was carried out or evaluation of their suitability to Lithuanian conditions. The paper deals with the performance of road pavement structure strengthening with geosynthetics in Lithuania national roads and city streets. There are presented research studies including performance of geotextiles separation function in road pavement structure and geotextile damage from transport loads; rehabilitation of asphalt pavements with new layer of asphalt and geogrid; performance of road pavement structure life time with reinforced and unreinforced pavement structure layers with geosynthetics.

1 INTRODUCTION

The structural strength of roads and streets as well as the uniformity of strength are ensured by a design strength of subgrade, sub-base and pavement layers, characterized by a deformation modulus, the value of which depends on the properties of materials used for the pavement structural layers and thickness of the layers. In road exploitation process heavy vehicle loads change thickness of pavement layers, the strength characteristics of these layers decrease, ruts, cracks and other damage are formed. The decrease of strength characteristics of layers leads to the decrease of the whole strength of road pavement structure. That's way, during road exploitation time in between the road repair periods the pavement or part of pavement should be repaired in order to get proper pavement structure characteristics. One of suitable reconstruction ways could be the use of geosynthetics.

Lithuania has only been using geosynthetics in road and street construction and reconstruction during the last decade.

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In the researches on the possibilities of the use of geosynthetics for the strengthening of road pavement structure scientists pay great attention to the damage during the installation of geosynthetics into road construction. The damage mechanisms are primarily related to the boundary conditions (fill material, subsoil, construction equipment and procedures) but will also vary with the type of geosynthetics. These conditions are considered during selection of geosynthetics according to normative. These normative are used in Nordic countries - *NorGeoSpec* (Want et al. 2002, Moe et al. 2008); and normative of Germany (Wilmers 2002).

The strengthening and stability encreasement of non rigid road pavement structure is assessed in different aspects. The recommendations on use of geosynthetics for such pavement type are suggested (Al-Qadi 2002) and other ways, such as use of modified bitumen and steel mesh are proposed (Tusar et al. 2009).

In Lithuania most of researches about use of geosynthetics for the strengthening of road pavement structure started in 2004. These researches include the installation of experimental sections as well as monitoring of exploitable reconstructed sectors (Cygas et al. 2008, Laurinavicius et al. 2006 Vaitkus et al. 2007,), the researches of roads constructed using geosynthetics (Vaitkus et al 2008) and laboratory research of geosynthetics (Vaitkus et al. 2006).

This article observes the last experimental investigations about the use of geosynthetics for the increase of strength and stability of road pavement in Lithuania. On the basis of the analysis of experimental investigation the conclusions are made and the suggestions for the future investigations are proposed.

2 RESEARCH ON INSTALLATION DAMAGE

Site damage tests have been performed on the main road of the Republic of Lithuania A1 (Vilnius – Kaunas – Klaipėda). In summer 2005 the road construction works were carried out. The cross section of the structure is presented in Figure 1. For the construction of the section, local and non-local materials were used. The subgrade was constructed of the existing soils – fine sand. The frost blanket course was constructed of gravel 0/32, the sub-base of road pavement was constructed of crushed dolomite 0/64. The road surfacing consists of three layers: base course asphalt 0/32-C, binder course asphalt 0/22-A and wearing course asphalt 0/16-SM.

