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SITE DAMAGE TESTS OF GEOTEXTILES USED FOR LAYER SEPARATION IN ROAD CONSTRUCTION

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Abstract. In recent decades Lithuania has witnessed an increase in road construction and reconstruction works involving the use of geosynthetics, which is usually concerned with special functions. One of them is separation of layers of aggregate by geotextile in the structure of road pavement. To successfully implement the separation, there are several crucial factors to be taken into consideration: the integrity, durability of the material and damages identified during installation. In Lithuania the geosynthetics is selected on the basis of eight-year-old interim guidelines and recommendations of suppliers. The paper deals with the systems of selecting geosynthetics in Lithuania and other countries. Then the results of experimental research are assessed. The present research has selected 5 types of geosynthetics of some manufacturers. The geotextiles were installed between different layers of road pavement structure. The analysis focuses on geotextile damages emerging during installation and their impact on performing the function of separation.

Keywords: separation, geotextile, geotextile damage, pavement structure, geosynthetics, specifications.

1. Introduction

Geosynthetics used in civil engineering can perform one of the following functions: separation, reinforcement, filtration, drainage, barrier or protection. Very often one type of material performs several functions at a time.

It is usually assumed that all geosynthetics, apart from its special function, can also perform the function of separating layers. However, if the latter function is not properly fulfilled, the main function will not be fully accomplished either. Still it does not mean that the function of separation is secondary in all cases. On the contrary, seeking for construction solutions, the function of separation is prioritised and then geotextiles are given primary importance [1]. The very fine aggregate base course produced by a contractor may cause unexpected problems concerned with the migration of particles, which requires additional costs for constructing a separating geotextile. Designers should be aware of this potential problem when dealing with fine aggregate [2].

A typical road pavement structure in Lithuania consists of subgrade soil, a frost blanket course, a road sub-base and asphalt concrete (Fig 1) [3].

When the road is in operation, the road structure weight and temporary loads lead to two simultaneous processes between the construction layers (ie between the sub-base and the frost blanket course and between the subgrade and the frost blanket course): first, the subgrade soil particles migrate into the frost blanket course and second, large particles of the aggregate of the road sub-base and the frost blanket course migrate into the weaker lower layer. As a

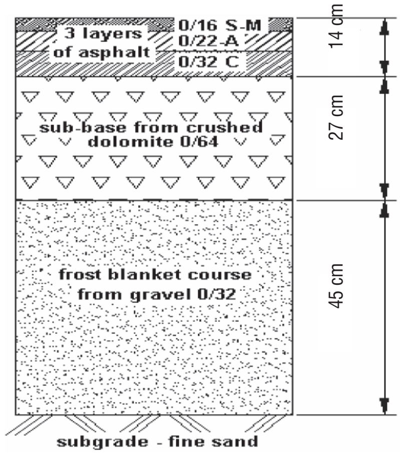

Fig 1. A typical road pavement structure

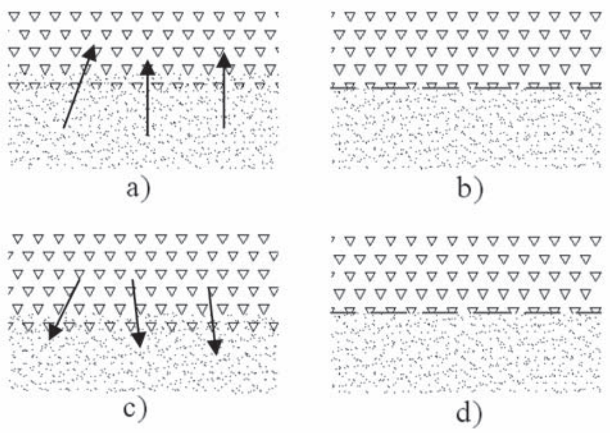

Fig 2. Processes active in the layers of the road structure and their prevention by a separation geotextile: a) fine particles of soil migrate into a more porous frost blanket course, b) the migration process of fine soil particles has been terminated, c) large aggregate particles migrate into a weaker layer, d) the migration process of large particles has been terminated

result, at first filtering properties of the frost blanket course decrease, and then the strength of the upper layers is reduced. The two processes are particularly active in the road pavement when geotextile is not used for layer separation. Fig 2 illustrates the processes in road pavement before the installation of geotextile between the layers and after it.

