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Temperature and moisture variation in pavement structures of the test road

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Abstract

Environmental conditions (temperature, moisture, intensity of sun, etc.) influence variation in asphalt pavement strength during the year. Lithuania is situated in a zone of cool average climate characterized by average warm summers and average cold winters. One of the most important climatic factors is the air temperature variation per day. In order to evaluate the dependence of road pavement strength on temperature and the dependence of Eo modulus of separate layers on seasonal factors a comprehensive research was carried out on the unique Test Road section that was constructed in 2007 in Lithuania and is operated almost for 8 years. This road is affected by real climatic conditions and high intensity heavy vehicle traffic. It consists of 27 different flexible pavement structures with the same class of pavement structure but the different type and composition of materials and all necessary electronic sensors (loop profilers, temperature and moisture sensors, stress and strain transducers). Temperature and moisture sensors are installed in 4 different pavement structures. In order to analyse behaviour of asphalt pavement structure under Lithuanian climatic conditions, taking into account temperature and moisture, as one of the most important climatic factors influencing structural strength of road asphalt pavement, the experimental research was carried out and results are presented in the article.

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1. Introduction

Lithuania belongs to a number of countries where design, construction and repair of roads are highly influenced by climatic conditions (air temperature, precipitation, wind direction and strength, thickness of a snow cover, etc.). Influence of climatic conditions on road pavement structure is called hydrothermal regime. Climatic factors form regular seasonal moisture and temperature variations in pavement structure and subgrade. Variations of positive and negative temperatures (freezing and thawing cycles) cause pavement defects and worsen subgrade condition. With the changing ambient temperature the structure condition properties of pavement materials are changed. Due to the freezing and thawing cycles the fatigue of road pavement materials increases, pavement becomes breakable, cracked are formed.

Not less important is the case when at a high air temperature plus 25–30 °C under the effect of traffic loads the wearing course of asphalt pavement becomes deformed, ruts and corrugations occur. The main disadvantage of asphalt pavements is a strong dependence of asphalt properties on temperature. With the increasing temperature the bitumen viscosity is decreasing and this causes the decrease in pavement strength. With the decreasing temperature an opposite process takes place – the bitumen viscosity is increasing and because of this the asphalt strength is also increasing.

The most distinguished asphalt pavement deformations are corrugations, heaves and ruts. A considerable increase in asphalt pavement deformations is found in a hot period of the year under increasing traffic loads and the lowest pavement stability (Braga 2005). Analysis of data, collected in the Road Weather Information System, shows that in winter, the air temperature being about –30°C, temperature of road pavement surface falls to minus 22 °C. In summer, at a temperature of plus 25–30 °C, road pavement surface heats up to plus 40–45 °C (Čygas et al. 2004).

In Lithuania, the most critical period of the year is spring when subgrades and road pavement structures thaw and structural layers are mostly saturated with water. The largest negative effect of water is made on subgrade where the strength of subgrade soils is directly dependent on their moisture. The strength of subgrade makes a large effect on pavement structural strength. Moisture, having got into pavement layers, increases moisture of pavement materials, also fills up the air voids between the frame of mineral materials. Water, having crystallized into ice during freezing, speeds up the occurrence of defects in pavement layers.

2. Climatic factors and their effect on road pavement strength in Lithuania

Roads are continuously and intensively influenced by climatic factors – high temperature in summer, low – in winter, thawing – in spring, abundant precipitation – in autumn. Lithuania is situated in a zone of cool average climate characterized by average warm summers and average cold winters. For the whole year the territory of Lithuania is strongly affected by the Atlantic Ocean and the Baltic Sea. In winter, Atlantic cyclones are very common bringing snow or wet snow, warmer weather, and determining a thicker snow cover. The climate of Lithuania is mostly determined by its geographical latitude, solar radiation, atmospheric circulation and interaction of these factors with the terrene. The warmest month in Lithuania is July, on the coast – it is August. Almost in the whole Lithuania, except coast, the coldest month is January. On the coast – February. Average temperature of the warmest month (July) varies from plus 16 °C on the coast to plus 18 °C in the southern Lithuania, of the coldest month (January) – from minus 3 °C on the coast to minus 6,5 °C in the Eastern Lithuania. However, sometimes Lithuania experiences very hot summers when the temperature rises up to plus 30 °C, and very cold winters when the temperature drops to minus 20 °C in a daytime, and to minus 30 °C at night (Juknevičiūtė-Žilinskienė 2009). Distribution of the average monthly air temperature in the certain cities and distribution of the average annual air temperature in Lithuania in 1961–1990 are given in Fig. 1 and Fig. 2.

One of the most important climatic factors is the air temperature variation per day. The lowest air temperature is recorded at sunrise, the highest – between 14–16 h. When the sun comes up the temperature quickly rises but having remained 2–3 hours to the maximum temperatures the rising slows down. Having achieved the highest point the temperature for 2–3 hours falls slowly and then – quickly. At night, with the approaching minimum temperatures,

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