



Rolandas OGINSKAS

**RUTTING ASSOCIATED WITH SHEAR
DEFORMATIONS ON ASPHALT CONCRETE ROAD
PAVEMENTS REDUCTION BY MEANS OF
GEOSYNTHETIC MATERIALS**

**Summary of Doctoral Dissertation
Technological Sciences, Civil Engineering (02T)**

1322



Vilnius LEIDYKLA TECHNICA 2006

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

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Scientific Supervisor

Prof Dr Alfredas LAURINAVIČIUS (Vilnius Gediminas Technical University, Technological Sciences, Civil Engineering – 02T)

The dissertation is being defended at the Council of Scientific Field of Civil Engineering at Vilnius Gediminas Technical University:

Chairman

Prof Dr Habil Romualdas MAČIULAITIS (Vilnius Gediminas Technical University, Technological Sciences, Civil Engineering – 02T)

Members:

Prof Dr Habil Edmundas Kazimieras ZAVADSKAS (Vilnius Gediminas Technical University, Technological Sciences, Civil Engineering – 02T)

Prof Dr Habil Gintaris KAKLAUSKAS (Vilnius Gediminas Technical University, Technological Sciences, Civil Engineering – 02T)

Assoc Prof Dr Vitalija RUDZKIENĖ (Mykolas Romeris University, Technological Sciences, Informatics Engineering – 07T)

Prof Dr Arvydas JUODIS (Kaunas University of Technology, Technological Sciences, Civil Engineering – 02T)

Opponents:

Prof Dr Habil Henrikas SIVILEVIČIUS (Vilnius Gediminas Technical University, Technological Sciences, Civil Engineering – 02T)

Assoc Prof Dr Virgaudas PUODŽIUKAS (The Lithuanian Road Administration under the Ministry of Transport and Communications of the Republic of Lithuania, Technological Sciences, Civil Engineering – 02T)

The dissertation will be defended at the public meeting of the Council of Scientific Field of Civil Engineering in the Senate Hall of Vilnius Gediminas Technical University at 2 p. m. on 22 January 2007.

Address: Saulėtekio al. 11, LT-10223 Vilnius, Lithuania

Tel.: +370 5 2744952, +370 5 2744956, fax +370 5 2700112;

e-mail doktor@adm.vtu.lt

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VILNIAUS GEDIMINO TECHNIKOS UNIVERSITETAS

Rolandas OGINSKAS

**PROVĖŽŲ, SUSIJUSIŲ SU ŠLYTIES DEFORMACIJOMIS
AUTOMOBILIŲ KELIŲ ASFALTBETONIO DANGOSE,
MAŽINIMAS NAUDOJANT GEOSINTETINES
MEDŽIAGAS**

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prof. dr. Alfredas LAURINAVIČIUS (Vilniaus Gedimino technikos universitetas, technologijos mokslai, statybos inžinerija – 02T).

Disertacija ginama Vilniaus Gedimino technikos universiteto Statybos inžinerijos mokslo krypties taryboje:

Pirmininkas

prof. habil. dr. Romualdas MACIULAITIS (Vilniaus Gedimino technikos universitetas, technologijos mokslai, statybos inžinerija – 02T).

Nariai:

prof. habil. dr. Edmundas Kazimieras ZAVADSKAS (Vilniaus Gedimino technikos universitetas, technologijos mokslai, statybos inžinerija – 02T),

prof. habil. dr. Gintaris KAKLAUSKAS (Vilniaus Gedimino technikos universitetas, technologijos mokslai, statybos inžinerija – 02T),

doc. dr. Vitalija RUDZKIENĖ (Mykolo Romerio universitetas, technologijos mokslai, informatikos inžinerija – 07T),

prof. dr. Arvydas JUODIS (Kauno technologijos universitetas, technologijos mokslai, statybos inžinerija – 02T).

Oponentai:

prof. habil. dr. Henrikas SIVILEVIČIUS (Vilniaus Gedimino technikos universitetas, technologijos mokslai, statybos inžinerija – 02T),

doc. dr. Virgaudas PUODŽIUKAS (Lietuvos automobilių kelių direkcija prie Susisiekimo ministerijos, technologijos mokslai, statybos inžinerija – 02T).

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Adresas: Saulėtekio al. 11, LT-10223 Vilnius, Lietuva.

Tel.: +370 5 2744952, +370 5 2744956, faksas +370 5 2700112;

el. paštas doktor@adm.vtu.lt

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1. General Characteristic of the Dissertation

Topicality of the problem. Lithuania is located between West and East, North and South and is considered a transit country. Lithuania transport sector comprises part of transeuropean transport system. The development of global economy as well as geographical location has predetermined that the country has become a transit country in the Baltic sea area. Lithuania together with other neighboring EU countries has got sufficiently developed transport infrastructure. Lithuania network of motor ways is one of the mostly developed between Baltic and North European countries and it is possible to state that it is satisfactory for the country. Transport has a direct influence on to the economical development of the country because of international and domestic trading and tourism. In Lithuania the sector of transport makes about 10 % of the total GDP but in other EU countries this part comprises only 6–8 %.