The research undertaken in Lithuania and focusing on the peculiarities of road pavement structure in public transport stops has identified that on some sections the layers of aggregate are partially merged with one another as a result of long-term transport loading [4].

Since the time when geosynthetics was first installed in road structures, the problem of damages in geosynthetics emerging in the course of installation has been identified. It has been a major cause for the failure of geosynthetics to fully perform its major functions.

Mechanical impact on geosynthetics may reduce or even totally destroy its ability to fulfil one or another function. On the other hand, it should be noted that the geosynthetics might still serve its intended function despite the damage. As part of design, it is therefore required to evaluate the expected mechanical damage and the consequences it might cause in terms of its ability to fulfil its intended function in the structure [5].

For the reinforcement of road constructions by geosynthetics, researchers [6, 7] suggest that the equation, based on the data from the tensile test, could be used.

$$T_d = \frac{T_{ch}}{A1 \times A2 \times A3 \times A4 \times \gamma}, \quad (1)$$

where T_d – possible design strength of a product for reinforcement, T_{ch} – characteristic value (tensile strength of the product), $A1$ – creep reduction factor, $A2$ – installation damage reduction factor, $A3$ – junction/connection reduction factor, $A4$ – durability reduction factor, γ – partial factor of safety.

Koerner and Koerner suggest that the same calculations could be used (1) for allowable strength of geosynthetics intended not only for reinforcement but for separation too [8]. But in this equation the partial factor of safety is eliminated:

$$T_{allow} = T_{ult}\left[\frac{1}{RF_{ID} \times RF_{CR} \times RF_{CBD} \times RF_{SM}}\right], \quad (2)$$

where T_{allow} – allowable (or design) strength, T_{ult} – ultimate (or as-manufactured) strength, RF_{ID} – reduction factor for installation damage, RF_{CR} – reduction factor for creep, RF_{CBD} – reduction factor for chemical and biological degradation, RF_{SM} – reduction factor for seams (if appropriate).

The installation damage and creep reduction factors exert greatest influence on the separation function of geosynthetics. This paper attempts to estimate the impact of installation damage on the geotextile separation function in road construction. The present research focuses on the assessment of major tendencies of damages emerging in geotextile used for separating different layers in the road structure depending on the conditions of installation, ie type of geotextile and the materials used for the installation of the construction layer. Whenever the materials for separating the layers of the road pavement structure in the course of their installation are selected and used inappropriately, the probability of failure to fully perform the required function is high. The research also aims at identifying whether the selection of geotextiles in accordance with the interim guidelines in Lithuania can ensure a proper separation of layers of the road pavement structure.

2. Damage mechanisms and visual assessment

Mechanical damages in geosynthetics might occur in the course of production, storage and transportation, when installing and operating geosynthetics in the road pavement structure. Experience has shown that the damage to a geotextile originates mostly in the installation and construction phase [5]. The present research has identified and assessed the damage to a geotextile used for separating different layers of asphalt pavement structure and originating in the installation phase.

The following key factors causing damage to geosynthetics in the installation phase have been identified: subsoil type, fill material, construction equipment and procedures, climatic conditions and characteristics of geosynthetics [5].

Research into the origin of damages to geosynthetics has identified 6 main damage mechanisms [5, 9–11]: abrasion, splitting, puncturing, stress rupture, fibre cutting and tearing. Abrasion is usually caused by a repeated friction of aggregate particles against the surface of geosynthetics during the operation of the road pavement structure. Abrasion can occur in all types of geosynthetics; however, the least resistant are non-woven needle punched geotextiles. Abrasion decreases the thickness of the material which leads to reducing its strength characteristics. The abrasion of non-woven geotextiles might also have impact on their water permeability characteristics. Splitting is caused by sharp angles of aggregate particles tearing the surface of the geosynthetics during compaction. It is observed principally in the ribs of extruded polyethylene geogrids. Splitting causes no immediate loss in strength when the split is in the direction of the load, but may do so when a biaxial grid splits in the direction transverse to the load. Puncturing usually occurs when a layer of pavement structure containing sharp angles of grains of the aggregate is installed over the geotextile or when a thin layer of aggregate installed on the geotextile layer is compacted by heavy compaction equipment. Stress rupture usually occurs when the layer-separating geotextiles are installed on very weak bases and are under continuous heavy loading. Stress rupture can also be identified in structures where the edge of the geotextile is fixed in the rigid structure and at that point the edge has no elasticity. Fibre cutting. This process is identified when sharp particles of aggregate incise or cut off the fibres of the geosynthetics. It usually occurs in woven and non-woven geotextiles and geogrids, when they are installed on hard surfaces. Tearing is usually identified as a result of impact of tearing forces on the geosynthetics after it has been already damaged by other factors.