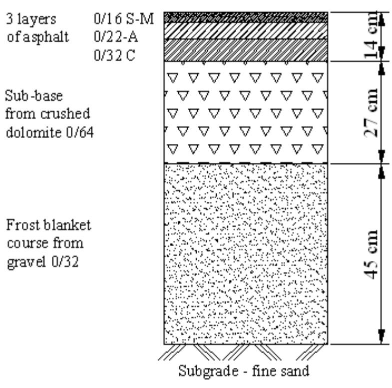

Figure 1. A cross-section of a new road structure

On the experimental section where the road pavement was being widened two test sub-sections were selected, each 15 m long. In each sub-section 5 types of nonwoven geotextile were installed. The 5 strips of geotextile were produced by different manufacturers. Their mass per unit area varied and was 110 g/m^2; 130 g/m^2; 170 g/m^2; 200 g/m^2 and 300 g/m^2, respectively. In the first section, the geotextile layer was installed between the subgrade and the frost blanket course; in the second – between the frost blanket course and the sub-base constructed of crushed dolomite 0/64. In the first section each geotextile covered an area of 12 m^2 (3 m * 4 m), in the second section each geotextile covered an area of 9 m^2 (3 m * 3 m). In the first test sub-section geotextile strips were laid on the subgrade, whose surface was even, with no major ribs; its static deformation modulus $E_{V2} \geq 45$ MPa. Over the geotextile a frost blanket course of 45 cm was installed consisting of good quality gravel (the largest grain size 30-35 mm). The layer over the geotextile was back-dumped and pressed. It was constructed by compacting two layers – one of 30 cm and the other of 15 cm. For compaction a vibratory roller of 12 t was used; it rolled over each layer 5 times forth and back. In the second test sub-section geotextiles of different types were laid on the frost blanket course. Over the geotextile a sub-base of crushed dolomite 0/64 with the thickness of 27 cm was constructed. The largest part of crushed stones there reached 60 mm. Like in the first section, the aggregate over the geotextile was back-dumped and then pressed. The layer then was compacted by a vibratory roller of 8 t, which rolled over it 5 times forth and back. After the installation of all relevant layers over the geotextile in both sub-sections and after their thickening until the design values of deformation moduli of the layers are reached, the excavation and sampling of geotextiles was carried out. To avoid damaging the test material, all works during excavation were performed manually.

Damages of the geotextile and their number on the already constructed test sections were assessed having excavated the test materials. In the test sections the following geotextile damages were identified: general abrasion, cuts and puncturing. General abrasion was identified exclusively on the geotextile whose mass per unit area was 130 g/m^2. It was installed in the first section between the subgrade and the frost-proof layer. Cuts were identified in the most tested geotextiles. However, their number and size is moderate. The most frequent damage was puncturing. Hence the number of punctures and the total area of puncturing (cm^2) per square meter of the material (m^2) have been selected as a basis for comparison (*tertium comparationis*).

The results of investigation indicate that all geotextile damages having occurred during the installation of road pavement structural layers over the geotextile had no significant impact on the pavement structure layer separation, one of the major functions of geotextile. The results obtained from the test sections are given in Figure 2 and 3.

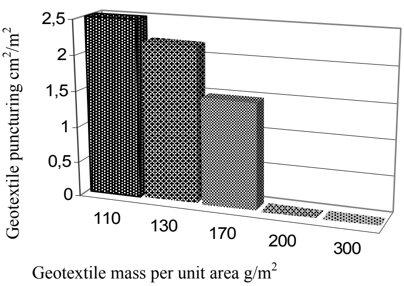

Figure 2. The total area of geotextile punctures cm^2 per m^2 on the first test section

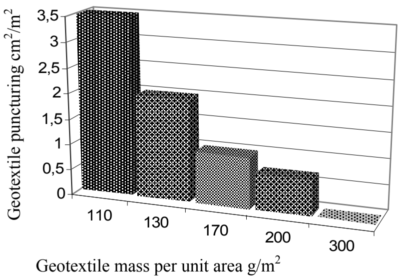

Figure 3. The total area of geotextile punctures cm^2 per m^2 on the second test section

3 RESEARCH OF GEOTEXTILE DAMAGE FROM VEHICLE LOADS

The experiment was done on 2006 and 2007. For the implementation of the experiment the test section of the local gravel road in Lithuania, which is regularly affected by the heavy vehicle traffic, was chosen. The experiment was divided in to two parts. One of them was assessment of the occurance of the damage of geotextile and the implementation of the separation function, depending on the kind of the material, used for the sub-base of the road pavement structure and the impact of permanent transport loads, other – depending on asphalt layer attendance in pavement structure.

The full factorial experiment was chosen, during which every factor and factor product influence on the quest value was determined. The quest value was the geotextile damage – $GTX_{dmg.}$ Geotextile damage are taken as percentage expression of total damage (puncturing) area compare to the unbroken material, (%). The factors, assessed during the experiment, that influence the damage of the geotextile, and its scale are as follows:

MM – the kind of the sub-base material;

h – the thickness of the wearing course;

A – equivalent single axle loads counted to 100 kN (ESALs).

