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RESEARCH OF EXPERIMENTAL ROAD PAVEMENT STRUCTURES

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ABSTRACT

The rapid growth of heavy traffic, the increase in the standard axle load make scientists to look forward for new durable road constructing materials and their mixes. The continuously increasing need for the strengthening of road pavement structures induces to use new road reconstruction technologies, to search for new methods in constructing pavement structural layers and investigate pavement structures under real conditions. The article presents construction of experimental pavement structures for the first time in the road history of Lithuania. The article also describes the installation process of stress and strain transducers in different layers of experimental pavement structures and initial results of stress and strain measurements. Stress and strain measurements will be carried out each time after passed 20 000 ESAL's calculated to 100 KN.

KEYWORDS

Road pavement structure, experimental section, stress, strain, transducer, road constructing material.

INTRODUCTION

The rapid growth of heavy traffic on the motor roads of Lithuania, the increase in the standard axle load, plastic deformations (ruts, waves) in the wearing courses of road pavement and other defects (cracks, alligator cracking, potholes) induce the scientists to look for new durable road building materials and their mixes [1, 2]. A fast increase in the prices of road building materials create a necessity to look for new cheaper possibilities of using local materials and their mixes in building, reconstructing and repairing roads and streets [3]. In order to increase the strength of road pavement structures and their separate layers the requirements for road building materials and their mixes are getting more and more strict [4], geosynthetic materials are installed between the pavement structural layers [5–7]. Various laboratory investigations showed that the mentioned measures are efficient and gave a positive effect. However, Lithuania still lacks experimental investigations to model the performance of new materials, their mixes and the combinations of separate pavement structural layers under real conditions.

The scientists of other countries made an attempt to determine the performance of road pavement structures under real conditions by constructing and testing them in special test polygons. One of the largest test polygons of road pavement structures was established in 1989 in the French Central Laboratory of Roads and Bridges [8]. Here the scientists of various European countries tested and evaluated the performance of three different pavement structures under the effect of different loads, the readings of the transducers of stresses, pressure, temperature and moisture were recorded, the tendencies for defects' development in the wearing courses were identified, etc.

In 2006–2007 the test of road pavement structures was carried out in the University of Maine by using six different transducers [9]. The transducers were installed in different pavement structural layers to determine seasonal effects on the structural strength of road pavement.

Within the framework of the SPENS project (Sustainable Pavements for European New Member States) WP 4 (Work Package 4), materials and pavement layers appropriate for road upgrading, considering the conditions in New Member States are evaluating [10]. Project focused on modified bitumen as asphalt binders and high modulus asphalt mixtures.

In USA the investigations of experimental pavement structures were carried out in order to find out the change in the strength of separate layers during freeze – thaw periods [11]. The Falling Weight Deflectometer (FWD) was used to measure pavement structures in different periods of the year and to define the resistance of each pavement layer to frost effect.

CONSTRUCTION OBJECTIVES OF EXPERIMENTAL ROAD PAVEMENT STRUCTURES

The structural strength of road pavements depends directly on the strength of subgrade, thickness and composition of pavement structure. The strength of pavement structures of the same thickness (of the same class of pavement structure), but erected from different materials have significantly differ strength and durability. The use of high-strength or high quality materials (for example, granite, modified bitumen, etc.) for the construction of sub-base and pavement layers increases the costs of road construction. Therefore, there is a continuous search of techniques to construct the pavement structure of the required strength and durability either using the local cheaper road building materials or the expensive high-strength materials to achieve the largest possible economic effect.

This research is carried out to confirm or deny suggestions made after a lot of laboratory researches of use of road constructing materials and to seek for the most suitable and economically effective pavement structures.