In the process of investigation, damages of geotextile separating the layers of the road pavement structure have been assessed on the basis of the visual assessment of site methodology as provided in the British Standard BS 8006, annex D [12]. Thus the damages fall into four categories: general abrasion, splits, cuts and bruises. The category of general abrasion defines geotextile damages when the geotextile surface has been damaged by a large number of fine particles aggregate. The particles usually leave marks of abrasion on the geotextile surface. Splits, cuts and bruises refer to damages which have occurred through the impact of large particles of the aggregate. Splits describe the region of the strip or rib when locally split into a number of small strands so that light passes through. A cut describes the rib or strip when a sharp indentation is made across or along the geotextile. A bruise describes the rib or strip when flattened but no light passes through.

3. Specifications of geotextiles for separation in road structures

Presently there are no generally accepted legislation regulating the specification of geotextiles intended for separating road pavement layers. Geotextiles are usually selected on the basis of norms and standards of a particular country or on the basis of the experience of designers and manufacturers.

The system, which serves as a basis for the specification of geotextiles intended for separation and filtration on roads in Finland, Sweden and Norway, is more than 20 years old. The system was developed on the basis of assumptions and suppositions; it has been revised and updated several times. In Norway, a new standard for the specification of geotextiles was introduced in 1999 [13]. In the same year to approximate the requirements and develop a new system for the specification and control of geotextiles in Northern Europe there was a new project started — NorGeoSpec [14]. A system developed in the framework of the Project was introduced in 2002 and revised in 2004.

The NorGeoSpec includes general requirements for geotextiles, requirements for the characteristics of geotextiles to be declared by manufacturers; specific requirements related to specification profiles; guidelines for the selection of a relevant specification profile; a system for the control of geotextiles delivered on site [15].

According to the system, geotextiles intended for separating the layers of the road pavement structure are divided into five specification profiles. Each of them shall be in conformity with physical and mechanical characteristics, including permitted tolerance (Table 1). The selection of a

Table 1. Specification profiles [15]

Characteristic	Maximum tolerance	Specification profiles				
		1	2	3	4	5
Min tensile strength, kN/m	–10 %	6	10	15	20	26
Min tensile strain at max load, %	–20 %	15	20	25	30	35
Max cone drop diameter, mm	+20 %	42	36	27	21	12
Min energy index, kN/m		1,2	2,1	3,2	4,5	6,5
Min velocity index, 10^{-3} m/s	–30 %	3	3	3	3	3
Max char opening size, O_{90}, mm	±30 %	0,2	0,2	0,2	0,15	0,15
Max tolerance for mass per unit area		±12 %	±12 %	±10 %	±10 %	±10 %
Max tolerance for static puncture strength		–10 %				

Table 2. Selection of a specification profile [15]

Sub-soil	Construction conditions	Traffic	Maximum grain size (d_{max}) in fill material, mm			
			d_{max} < 60	60 < d_{max} < 200	200 < d_{max} < 500	d_{max} > 500
Soft	Normal	High	3	4	5	5
		Normal	3	4	4	5
	Favourable	High	3	3	4	5
		Normal	2	3	4	4
Firm	Normal	High	2	3	3	4
		Normal	2	2	3	3
	Favourable	High	2	2	3	3
		Normal	2*	2	2	3

* specification profile 1 may be used for roads with temporary traffic, access roads or similar

specification profile depends on the type of subsoil, construction conditions, traffic and maximum grain size in fill material adjacent to the geotextile (Table 2).