In Lithuania, as in all the world, the most widely applied are the asphalt road pavements installed on the roads with the most intensive traffic flow of cars and the most intensive traffic of light and heavy trucks. Therefore, under the influence of car traffic loads and environmental factors directly onto the road pavements of asphalt concrete there is a tendency of various disturbances to be formed. It is the most unpredictable and the most difficult fight to keep with it because it is connected with the appearance of rutting due to the shear deformations. The problem of causing rutting exists as long as the asphalt pavements however in the recent years together with the increase of car traffic flows this problem has become more and more relevant. The mentioned above deformations not only increase the maintenance costs of roads but the expenses of road users as well and in cases of wet pavements it might become the cause of serious fatal traffic accidents.

The possibilities of rutting reduction are aggravated by the fact that asphalt concrete is the material which changes its characteristics in accordance with the temperature of the environment and within rather great boundaries. The climate of Lithuania is characterized by the fact that there are hot summers and cold winters. The asphalt concrete satisfactory to be applied in cold season of the year is not good for the period when high temperatures prevail and then asphalt concrete resistant to deformations connected with high temperatures is very quickly destroyed in cases of low and minus temperatures. To compile and perfect asphalt concrete mixtures which could be able to function reliably both in low and high temperatures is to provide the change of the components of the mixture of asphalt concrete as well as their ratio. But as the experience showed in practice these measures reach the results far from the expected ones. One of

the supplementary decisions on the design is to reinforce the rutting by means of geosynthetic materials placing them between the layers of asphalt concrete.

Reduction of rutting on the pavements of asphalt concrete by applying geosynthetic materials is not considered a new phenomenon: the method has been widely applied in Lithuania and globally in recent years, but the reliability of these materials was only on theoretical level. There haven't been carried out any extensive experimental study proving the influence of geosynthetic materials on the formation of rutting, besides that there hasn't been analyzed the way these materials influence reological characteristics of asphalt concrete determining disturbances.

The objective and the task of work. To analyze the main characteristics of asphalt concrete influencing shear deformation, appearance and increase of rutting connected with them, analyze the influence of geosynthetic material characteristics onto asphalt concrete functioning.

Tasks:

- To determine the main causes influencing the appearance of shear deformations and increase in the asphalt concrete road pavements;
- To analyze the methods that have already been applied for reduction of these deformations;
- Review the usage of geosynthetic materials in the global and Lithuanian experience in road building;
- To describe the influence of geosynthetic materials on shear deformations and on the characteristics of asphalt concrete;
- To submit the expected influence on the mentioned above deformations and reological characteristics of asphalt concrete;
- To carry out experimental tests on the pavements of asphalt concrete reinforced by geosynthetic materials and present the analysis of data and evaluation received from the research;
- To present the possibilities of the received results of the research for the rutting calculation methods and practical usage;
- To calculate the economic effect after having applied them in practice.

Scientific novelty

- Research of asphalt concrete covers reinforced by geosynthetic materials (material laid between the layers of asphalt concrete);
- Influence determining of geosynthetic materials on to the characteristics of asphalt concrete and its functioning;
- Application of the obtained results in methods of rutting calculations;
- Model of implementation into practice the results obtained.

The objective of the researches and methods. The structure of the asphalt concrete is reinforced by geosynthetic materials. The methods of research are the experimental tests, the analysis of their results in using mathematical statistical methods, compiling the models of experimental calculations and their application to underline the usage of geosynthetic materials in asphalt concrete road pavements.

Approval of the results of the work. The main statements and proposals of the thesis have been presented and discussed at 7 conferences and there have been published 8 articles.

Structure and size. The dissertation contains 99 pages. There are 74 figures and 23 tables. It consists of: introduction, four parts, general conclusions and recommendations. The structure of dissertation is presented in Figure 1.