The location in Pagiriai settlement was selected for the construction of a test section. This location fulfil all the conditions required for such an experiment: it has a sufficient heavy traffic volume, lies in an open terrain, has no horizontal plan curves or vertical curves in longitudinal section and could be distinguished by the same irrigation conditions within the whole route of the road section. The cross-section parameters of a test section of experimental pavement structures meet the road category III and class III of pavement structure according to the Regulation of Motor Roads STR 2.06.03:2001. A test section, the total length of which is 710 m, consists of 24 segments of the same length (30 m) and 1 segment – 20 m long. In each segment the pavement structure of different composition was constructed. Three 30 m long segments are of the same pavement structure with the different type of geosynthetic materials installed in asphalt layers and sub-base. As the main (base) structure for the investigation purposes the most widely used pavement structure was assumed. The cross-section of the base pavement structure and the required values of static deformation modulus of the sub-base and subgrade are given in (Figure 1).

Other pavement structures were selected by varying the materials of all structural pavement layers compared to the base structure.

For the frost blanket course sand 0/11 and 0/4 were used.

For the base layer were used:
- crushed dolomite mix 0/56;
- crushed granite mix 0/56;
- crushed granite and sand mix 0/32;
- crushed fine sand mix 0/32;
- gravel and sand mix 0/32;
- aggregate – milled asphalt concrete.

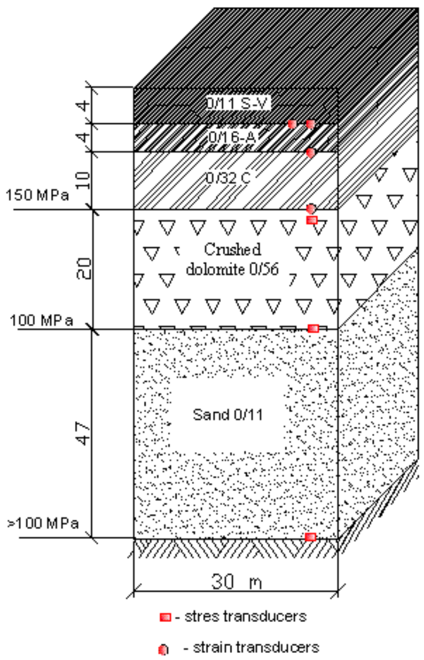

Figure 1. The base structure of experimental pavements and positions of transducers

For asphalt base course were used:
- 0/32 C crushed dolomite;
- 0/32 C crushed gravel;
- 0/32 C crushed dolomite and crushed gravel.

For asphalt binder course were used:
- 0/16 A crushed dolomite;
- 0/16 A crushed dolomite with PMB;
- 0/16 A crushed granite and crushed dolomite;
- 0/16 A crushed granite and crushed gravel;
- 0/16 A crushed dolomite and crushed gravel;
- 0/16 A crushed granite and sand;
- 0/16 A crushed granite;
- 0/16 A crushed gravel.

For asphalt wearing course were used:
- 0/11 S-V crushed granite;
- 0/11 S-M;
- 0/11 S-M with PMB;
- Confalt.

The aims of constructing a test section were as follows:
- to analyze and evaluate the design methods of road pavement structures under Lithuanian conditions;
- to evaluate suitability of materials suggested for the construction of road pavement structures;
- to determine the impact of heavy vehicles on pavement structures.

The following investigations will be carried out to reach defined aims:
1. taking of subgrade soil from each separate segment, determination of soil type;
2. during the construction of pavement structure taking of materials from sub-base layer and frost blanket course from each separate segment, determination of grading and filtration coefficient;
3. taking of asphalt concrete specimens from each pavement layer to determine mechanical properties;
4. taking of asphalt concrete cores, determination of compaction, type of mixtures, physical and mechanical properties of all asphalt concrete layers in each separate segment;
5. measuring of deformation modulus of subgrade, frost blanket course and sub-base layer in each separate segment by static beam;
6. measuring of evenness of the asphalt concrete wearing course in each separate segment;

7. measuring of the asphalt concrete wearing course in each separate segment by the Falling Weight Deflectometer (FWD);
8. measuring of the asphalt concrete wearing course in each separate segment by the Light Weight Deflectometer (LWD);
9. measuring of the cross-section, longitudinal section and texture of each separate segment;
10. measuring of skid resistance of asphalt concrete wearing course in each separate segment;
11. measuring of stresses and strains in the structural layers of pavement of each separate segment each time after the passage of 20 000 ESAL's calculated to 100 KN.