The system NorGeoSpec classifies geotextiles and thus regulates a number of physical and mechanical characteristics of geotextile and maximum tolerance; however, the parameters of mass per unit area and static puncture strength are only specified in terms of tolerance from the values declared by the manufacturer. This is the key difference between Western European and Lithuanian standards. The latter give priority to the parameters of static puncture strength and mass per unit area.

Since 1980 Germany has been successfully using GRC, a geotextile robustness classification. At first, it classified the robustness of geotextiles against mechanical damage into 4 classes. Later, having adopted a Norwegian proposal in 1994, the classification was extended to 5 classes [6]. To find out a GRC for a given site, Germans classify the fill material into 5 levels according to the diameter and the sharpness of aggregates. The types of loading are classified into 4 levels and depend on installation and construction works [16]. The determination of geotextile GRC for its application in separation situation is presented in Table 3 and GRC for nonwovens in Table 4 [6].

Lithuania has only been using geotextiles for road construction and reconstruction during the last decade. In 1998 the Lithuanian Road Administration adopted the interim guidelines Using Geotextiles and Geogrids for Road Construction, which are still used by road designers and suppliers of geosynthetics [17]. The guidelines are based on the experience of German specialists and their standards specifying the use of geotextiles on roads; however, no on-site research or adoption for local conditions has ever been done. In accordance with the guidelines, the classes of geotextile robustness are selected and geotextiles attributed to one or another class in accordance with the specifications (Tables 3 and 4). Therefore, to ensure an appropriate use of geosynthetics in the pavement structure of Lithuanian roads and streets, the specifications should be revised. Also it is important that experimental research is done.

The NorGeoSpec, a system of geotextile selection and control used in Nordic countries, specifies the strength characteristics of non-woven geosynthetics and maximum tolerance. However, the static puncture strength and mass per unit area, the characteristics of utmost importance for German and Lithuanian designers when selecting geotextiles, have only tolerance values specified. Some researchers have proved a direct dependency between the mass per unit area and the static puncture strength [18]. Others have identified a dependency of the geotextile susceptibility to damage on its mass per unit area. But it should be noted that the mass per unit area alone is not sufficient as a basis for com-

Table 3. Determination of a geotextile robustness class for separation [6]

Classes of fill	Loading classes			
	AB1	AB2	AB3	AB4
AS1	Grc1			
AS2	Grc2	Grc2	Grc3	Grc4
AS3	Grc3	Grc3	Grc4	Grc5
AS4	Grc4	Grc4	Grc5	(*)
AS5	Grc5	Grc5	(*)	(*)

(*) – a site test necessary or an increased thickness of the cover layer required

Table 4. Geotextile robustness classes for nonwovens [6]

Geotextile robustness classes	Static puncture strength	Mass per unit area
Grc1	≥ 0,5 kN	≥ 80 g/m^2
Grc2	≥ 1,0 kN	≥ 100 g/m^2
Grc3	≥ 1,5 kN	≥ 150 g/m^2
Grc4	≥ 2,5 kN	≥ 250 g/m^2
Grc5	≥ 3,5 kN	≥ 300 g/m^2

parison between different types of products as the susceptibility is also related to polymer type, fibre type, production technology etc [19]. Therefore, the parameter of mass per unit area should not be treated as a crucial factor assessing the susceptibility to damage of the geotextile when selecting it for layer separation.

4. Selecting geotextiles for experimental research according to standards

Considering the materials used for constructing the layers of the road pavement structure and methods of their construction, in accordance with the specifications discussed in Section 3, the following geotextiles should be selected for layer separation:

- When selecting a geotextile in accordance with the NorGeoSpec specifications, first, the specification profile should be identified (Table 2). It depends on the type of subsoil on which the geotextile is laid, on the construction conditions of the road pavement structure, the maximum grain size in fill material constructed over the geotextile layer and the traffic volume of the road under construction. In accordance with the types of materials used for constructing different layers of an experimental road pavement structure and their construction conditions, for separating the subgrade from the frost blanket course as well as for separating the frost blanket course from the sub-base the 2nd specification profile is selected. According to Table 1, the 2nd specification profile would require a geotextile whose mass per unit area is 150 g/m^2 (selected for testing 170 g/m^2).
- Following the interim guidelines, a class of geotextile robustness is selected from Table 3 [17]. It depends on the loading class of the fill material (AS) laid over the geotextile and the loading class of technological transport during construction (AB). To separate the subgrade from the frost blanket course on the experimental pavement structure the geotextile in conformity with Class Grc3 is required. To separate the frost blanket course from the base the geotextile in conformity with Class Grc4 is required. The geotextile of Class Grc3 should have the mass per unit area not less than 150 g/m^2 (selected for testing 170 g/m^2), the geotextile of Class Grc4 should have the mass per unit area not less than 250 g/m^2 (selected for testing 300 g/m^2).