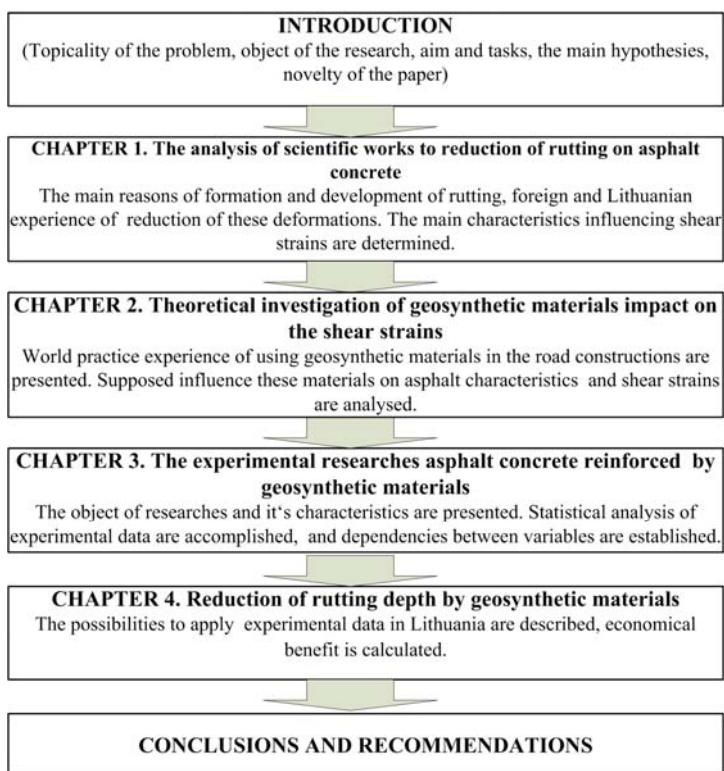


Fig 1. Structure of the dissertation

2. The Impact of Geosynthetic Material on the Shear Strains of Asphalt Concrete

Rutting in other words called the path of wheels is one of the mostly spread defects of asphalt concrete. The formation of rutting at the very initial stage of the maintenance of pavements increases by increasing the flow of traffic of heavy cargo vehicles. The rutting formed not only increases the costs of retaining of road network, but has an effect on the comfort of driving as well as causes additional risk to life safety. When driving a car the water collected in the furrows of the road or cavities is the cause of extra slippage, and in winter the water collected in the cavities and the ice formed makes the time of stop for a vehicle longer. These causes could serve the reasons for fatal car accidents. The rutting is being formed on the motor roads possessing asphalt pavement that covers about 60 % of the country highways.

The depth of maximum allowable rutting in the Republic of Lithuania is 20 mm. The results of the measurements made have indicated that at present there are 2 % of roads that exceed maximum allowable limit of rutting depths (table 1).

Rutting is an actual problem which in future might increase due to such circumstances: growth of traffic intensity, heavy cargo vehicles as well, the increased load to the axis of heavy cargo trucks. By increasing the number of repeated loads and their numerical values, asphalt concrete pavements are deformed more intensively. The deepest rutting are on the motor way VIA BALTICA, the highway that is considered to have the highest traffic intensity of heavy cargo trucks.

Table 1. Distribution of ruts dept on the motorways in the Republic of Lithuania

Rut depth	
mm	%
< 5	52,0
5-10	31,0
10-15	11,3
15-20	3,9
20-30	1,5
>30	0,3

Traditional measures used against the appearance of rutting haven't proven the expected results, consequently the status of asphalt concrete cover is getting worse, the users of highways tend to suffer higher losses. The situation

requires additional measures to be taken to be able to reduce the increase of concrete pavements, improve the functioning asphalt concrete. Reinforcing asphalt concrete by means of geosynthetic materials is one of the additional measures to reduce shear deformations causing the appearance of rutting. Both in global and Lithuanian practice of laying highways this method has been applied for a long time but up to now there haven't been any systematic research determining the efficiency of usage of these materials. To prove that in Vilnius in Ozo street the renovation works have been going on. There has been constructed an experimental site at a certain section of a street that has been, reinforced by geosynthetic materials (Fig 2). In order to determine the way the reinforcing influences the reological characteristics of asphalt concrete and deformations in asphalt concrete, there has been reinforced the layer of asphalt concrete, namely geosynthetic materials have been laid between the first and the second layers of asphalt concrete.

In order to avoid the errors of the research carried the selected section of the street for the research has been turned into new carriage way. The asphalt concrete layers on the whole testing section were of equal thickness, of the same type and of the same composition. Due to the equal characteristics of the base of the road pavement cold resistant layer and soil subgrade materials and modulus of elasticity along the whole section being investigated so it is considered that it won't be a variable value. The variation of numerical expressions of values of several dimensions will be connected with reinforcing of asphalt concrete. On the experimental section there have been used such geosynthetic materials as: geogrids – HaTelit C 40/17, Bitutex Stargrid Glu 50, Armapal MP 50 and geotextiles – Pavemat, Pavegrid G-50, Fibertex AM – 2.

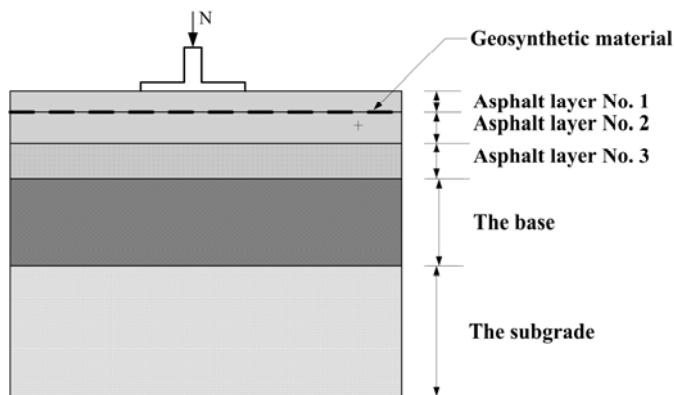


Fig 2. Construction scheme of an experimental section

In further stages these geosynthetic materials have been used after having coded them correspondingly GT1, GT2, GT3, GT4, GT5 and GT6. The order of coding does not agree with the system of the materials that have been submitted in the previous descriptions.

The structural layers and the materials used for constructing them are in conformity with the requirements of the Republic of Lithuania.

