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Evaluation of pavement temperatures in Poland during winter conditions

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Abstract

The paper presents the analysis of pavement temperatures from meteorological stations located at the Polish national roads during the impact of low winter temperatures. Presented issue is particularly important in view of the problem of low-temperature cracks that occur in the asphalt pavement under the influence of low temperatures. For each location of meteorological station there were analysed measurements of the temperature on the road pavement surface, at depth of 5 cm and 30 cm in the pavement structure and air temperature 20 cm above the pavement surface. The analysis of the data included determination of minimum surface temperatures, duration of low temperatures, distributions of temperatures at the depth of pavement structure and the rate of cooling of the pavement surface. The number of temperature transitions for a specified level of low temperatures: 0 °C, -5 °C, -10 °C, -15 °C and -20 °C were also determined. It was found that the longest uninterrupted period of surface temperature hold below -20 °C is 18 hours, but below -15 °C is already 85 hours. On the basis of the distributions of temperature at the depth of pavement structure it was found that the recorded values of the minimum temperature of up to -25 °C on the surface of the asphalt pavement, the temperature at a depth of 5 cm, is higher by about 2–4 °C than the surface temperature, while at depth of 30 cm it is already higher by about 20 °C than the surface temperature. Another important factor affecting the performance of asphalt pavement and in particular the resistance to low-temperature cracking is the cooling rate. With increase of cooling rate during severe winter conditions the probability of low temperature cracking increase. It was found that the cooling rate of the asphalt pavement surface is up to 3 °C/h.

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1. Introduction

Temperature is one of the most important factor that influences on pavement condition. The properties of asphalt pavement vary significantly according to temperature. In lower temperatures bitumen and consequently asphalt mixture behaves as hard, stiff and even brittle substance. This can be a reason of transverse cracks in the asphalt layers of pavements, which can arise in connection with the quick contraction at rapid temperature decrease during severe winter conditions. Influence of pavement temperature, especially low temperature distribution in asphalt pavement was the aim of many comprehensive studies, i.e. Bosscher et al. (1998), Hermansson (2001), Herb et al. (2006, 2009), Wang et al. (2012), Yaning et al. (2013) and Wistuba et al. (2013). This paper is a result of research program conducted by Judycki et al. (2014) commissioned by Polish Road Administration on evaluation of pavement temperature in high modulus asphalt concrete (HMAC) layers.

The main objective of the paper is to evaluate temperatures of air and pavement structures in winter conditions in Poland for pavement design and analysis of road materials. The scope of the analysis was as follows:

- Collection of the measurement data from meteorological stations, which included the results of measurements of air temperature and pavement temperature.
- Verification of collected data.
- For the complete data available from measurement period determination the minimum surface temperatures, the duration of such temperatures and the rate of cooling of the pavement surface

For the selected measurement data (the period from 10.09.2012 to 11.09.2013) number of transitions in the surface temperature by a certain level of low temperature (0 °C, -5 °C, -10 °C, -15 °C, -20 °C) was determined.

2. Climate in Poland during winter conditions

Poland is located in temperate warm transitional climate zone. Its territory is crossed by air masses from both the Atlantic Ocean and the heart of the Eurasian landmass. The continental impact increases gradually with a move from west to east. Thermal conditions are mostly influenced by: air circulation, solar radiation and elevation above sea level. Mean annual air temperature decreases from South-West to North-East, Blazejczyk (2006). Figure 1 presents the map of mean values of winter temperatures in Poland in January, Kozuchowski (2011).

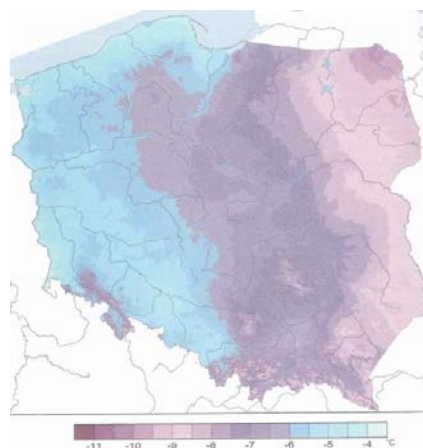


Fig. 1. Mean values of winter temperatures in Poland in January, Kozuchowski (2011).

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