If calculated in accordance with the NorGeoSpec specifications, the same specification profile is obtained for the separation of subgrade from the frost blanket course as well as for the separation of the frost blanket course from the sub-base, despite the fact that the load and composition of the aggregate are different. Thus it indicates that the system is not sufficiently precise, when the aggregate used for the construction of different layers is similar in its composition but different in its characteristics.

An attempt to select a geotextile according to the interim guidelines has manifested that the system is able to assess the composition of the aggregate used for the construction of different layers of the pavement structure as well as the physical characteristics of the fill material (form, origin etc) [17].

5. Installation of experimental sections and their investigation

Site damage tests have been performed on the main road of the Republic of Lithuania A1 (Vilnius – Kaunas – Klaipėda). In the summer of 2005 there were road construction works carried out. They aimed at widening the road pavement so that it would conform to the requirements for motorways. Site damage tests were performed on a section in the vicinity of Kariotiškės (24–31 km). The pavement width was increased towards the road shoulder by constructing a new road structure of 5 m. The cross section of the structure is provided in Fig 1. For the section construction there were local and other materials used. The subgrade was constructed of the existing soils – fine sand SG in accordance with standard LST 1331 [20]. The frost blanket course was constructed of gravel 0/32, the sub-base of road pavement of crushed dolomite 0/64. The road pavement consists of three layers: base asphalt concrete 0/32-C, lower layer 0/22-A and wearing course 0/16-SM.

On the experimental section where the road pavement was being widened, there were two test sub-sections selected, each 15 m long. In each sub-section there were 5 types of geotextile 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 ir 300 g/m^2, respectively. The characteristics of the geotextile as declared by the manufacturer are given in Table 5. 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 (Fig 3). 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 $E_{V_2} \geq 45$ MPa. Over the geotextile there was a frost blanket course of 45 cm installed consisting of good quality frost blanket course (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.

Table 5. Characteristics of testing geotextiles as declared by manufacturers

Product No	Polymer type	Mass per unit area	Tensile strength	Strain at peak	Static puncture strength (CBR)	Dynamic puncture opening	Water permeability normal to the plane	Opening size
		Standard						
		EN 965	EN ISO 10319	EN ISO 10319	EN ISO 12236	EN 918	EN ISO 11058	EN ISO 12956
		Units						
		g/m²	kN/m	%	kN	mm	m/s	μm
1	PP	110	MD 5,5 CD 6,5	60–70	1,0	32	0,09	100
2	PP	130	MD 7,5 CD 8,5	60–70	1,4	27	0,09	100
3	PP	170	MD 11 CD 13	55–65	2,0	24	0,09	90
4	PP	200	MD 12 CD 14	55–65	2,2	22	0,08	80
5	PP	300	MD 17,4 CD 19,5	50	3,1	16	0,065	50

PP – polypropylene, MD – longitudinal, CD – transversal

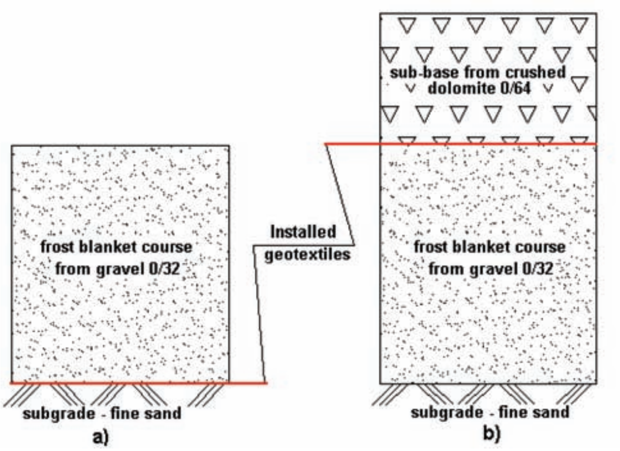

Fig 3. The levels of geotextile installation: a) geotextile separating the subgrade and the frost blanket course, b) geotextile separating the frost blanket course and the sub-base