While carrying out the measurements there have been fixed the following values:

- Asphalt concrete pavement modulus of elasticity E , MPa,
- Vertical displacement r , mm,
- Permanent deformations d , mm,
- Depth of rutting PG , mm.

The characteristics have been calculated for:

- Asphalt concrete viscosity η , MPa $\times$ s.

The modulus of elasticity for asphalt concrete, vertical displacement and permanent deformations has been measured by the static load plate. The depth of rutting has been measured by a 3 m length ruler. After having made the experimental measurements by means of statistical methods there have been determined whether the obtained results are reliable. After having carried out the analysis of undertakings it is possible to state that data received at the experiments are reliable because separate totality is homogenous.

Table 2. The data of experimental measurements reinforced asphalt pavements

Experimental section number	Geosynthetics code	The modulus of elasticity E , MPa	Viscosity η , MPa $\times$ s
00	—	347	96
01	GT1	359	135
02	GT2	351	132
03	GT3	306	114
04	GT4	291	119
05	GT5	259	106
06	GT6	277	111

The data could be used for further calculations. In table 2 there are presented the results both of the modulus of elasticity and modulus of viscosity of asphalt concrete pavement. The table presents the arithmetic averages of measurements. But in separate cases the standard deviation of asphalt concrete pavement modulus of elasticity is higher than the difference between the

elasticity modulus discrepancies in separate sections. During the experiments there has been determined the bearing capacity of asphalt concrete.

The deformations have been measured by impressing asphalt concrete pavement over different loads and after having taken the load off and after the recovery of asphalt concrete finished there (Fig 3).

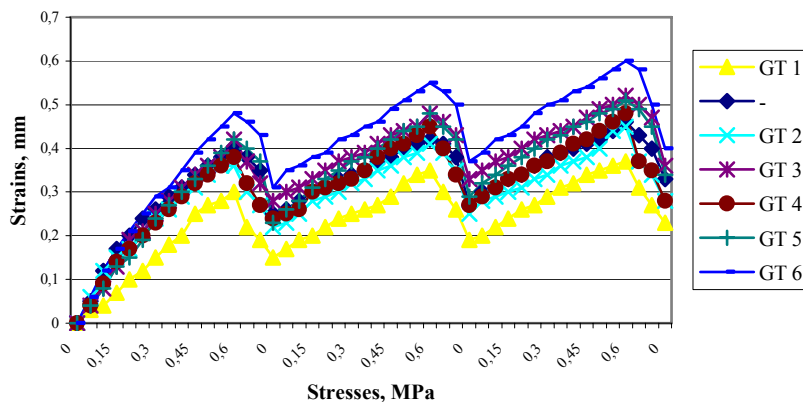


Fig 3. Bearing capacity of asphalt concrete in connection with different geosynthetic materials

It is clear from the submitted data that geosynthetic materials influence the bearing capacity of asphalt concrete pavements. The received data are very similar to those obtained at the research of elasticity of asphalt concrete. In some sections of the routes vertical sediments are lower than in the control ones and in some sections there is an opposite process. So it is possible to state that not all the materials positively influence the bearing capacity of asphalt concrete pavements.

In carrying research on the experimental sections of the street there has been measured the depth of the rutting. The first measurement was made in April, 2005, the second was made together with measurements for elasticity modulus of asphalt concrete in September 2005. The results of measurements are presented in Figure 4.

In analyzing the depth of rutting in spring there was noticed that the depth of rutting does not depend on the geosynthetic material. In some sections the depth is lower than in the control and in some even higher. This could be explained by the fact that the functioning of asphalt concrete pavement was caused by low temperatures and the rutting caused is not the consequence of the

shear stresses. These rutting are connected with compacting of asphalt concrete layer under the influence of car traffic.

In analyzing the measurements made on the depth in autumn after hot summer season the received result was different. There is noticed a striking influence of geosynthetic materials on the mentioned above deformations Especially there is a dramatic influence of geosynthetic materials, if not the final results are analyzed but the growth of rutting depth within hot time of the year.

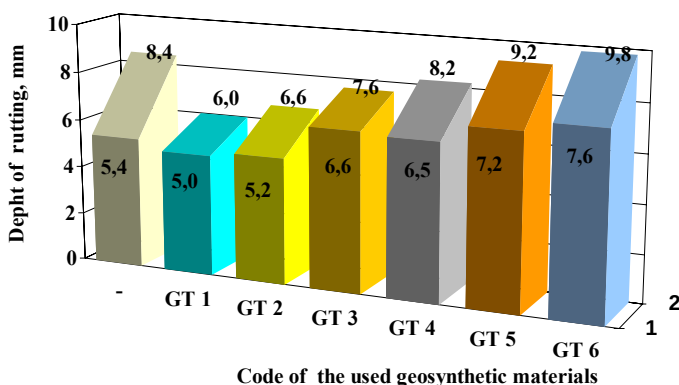


Fig 4. Measurements on rutting depth

Note: numbers 1 and 2 reflect measurements of depths in spring and in autumn in sequence

In sections with geosynthetic materials the increase of rutting depth from 1,3 to 3 times be lower than in the section under control. It is possible to state that decisively the geosynthetic materials despite their type influence the formation of rutting within the hot time of the year.