According to the made matrixes of the full factorial experiment, three test sections were installed successively (Figure 4). Test sections were installed at the 70 meters long part of the road, width of pavement structure – 8 meters. Geotextiles were installed on the present road covering after installation of the 5 cm thick sand –gravel mix layer. The 30 cm sub-base of 3 different kinds of material was installed on the geotextiles. On the sub-base the 6 cm thick and 28 m long wearing course of asphalt 0/16-Vn was installed.

Two kinds of the nonwoven needle punched geotextiles were chosen for the experiment: GTX1 – one of the strongest needle punched geotextiles used for the separation of the layers of pavement structure. It's mass per unit area 300 g/m^2, and GTX2 – one of the slightest. It's mass per unit area 110 g/m^2. In the first section, the geotextiles were installed between the sub-base of gravel-granite mix 0/45 and the frost blanket layer; in the second – between the sub-base of granite 16/45 and the frost blanket layer; in the third – between the sub-base of dolomite 16/45 and the frost blanket layer.

The first excavation of the geotextiles was done on 21-10-2006 almost after 34000 ESALs. During the first excavation 2 meter length for the whole width of the geotextile sectors in the each section were exposed. In 1st and 2nd sections four and four and in 3d section two samples of geotextile were exposed. The main amount of sub-base material from geotextiles was removed by excavator and to avoid damage of the geotextiles residual material was excavated manually. The separation function was performed in all excavations. Like in installation damage research the most frequent damage was puncturing of geotextile. From each excavated geotextile sample 6 independent specimens (30×30) cm were cuted. The total area of puncturing was counted in all 6 independent specimens. The mean damage (puncturing) area values of all excavated geotextiles are presented in Figure 5.

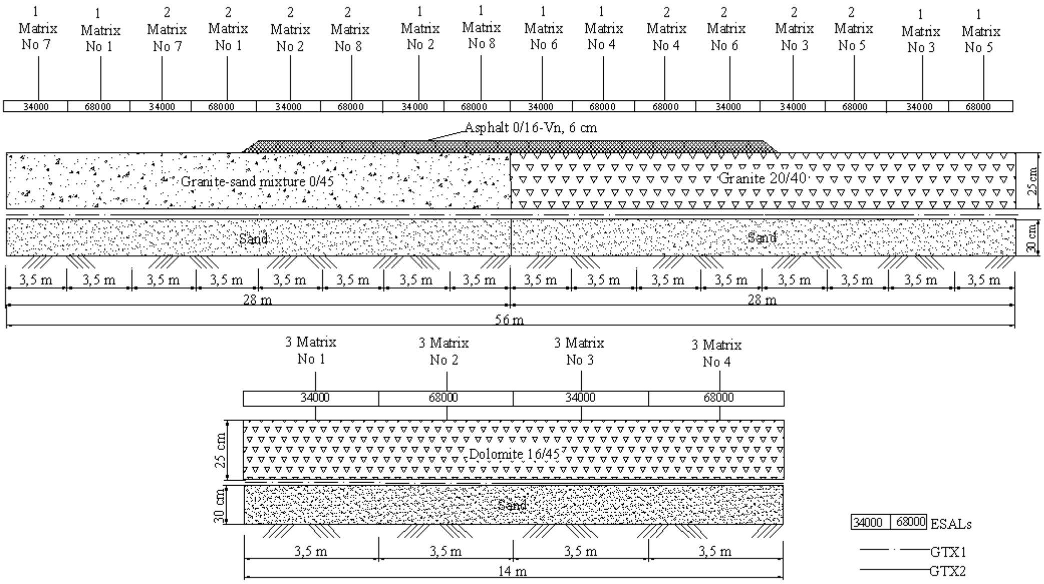

Figure 4. The longitudinal section of the test sections

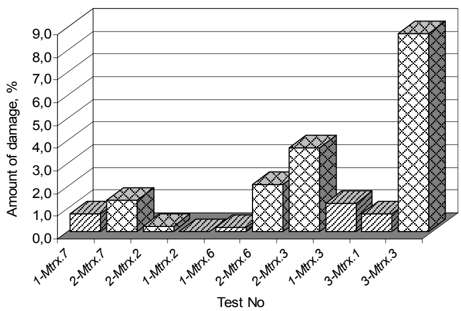

Figure 5. Mean values of geotextiles damage area (GTX1 in lines, GTX2 in mesh)