For compaction there was a vibratory roller of 12 t 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 there was a sub-base of crushed dolomite 0/56 with the thickness of 27 cm constructed. The largest part of crushed stones there reached 50 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 ever 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 modulus of the layers are reached, there were excavation and sampling of geotextiles carried out. To avoid damaging the test material, all works during excavation were performed manually.

6. Results of experimental research and their analysis

Damages of the geotextile and their number on already constructed test sections were assessed having excavated the test materials. In the test sections there were the following geotextile damages identified: general abrasion, cuts and puncturing. General abrasion was identified exclusively on the geotextile whose mass per unit area was 130 g/m². It was installed in the first section between the subgrade and the frost blanket course. Cuts were identified in most tested geotextiles. However, their number and size is moderate. The most frequent damage was puncturing. Samples of puncturing are given in Figs 4 and 5. Hence the number of punctures and the total area of puncturing (cm²) per square metre of the material (m²) have been selected as a basis for comparison (tertium comparationis).

In the geotextiles installed between the subgrade and the frost blanket course and excavated from the first section there were the following damages (punctures) identified:

- The geotextile whose mass per unit area was 110 g/m² had visually easily identifiable indentations and approx two punctures per m², their total area covering up to 2,5 cm²/m²;
- The geotextile whose mass per unit area was 130 g/m² had approx one puncture per m², its total area covering up to 2,2 cm²/m². There was also general abrasion noticed;
- The geotextile whose mass per unit area was 200 g/m² had insignificant indentations; no puncturing was identified;
- The geotextile whose mass per unit area was 300 g/ m² had neither indentations nor puncturing.

The results obtained from the first test section are in Fig 6.

In the geotextiles installed between the frost blanket course and the pavement sub-base and excavated from the second section there were the following damages identified:

- In all tested geotextiles there were indentations of large particles of dolomite.
- The geotextile whose mass per unit area was 110 g/m^2 had two punctures of up to 2 cm^2 per m^2 on average; their total area covering up to 3,5 cm^2/m^2.
- The geotextile whose mass per unit area 130 g/m^2 had 2 punctures per m^2; their total area covering up to 2 cm^2/m^2.
- The geotextile whose mass per unit area was 170 g/m^2 had several single punctures of up to 1 cm^2. The total area of puncturing was up to 1 cm^2/m^2.
- The geotextile whose mass per unit area was 200 g/m^2 had the total area of puncturing within 0,7 cm^2/m^2.
- The geotextile which mass per unit area was 300 g/m^2 had insignificant indentations and no puncturing.

The results obtained from the second test section are given in Fig 7.

Fig 4. Samples of geotextile damages (puncturing) whose mass per unit area is 110 g/m^2 laid between the subgrade and the frost blanket course

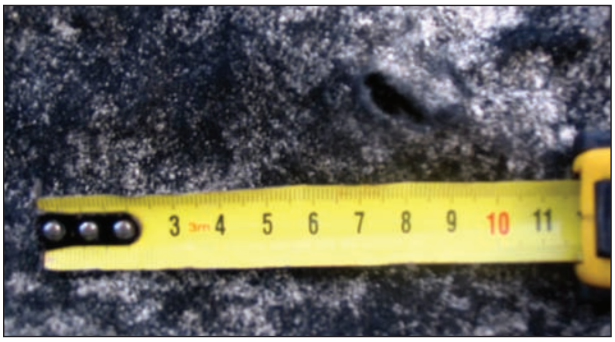

Fig 5. Samples of geotextile damages (puncturing) whose mass per unit area is 130 g/m^2 (laid between the frost blanket course and the sub-base of the pavement)