Based on the experimental research there have been derived coefficients of reinforcing, reflecting the change of elasticity modulus of asphalt concrete pavement, viscosity of asphalt concrete viscosity and depth of rutting within different seasons of the year and may be used in the methods of calculating the depth of rutting.

In carrying out calculations of economic significance there have been chosen three materials with the help of which in some reinforced sections there have been received the best results. The economic effect has been calculated (Table 2) in order to evaluate the losses of time due to reduced driving speed after the rutting have been formed as well as after having reduced the speed of a

car in case of wet pavements. Time losses have been calculated for one kilometer per highway the intensity of which corresponds to the intensity of traffic on the experimental site. Time losses in case of wet pavements are calculated based on the fact that water collecting in the rutting reduces the speed of driving for 10 km/h. From meteorological aerial station there have been received data on the number of rainy days for that location. The received results of the calculation indicate that during the year there are 18 rainy days and nights. These data have been applied in calculations presented in table 3 concerned with the final economical calculations.

Table 3. Time losses summation due to reduced speed of driving in experimental section in Vilnius City

	GT1	GT2	GT3
Time losses caused by reducing speed of driving on the non reinforced highway section comparing it with the reinforced one in Lt	41929	24238	11568
Time losses caused reducing speed of driving on wet pavement, due to non reinforced highway section comparing with reinforced one in case of road pavement in Lt	7628	7967	8215
Total per year	49557	32205	19783
Additional costs on the building of the pavement of highway (price of geosynthetic materials)	105000	99000	103500

Additional costs for installation of the opening are the average prices of geosynthetic materials. In this work there haven't been calculated the costs related with highway maintenance and repair. Because experimental investigations reflect one year of maintenance of the pavements of roads so it is very difficult to foresee the way the rutting are going to develop in further maintenance. The mentioned above economic characteristics are worth to be calculated only if we have the data received after long observations and research.

The influence of the depth of rutting to the number of accidents in the Republic of Lithuania hasn't been investigated that is why there haven't been carried out economical calculations of the losses suffered and connected with the rutting.

In order to carry out the mentioned above calculations it is necessary to make integrated research, determining the number of accidents due to rutting being formed.

General Conclusions and Recommendations

1. The main reason of rutting forming is shear stresses formation in the upper layers of the asphalt concrete pavements of the highway caused by traffic flow loads. The increase of rutting due to mentioned above stresses is increasing in the periods when the pavement temperature is up to 35 °C and asphalt concrete gradually loses its capacity to resist shear stresses. The appeared rutting increases the costs of road users and roads maintenance and in case of wet or icy pavement of the roads it might become the cause of fatal accidents. The major methods for reducing the depths of rutting in Lithuania and in other countries are targeted towards the increase the strength of asphalt concrete towards such stresses. To achieve such goals there are being investigated new compositions of the mixtures for asphalt concrete, the ratio of the constituent materials is changed by modified binding materials used. But as the practice indicates the mentioned above measures not always present the best expected results.

2. The carried out theoretical investigation indicated that geosynthetic materials are used for shear deformations connected with rutting but their usage in Lithuania and world wide is not based on scientific research or experience of highway maintenance. The separate observations carried haven't made the motivation enough for the usage of these materials.

3. After having investigated the research of other scientists connected with the usage of geosynthetic materials for the structures of road pavements there has been determined that the influence of geosynthetic materials to the characteristics of asphalt concrete and depth of rutting will be connected with the coefficients of reinforcing. The mentioned above coefficients reflect the changes of these parameters and values determined by the influence of geosynthetic materials.

4. The analysis of the results of the research carried out on the section of experimental street site approved that in using geosynthetic materials the depth of rutting decreases. By using these materials the viscosity of the asphalt concrete the viscosity which is the main characteristics determining shear deformations increases from 1,1 to 1,4 times. The rutting formed in the hot season of the year in the sections of reinforced by geosynthetic materials is from 1,4 to 3,0 times lower than in the section in which there have been used

any geosynthetic materials. The increase of rutting in cold seasons (when temperature of pavement till 35 °C) is not influenced by geosynthetic materials.

5. Based on research and guided by the carried out calculations of economic profit there have been compiled the following priorities of geosynthetic materials usage: geotextiles are not good for reinforcing of asphalt concrete. To fight against the shear deformations we propose to use geogrids codes coded by the codes GT1 and GT2. After having calculated the ratio of usefulness and costs (respectively 2,5 for material GT1 and 1,7 for material GT2) and the average norm of return (proportionally 33,1 % for material GT1 and 17,32 % for material GT2) the economically best option is received when for reinforcing asphalt concrete is used geonetwork GT1.

6. Based on the results of theoretical research and experimental one there have been determined the main characteristics (tensile strength, elongation at break, softening point), which have to satisfy geosynthetic materials meant to be used for reducing the rutting.