4 RESEARCH OF ASPHALT REINFORCEMENT WITH GEOSYNTHETICS

In the city of Vilnius, there has been a testing road section constructed. The experimental section has been constructed in September 2004. In order to identify the impact of reinforcement on the rheological characteristics and strains of asphalt concrete, asphalt wearing course was reinforced; i.e. geosynthetics was laid between the asphalt wearing and binder layers. The experimental pavement construction consists of 4 cm 0/11 S-M asphalt wearing course , 5 cm 0/16 S-A asphalt binder layer, 6 cm 0/22 A asphalt base layer, 25 cm base layer from crushed stone and 40 cm frost-blanket layer.

The geosynthetics materials were used: HaTelit C 40/17, Bitutex Stargrid Glu 50, Armapal MP-50, Pavemat, Pavegrid G-50, Fibertex AM – 2.

The asphalt concrete layers on the whole testing section were of equal thickness, of the same type and composition. The elasticity modulus of the road base, frost blanket layers and the embankment was the same on the total length of the asphalt concrete section; therefore, it is taken as a non-variable value. Hence, the variability of different values is associated solely with the reinforcement of asphalt concrete. During the first stage of experimental research thefollowing parameters have been measured: the modulus of elasticity of asphalt concrete *E* and depth of rutting.

The first measurement of the depth of rutting was accomplished in April 2005, the second – in September, immediately after the hot season. The modulus of elasticity was measured in September 2005. The modulus of elasticity has been measured 10 times in every sector with a different geosynthetics. The numbers of experimental measurements have been calculated on the basis of previous measurements of the same pavements construction. The depth of rutting has been measured 10 times in sectors with geogrid and 20 times in sectors with geotextiles. The rutting depth has been measured in different seasons of the year with the purpose to estimate how geosynthetics influences the development of these strains in different seasons.

After the first measurement in spring, it has been identified that the rutting depth does not depend on the geosynthetics material. In section without geosynthetics, the depth of rutting was less than in sections with geosynthetics. However, after the second measurement the influence of geosynthetics has been clearly identified. The regression analysis has shown a clear relationship between the depth of rutting and the modulus of elasticity of asphalt concrete, particularly in the first case of rutting. However, the relationship between the increase of the depth of rutting and the modulus of elasticity of asphalt concrete is not marked.

5 CONCLUSIONS

All geotextiles selected for the installation damage testing, including the weakest, fully performed the function of road pavement layer separation. The damages that occurred in the course of its installation had no significant impact on the fulfillment of the function.

Puncturing damages of the geotextile were the most numerous. The area of puncturing (cm^2/m^2) decreases with the increase in the mass per unit area.

After research of geotextile damage from vehicle loads was defined that:

separation function was performed perfect in all sections but puncturing of geotextiles weren't spreaded gradually in all area of geotextiles;

the most damaged geotextile was excavated from road pavement structure without asphalt layer in which sub-base was from dolomite;

much less damage observed in geotextile excavated from road pavement structure without asphalt layer in which sub-base was from granite;

in other excavated geotextiles the amount of damage was too small to find dependence.

the main factors were identified having influence on the occurrence of the geotextile damages during pavement installation and in the phase of road operation, i.e.: grading and size of the largest aggregate particle of the layer constructed over the geotextile, thickness of the pavement layers over the geotextile, loads during the pavement installation (traffic of the road building mechanisms on the layer constructed over the geotextile), traffic loads during the operation of the road.

After research of asphalt reinforcement with geosynthetics was defined that:

The research has established the dependence of the rutting depth on the modulus of elasticity as the first condition of rutting. In its turn, the modulus of elasticity of asphalt concrete depends on the type of geosynthetics material used. To improve the strength properties of asphalt concrete it is expedient to use geogrid.

The accomplished research into reinforced asphalt concrete has established that the rutting depth depends on the type of geosynthetics material used. The rutting depth increases from 1,4 to 2,2 times with geosynthetics materials and 3 times without a geosynthetics material. However, to reduce shear strains and rutting, it is expedient to use geogrid.

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