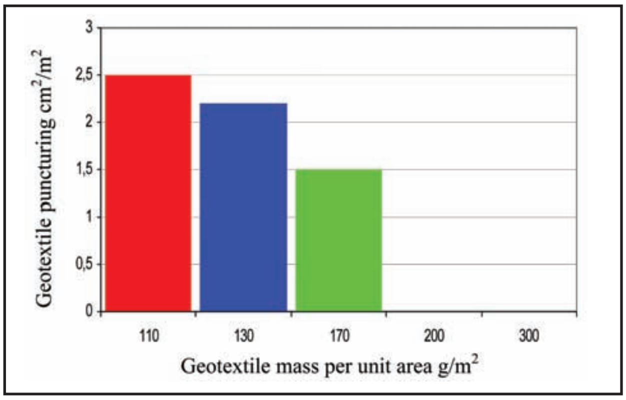

Fig 6. The total area of geotextile punctures cm^2 per m^2 in the first test section

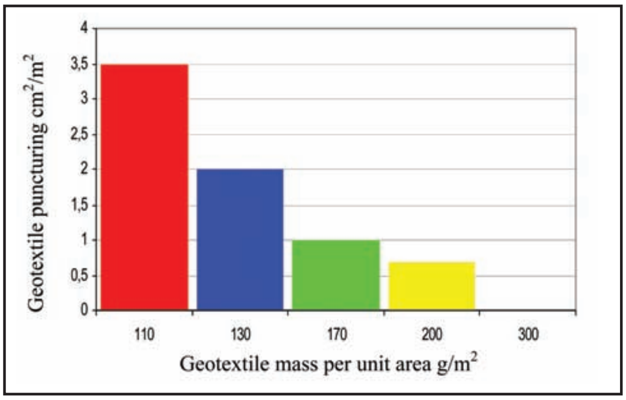

Fig 7. The total area of geotextile punctures cm^2 per m^2 in the second test section

Fig 8. The performance of the road pavement layer separation by geotextile after uncovering the layers of the first test section of the pavement structure – the separation of the subgrade and the frost blanket course

Fig 9. The performance of the road pavement layer separation by geotextile after uncovering the layers of the second test section of the pavement structure – the separation of the frost blanket course and the sub-base

The results of investigation indicate that all geotextile damages having occurred during the installation of road pavement layers over the geotextile had no significant impact on the pavement structure layer separation, one of major functions of geotextile. It can be easily noticed in Figs 8 and 9.

7. Conclusions and recommendations

Having analysed the systems of selecting geotextiles for separating the layers of road pavement structure and having assessed the results of experimental research, the following conclusions can be made:

1. All geotextiles selected for testing, including the weakest, fully performed the function of road pavement layer separation. The damages that occurred in the course of its installation did not have any significant impact on the fulfilment of the function.
2. 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.
3. NorGeoSpec, the system for selecting separation geotextiles, has been adopted for Scandinavian countries and can be successfully implemented for the construction of road pavement layers when the aggregate consists of large particles ($d_{max} \geq$ 500 mm). However, the system is not sufficiently precise if the composition of particles of crushed gravel used for the installation of different pavement layers is similar but the physical characteristics of aggregate are different.
4. Lithuania is still using a system of geotextile selection which specifies exclusively the mass per unit area and the static puncture strength. However, other researchers have proved a direct dependency between the two characteristics. They are not sufficient to be able to fully assess the quality of separation geotextiles.
5. The NorGeoSpec includes many more specifications for geotextile characteristics than other systems in Europe. The system specifies the strength characteristics of non-woven geotextiles and tolerance from the established values. The characteristics of static puncture strength and mass per unit area, which are of utmost importance for Lithuanian designers when selecting geotextiles have only tolerance values specified.
6. The system of geotextile selection used in Lithuania ensures a proper separation of pavement structure layers. However, even weaker geotextiles, which are considered within the system as too weak to perform the separation function, have fulfilled this function. Therefore the system should be updated and improved; to define the geotextile robustness classes more characteristics should be introduced. Therefore we recommend that the limits of geotextile characteristics which serve as a basis for dividing geotextiles into robustness classes should be revised.
7. To improve the existing system of geotextile selection it is important to undertake a detailed research into geotextile damages occurring in the course of geotextile installation between the pavement layers containing different materials. Further research should focus on the assessment of creep of geotextiles used for separation and its dependency on road structure weight and the dynamic impact of external loading; it should also assess the durability of geotextiles.

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