7. There have been compiled the model of geosynthetic materials implementation which may be used in implementing geosynthetic materials in road building. The model will have a direct positive influence on the usage of these materials on the asphalt concrete road pavements of the Republic of Lithuania. After having applied the model there will be avoided financial unnecessary expenses and after having presented the normative literature there will be ensured the goal and quality assurance in usage of these materials.

Published works on the topic of the dissertation

In the acknowledged editions

1. Oginskas, R.; Laurinavičius, A. Impact of Various Factors on the Elasticity Characteristics of Asphalt Concrete. In the Proceedings of the 6-th International Conference "Environmental Engineering". Vilnius 2005. Vol. II, p. 753–758. ISBN 9986–05–851–1.

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4. Povilaitene, I; Oginskas, R. Geosynthetic materials in road and railways constructions. *Building materials*, 2005, No. 10, p. 74-75. ISSN 0585-430X. (In Russian).

In the other editions

5. Oginskas, R; Čygas, D; Laurinavičius. A. Experience applications of geosynthetic materials in Lithuania, for improvement of highways quality. In the Proceedings of the 3-th International Conference “Problems of quality and operation of vehicles” Penza, Russia, 2004. Vol. I. p. 380-385. ISBN 5-9282-0320-9. (In Russian).

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7. Oginskas, R. Investigation of Roads Reinforced Asphalt Concrete Coverings in Lithuania. In the proceedings of 8-th conference of young researchers “Lithuania without Science – Lithuania without Future”. Vilnius, 2005, p. 90-95. ISBN 9986-05-849-X. (In Lithuanian).

8. Oginskas, R.; Laurinavičius, A. Possibilities of Geosynthetic Materials Usage in Environmental Engineering. In the proceedings of 6-th conference of young researchers “Lithuania without science – Lithuania without future”. Vilnius, 2003, p. 121-129. ISBN 05-645-4. (In Lithuanian).

About the author

Rolandas Oginskas was born in January 19, 1976 in Ignalina.

In 1998 graduated from Vilnius Gediminas Technical University and was awarded the Bachelor Degree of Civil Engineering. In 2001 he received the Master Degree in Civil Engineering. Since 1999 he worked for Vilnius Gediminas Technical University in the Department of Roads. In 2002-2006 he was accepted as a doctoral student (PhD) at Vilnius Gediminas Technical University. In 2004 he studied at the Department of Technology and Society of Lund University (Sweden).

PROVĖŽŲ, SUSIJUSIŲ SU ŠLYTIES DEFORMACIJOMIS AUTOMOBILIŲ KELIŲ ASFALTBETONIO DANGOSE MAŽINIMAS, NAUDOJANT GEOSINTETINES MEDŽIAGAS

Darbo aktualumas. Lietuva yra tranzito valstybė tarp Vakarų ir Rytų, Šiaurės ir Pietų. Lietuvos transporto sektorius yra transeuropinio transporto dalis. Pasaulinė ekonomikos plėtra ir Lietuvos geografinė padėtis sudarė sąlygas mūsų šaliai Baltijos jūros regione tapti tranzito valstybe. Lietuva, kaip ir kitos kaimyninės ES šalys, turi gerai išplėtotą transporto infrastruktūrą. Lietuvos automobilių kelių tinklas yra vienas labiausiai išplėtotų Baltijos ir Šiaurės Europos šalyse ir pakankamas. Dėl tarptautinės ir vidaus prekybos bei turizmo šalies ekonominiam augimui transportas turi tiesioginę įtaką. Lietuvoje transporto sektorius sukuria apie 10 % viso šalies BVP, o tuo tarpu kitose ES šalyse ši dalis tesiekia 6–8 %.

Lietuvoje, kaip ir visame pasaulyje, labiausiai paplitusios yra asfaltbetonio dangos, dengiančios kelius, kuriuose vyksta intensyvus lengvųjų ir krovininių automobilių eismas. Veikiant automobilių eismo apkrovoms ir aplinkos veiksniams, asfaltbetonio dangose formuojasi įvairios pažaidos, tarp kurių sunkiausiai prognozuojamos ir sudėtingiausiai mažinamos yra provėžos, susijusios su šlyties deformacijomis. Įrengiant ir eksploatuojant asfaltbetonio dangas, provėžų susidarymo problema egzistuoja visuomet, tačiau tik pastaraisiais metais, sparčiai intensyvėjant automobilių eismui, ši problema darosi vis aktualesnė. Provėžos ne tik padidina kelių eksploatavimo bei kelių naudotojų išlaidas, be to, kai yra šlapios dangos, provėžos gali tapti skaudžių eismo įvykių priežastimi.

Provėžų mažinimo galimybes apsunkina tai, kad asfaltbetonis yra medžiaga, keičianti savo savybes ganėtinai plačiame aplinkos temperatūros spektre. Be kita ko, Lietuvos klimatas ypatingas tuo, kad pasižymi karštomis vasaromis ir šaltomis žiemomis. Asfaltbetonis, tinkantis šaltajam metų periodui, visiškai netinka periodui, kai vyrauja aukštos temperatūros. Sukurti bei tobulinti asfaltbetonio mišinius, kurie kelio dangoje patikimai funkcionuotų vyraujant tiek žemoms, tiek aukštoms temperatūroms, stengiamasi keičiant asfaltbetonio mišinio sudėties komponentus ir jų santykį. Tačiau, kaip parodė praktika, šios priemonės ne visada duoda laukiamus rezultatus. Taigi vienas iš papildomų konstrukcinių sprendimų, skirtų provėžoms mažinti, yra asfaltbetonio armavimas geosintetinėmis medžiagomis, jas paklojus tarp asfaltbetonio dangos sluoksnių.