Duration of investigations will depend on pavement condition and the passage of equivalent axles of heavy vehicles but not less than 5 years.

INVESTIGATION METHODS AND MEASURING EQUIPMENT

The strength of road pavement and its separate structural layers in Lithuania is regulated by a static deformation modulus. Most frequently deformation modulus is determined by non-destructive static and dynamic methods. In static method deformation modulus is determined using the Benkelman Beam (for flexible pavements) and static press (for sub-base layers from unbound materials). In dynamic method the following equipment are used: light dynamic device (for sub-base layers from unbound materials) and Falling Weight Deflectometer (for all pavement structural layers). When taking measurements by dynamic devices a load pulse is imparted on the pavement surface. The load is produced by dropping a large weight and transmitted to the pavement through a circular load plate. Dynamic load cause the deflections in the pavement structure. When taking measurements by static device a certain area of the pavement structure is being gradually loaded and unloaded.

When constructing a test section of experimental pavement structures the deformation modulus of separate structural layers and of the whole pavement structure were determined by static and dynamic methods using the following equipment:

In static method:

1. static press „Strassentest";
2. Benkelman Beam „Infratest.

In dynamic method:

1. light dynamic device „ZORN ZSG 02";
2. Light Weight Deflectometer „Prima 100";
3. Falling Weight Deflectometer „Dynatest 8000".

STRESS AND STRAIN TRANSDUCERS

In each different pavement structure of a test road section in each pavement structure layer the stress and strain transducers were installed (Fig 1). At the bottom of the asphalt wearing course, binder course and base course special strain transducers were installed (Fig 2, a). The transducers were installed in the right-of way, along which the loaded heavy-weight vehicles travel from the query. Totally, 80 strain transducers were installed in asphalt pavement layers of a test road section. On the surface of the crushed stone sub-base, frost blanket course and subgrade of specific and the main pavement structures 11 stress transducers were installed (Fig 2, b). The stress transducers were also installed in the axis of the first track from the road shoulder. The cables of transducers erected in a different pavement structural layer were connected to the data registration boxes erected in the roadside of a test section. When connected to special equipment the boxes register the transducer readings. During this investigation readings of the transducers will be registered each time after the passage of 20 000 ESAL's (estimated to 100 KN) of the loaded heavy-weight vehicles travelling along the right-of way from the query.

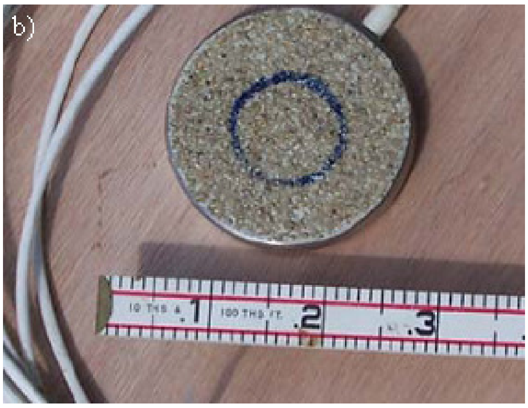

Figure 2. Strain and stress transducers installed in experimental pavement structures:
a) strain transducer, b) stress transducer

RESULTS FROM STRENGTH, STRESS AND STRAINS MEASUREMENTS

This chapter gives the results of measuring strength, stresses and strains of experimental pavement structures. The strength measurements were carried out during the construction of pavement structures and after final completion of a test road section. Measurements of stresses and strains were taken before the opening of the road section to traffic. Fig 3 gives the distribution of the mean values of equivalent deformation modulus of different pavement structures measured by the Falling Weight Deflectometer (FWD) on the asphalt wearing course. Measurements by the FWD were taken in 3 points in each section of a different pavement structure.