Provėžų mažinimas asfaltbetonio dangose naudojant geosintetines medžiagas yra nenaujas reiškinys: pastaraisiais metais šis būdas dažnai taikomas tiek pasaulyje, tiek Lietuvoje. Tačiau šių medžiagų naudojimo motyvai iki šiol tik teorinio lygmens, nes nebuvo atlikta eksperimentinių tyrimų, kurie būtų išsamesni ir įrodantys geosintetinių medžiagų įtaką provėžoms mažinti asfaltbetonio dangose. Taip pat nebuvo ištirta, kaip šios medžiagos veikia reologines asfaltbetonio savybes, sukeliančias šias pažeidas.

Darbo tikslas ir uždaviniai. Ištirti pagrindines asfaltbetonio charakteristikas įtakojančias šlyties deformacijas ir provėžų susijusių su jomis atsiradimą ir didėjimą, ištirti geosintetinių medžiagų įtaką šioms savybėms ir asfaltbetonio dangos funkcionavimui.

Uždaviniai:

- ištirti jau taikomus metodus provėžoms mažinti ir nustatyti pagrindines asfaltbetonio savybes, nulemiančias šių deformacijų atsiradimą ir plėtrą;
- apžvelgti geosintetinių medžiagų naudojimą pasaulinėje ir Lietuvos kelių tiesyboje;
- apibūdinti geosintetinių medžiagų įtaką šlyties deformacijoms ir asfaltbetonio reologinėms savybėms;
- ištirti geosintetinėmis medžiagomis armuotas asfaltbetonio dangas, pateikti tyrimo duomenų analizę ir vertinimą;
- pateikti tyrimų rezultatų taikymo galimybes provėžų skaičiavimo metodams ir praktiniam naudojimui;
- apskaičiuoti šių medžiagų taikymo praktikoje ekonominę naudą.

Darbo mokslinis naujumas

- Geosintetinėmis medžiagomis armuotų asfaltbetonio dangų tyrimai (medžiagos paklotos tarp asfaltbetonio sluoksnių);
- Geosintetinių medžiagų įtakos, asfaltbetonio charakteristikoms ir jo funkcionavimui, nustatymas;
- Gautų tyrimų rezultatų pritaikymas provėžų skaičiavimo metuose;
- Gautų tyrimų rezultatų įdiegimo į praktiką modelis Lietuvos sąlygoms.

Tyrimo objektas ir metodai. Geosintetinėmis medžiagomis armuota asfaltbetonio dangos konstrukcija. Tyrimo metodai – eksperimentiniai tyrimai, jų rezultatų analizė naudojant matematinės statistikos metodus, eksperimentinių skaičiavimo modelių sudarymas bei jų taikymas geosintetinių medžiagų panaudojimui asfaltbetonio dangose pagrįsti.

Darbo rezultatų aprobavimas. Pagrindiniai disertacijos teiginiai ir siūlymai buvo pristatyti ir aptarti 7 konferencijose ir išspausdinti 9 straipsniai.

Darbo apimtis ir struktūra. Disertacijos apimtis 99 puslapiai. Disertacijoje yra 74 paveikslai ir 23 lentelės. Disertaciją sudaro: įvadas,

keturios dalys, bendrosios išvados ir rekomendacijos, literatūros šaltinių sąrašas ir autoriaus publikacijų sąrašas.

Pirmame skyriuje apžvelgti mokslo darbai, skirti provėžoms asfaltbetonio dangose mažinti. Nustatyti pagrindiniai veiksniai, nulemiantys šių deformacijų atsiradimą ir vystimąsi, ir pagrindinės asfaltbetonio charakteristikos, nulemiančios šias pažaidas.

Antras skyrius skirtas geosintetinių medžiagų naudojimui asfaltbetonio dangose. Apžvelgta pasaulio ir Lietuvos patirtis, pateikta numatoma šių medžiagų įtaka šlyties deformacijoms ir asfaltbetonio reologinėms charakteristikoms.

Trečias skyrius skirtas geosintetinėmis medžiagomis armuotų asfaltbetonio dangų eksperimentiniams tyrimams. Aprašytas tiriamasis objektas, atlikta gautų tyrimų rezultatų analizė, išvestos regresinės priklausomybės.

Ketvirtame skyriuje pateiktos gautų tyrimų rezultatų taikymo galimybės Lietuvoje. Atlikti ekonominiai skaičiavimai, sukurtas šių medžiagų įdiegimo modelis Lietuvos sąlygoms.

Galutinės išvados ir rekomendacijos

1. Nuo automobilių eismo apkrovų susiformavę šlyties įtempiai viršutiniuosiuose asfaltbetonio dangų sluoksniuose yra pagrindinė provėžų susidarymo priežastis. Provėžų didėjimas suintensyvėja tais periodais, kai dangos temperatūra yra aukštesnė kaip $+35^{\circ}\text{C}$ ir kai asfaltbetonis laipsniškai praranda savo gebėjimą priešintis šlyties įtempiams. Atsiradusios provėžos didina kelių naudotojų ir kelių eksploatavimo išlaidas, o kai danga šlapia ar apledėjusi, provėžos gali tapti skaudžių eismo įvykių priežastimi. Teoriniais tyrimais nustatyta, kad dauguma provėžų gylio mažinimo metodų Lietuvoje ir pasaulyje orientuoti į asfaltbetonio atsparumo šlyties įtempiams didinimą. Šiam tikslui projektuojami nauji asfaltbetonio mišiniai, keičiamas jų sudėties komponentų santykis, naudojamos modifikuotos rišamosios medžiagos. Tačiau, kaip rodo praktika, šios priemonės ne visada duoda laukiamus rezultatus.

2. Teoriniais tyrimais nustatyta, kad geosintetinės medžiagos naudotinos mažinti provėžoms, susijusioms su šlyties deformacijomis, tačiau jų naudojimas Lietuvoje ir pasaulyje nėra paremtas mokslo tyrimais ar kelių eksploatavimo patirtimi. Pavieniai stebėjimai nesuteikia pakankamai prielaidų šias medžiagas naudoti tiesiant ir rekonstruojant kelius.

3. Kitų mokslininkų geosintetinių medžiagų naudojimo dangų konstrukcijose tyrimais įrodyta, kad šių medžiagų įtaka asfaltbetonio reologinėms savybėms ir provėžų gyliui susijusi su armavimo koeficientais.

Armavimo koeficientai atspindi šių savybių ir provėžų susidarymo pokyčius, nulemtus geosintetinių medžiagų poveikio.

4. Eksperimentinių ruožų tyrimais nustatyta, kad naudojant geosintetines medžiagas provėžų gylis mažėja. Provėžos, susidariusios karštuju metų periodu dangos ruožuose, armuotose geosintetinėmis medžiagomis, yra nuo 1,4 iki 3,0 karto mažesnės, kaip ruožuose, kuriuose nenaudotos jokios geosintetinės medžiagos. Be to, naudojant šias medžiagas, asfaltbetonio klampumas didėja nuo 1,1 iki 1,4 karto. Šaltuoju metų periodu, kai dangos temperatūra nesiekia $+35^{\circ}\text{C}$, vienodos provėžos susidaro geosintetika armuotuose ruožuose ir ruožuose be geosintetinių medžiagų.

5. Eksperimentiniais tyrimais ir ekonominės naudos skaičiavimais nustatytas toks geosintetinių medžiagų naudojimo prioritetas: asfaltbetonį armuoti geotekstile neefektinga. Šlyties deformacijoms mažinti siūloma naudoti GT1 ir GT2 kodų geotinklus. Apskaičiavus naudos ir kaštų santykį (atitinkamai 2,5 – GT1 medžiagai ir 1,7 – GT2 medžiagai) ir vidinę gražos normą (atitinkamai 33,1 % – GT1 medžiagai ir 17,32 % – GT2 medžiagai), ekonomiškai geriausias variantas asfaltbetonį armuoti geotinklu GT1.

6. Teoriniais ir eksperimentiniais tyrimais apibūdintos pagrindinės savybės (medžiagos stiprumas tempiant, maksimalus pailgėjimas trūkio metu, medžiagos lydymosi temperatūra), kurias turi tenkinti geosintetinės medžiagos, skirtos provėžoms mažinti.

7. Sukurtasis geosintetinių medžiagų diegimo modelis gali būti taikomas ne tik klojant Lietuvos Respublikos automobilių kelių asfaltbetonio dangas, bet ir įrengiant kitus kelio elementus. Pritaikius šį modelį būtų išvengta nereikalingų finansinių išlaidų, o parengus norminius dokumentus, būtų užtikrintas šių medžiagų naudojimo tikslingumas ir garantuota kokybės kontrolė.

Trumpos žinios apie autorių

Rolandas Oginskas gimė 1976 metų sausio 19 d. Ignalinoje.

1998 m. baigė Vilniaus Gedimino technikos universitetą įgydamas civilinės inžinerijos bakalauro laipsnį. 2001 įgijo civilinės inžinerijos mokslo magistro laipsnį. Nuo 1999 metų dirba Vilniaus Gedimino technikos universitete, kelių katedroje. 2002–2006 Vilniaus Gedimino technikos universiteto doktorantas. 2004 metais stažavosi Lundo universitete (Švedija)

Rolandas Oginskas

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ASPHALT CONCRETE ROAD PAVEMENTS REDUCTION BY
MEANS OF GEOSYNTHETIC MATERIALS**

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Technological Sciences, Civil Engineering (02T)**

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NAUDOJANT GEOSINTETINES MEDŽIAGAS**

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