When measuring stresses and strains the loading of transducers was carried out by a two-axle vehicle having twin-wheels of the rear axle. The load of twin wheels was 50 KN. The tyre pressure was 0,65 MPa. The speed of the moving vehicle - 50 km/h, mean temperature of the pavement surface +5,6°C. Transducer readings were registered by a universal digital measuring device "Spider 8" and a computer program „CatmanEasy". The variation charts of stresses and strains are presented in Fig 4 and Fig 5.

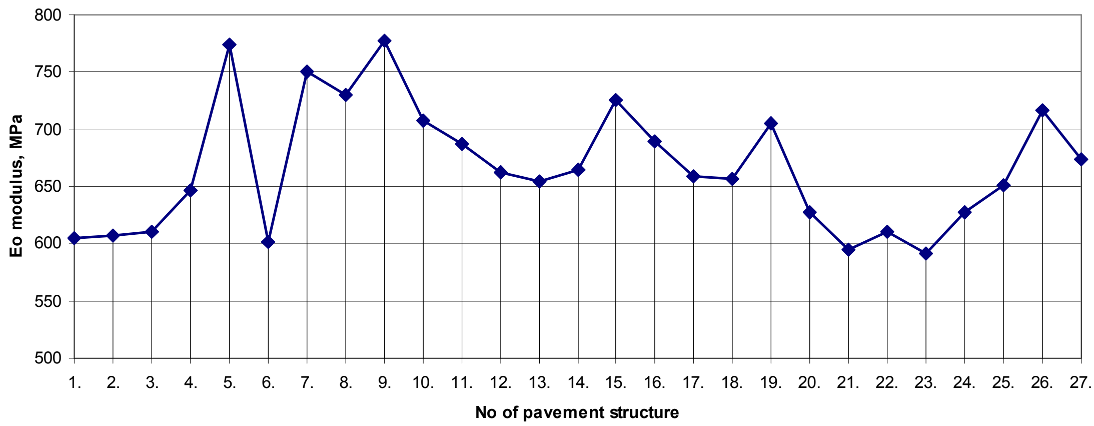

Figure 3. Mean values of equivalent deformation modulus on the asphalt wearing course
of different pavement structures of a test road section

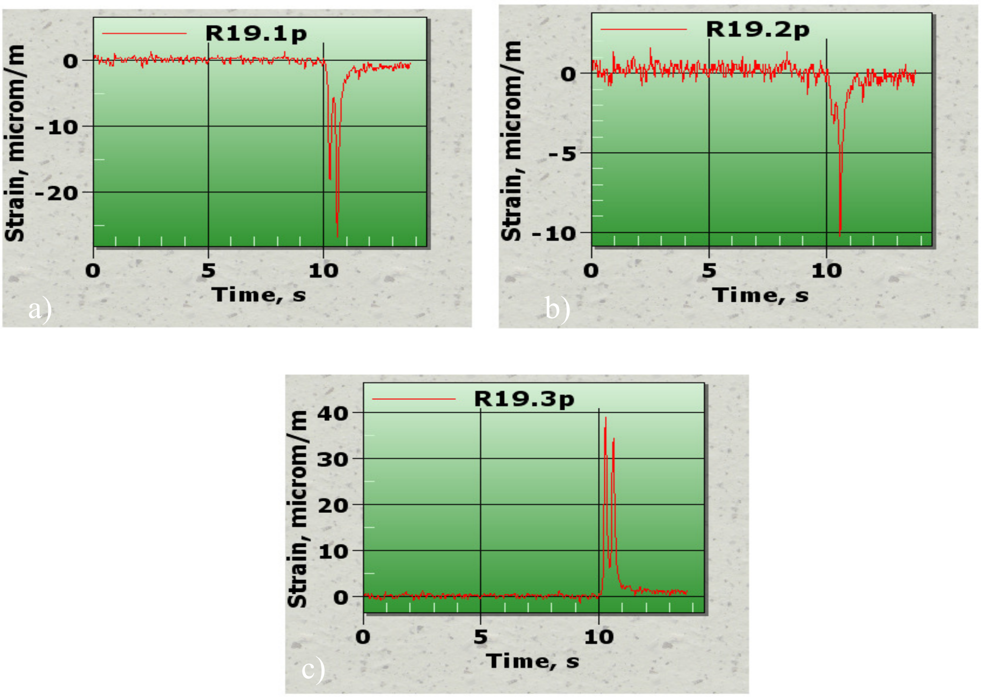

Figure 4. The charts of stresses and strains of the main pavement structure of a test road section: a) transverse strain at the bottom of the asphalt wearing course, b) transverse strain at the bottom of the asphalt binder course, c) transverse strain at the bottom of the asphalt base course,

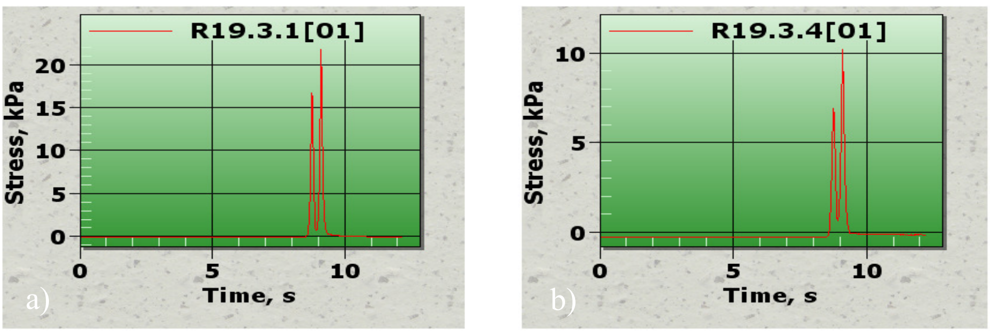

Figure 5. The charts of stresses and strains of the main pavement structure of a test road section: a) stress on of the sub-base course, b) stress on of the sub-grade

The mean values of equivalent deformation modulus of different experimental pavement structures measured by the Falling Weight Deflectometer vary from 591 MPa to 777 MPa. Equivalent deformation modulus show that the structural strength of pavements attributed to the same class of pavement structures differs between each other up to 25%.

Stress and strain measurements shows that the greatest measured transverse strain was in pavement structure No 8 (base course from crushed granite 0/56, base asphalt - 0/32 C crushed dolomite, binder asphalt - 0/16 A crushed dolomite, wearing asphalt - 0/11 S-V crushed granite) – 60.03 (μm/m) tension. The smallest transverse strain was in pavement structure No 3 (the same pavement structure as in No 8 but in base course insted of granite – crushed dolomite) – 12.76 (μm/m) tension. The bigest measured stress was in pavement structure No 22 (the same pavement structure as in No 8 but geogrid instaled between asphalt wearing and binder course) under asphalt base course – 54.5 kPa.

CONCLUSIONS AND RECOMMENDATIONS

1. In order to check the results of long-lasting laboratory investigations of the road building materials under natural field condition it became a necessity to construct a test section of experimental pavement structures.
2. A test road section was constructed from 24 different pavement structures of the class III. The total length of the section - 710 m. 80 strain transducers and 11 stress transducers were installed in experimental pavement structures of a road section.
3. When constructing a test section and after it was opened to traffic the strength of the subgrade and of the separate pavement structural layers was measured using different measuring devices, the cross fall and the gradient were determined, also pavement roughness, skid resistance and pavement defects.
4. Before opening a test section to traffic the stress and strain measurements were performed in the structural pavement layers. The measurements will be carried out each time after the passage of 20 000 ESAL‘s (estimated to 100 KN).

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