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The effect of time on acoustic durability of low noise pavements – The case studies in Poland

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ABSTRACT

The tyre/road noise depends on type and speed of vehicles and on the characteristics of road pavement. Vehicle traffic load and weather conditions lead to significant changes in the characteristics of the materials used to build the wearing course. This applies especially to road pavements with the increased void contents. Clogging of the pores, changes in the characteristics of the binder and the damage to the wearing course influence changes in the acoustic properties of the road pavement over time. The article presents the results of the studies on noise level carried out in 2011 and 2014 by the Statistical Pass-By method (SPB) on porous asphalt concrete (PAC), very thin asphalt concrete (VTAC) and stone mastic asphalt (SMA). The wearing courses with the increased void contents immediately after building constitute a very advantageous solution compared with traditional road pavements (dense asphalt concrete, stone mastic asphalt). However, the unfavourable location of the road with porous wearing course, lack of systematic cleaning of porous layers or inappropriate maintenance methods in winter lead to the loss of the acoustic durability of low-noise pavements within a few years of their exploitation.

Introduction

The traffic noise mainly depends on the traffic volume, flow composition, speed of vehicles and road pavements. The traffic, road characteristics and road pavements are very important because they have the impact on noise annoyance (Freitas et al., 2012).

The tyre/road noise depends on type and speed of vehicles and on the road pavement characteristics (Sandberg and Ejsmont, 2002). It is predominant source of overall vehicle noise when speed of passenger cars exceeds 40–50 km/h and speed of heavy vehicles exceeds 70–80 km/h. The parameter used for describing the rolling noise of vehicles is the A-weighted maximum sound pressure level (L_{Amax}), emitted at the time of passage of a single vehicle. Its value can be determined by the Statistical Pass-By method (SPB) or by the Controlled Pass-By method (CPB). SPB method is based on the procedure recommended by the standard (ISO 11819-1, 1997). The noisiness of the road pavement can be described by the Statistical Pass-By Index (SPBI).

The A-weighted maximum tyre/road noise level generated in the pavement/tyre interface is determined according to the Close Proximity method (CPX) (ISO 11819-2, 2012). Under this method the noisiness of the road pavement is described by

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the CPXI index, calculated as the arithmetic average of the maximum sound level for the set of test tyres. The tyre/road noise can also be evaluated with the On-Board Sound Intensity (OBSI) test according to AASHTO TP 79-08.

Within the last years higher attention has been paid to the construction of low-noise pavements which in some localisations can replace the acoustic barriers. A selection of appropriate wearing course is a very important issue as it should contribute to the reduction of tyre/road noise.

In the case of the stone mastic asphalt (SMA) and the dense asphalt concrete (DAC) the tyre/road noise level depends mainly on macrotexture of these surfaces. There exists relationship between tyre/road noise and macrotexture of the surface, described by a mean profile depth (MPD) or mean texture depth (MTD) (Sandberg and Ejsmont, 2002; Gardziejczyk, 2005). Fast Fourier transform was applied for spectrum analysis between tyre/road noise and road texture (Mak et al., 2012).

The noisiness of cement concrete pavement depends largely on the method of texturing of its surface. It is believed that the textured concrete surfaces using exposed aggregate method are the best solution from the acoustic point of view. Currently, the diamond grinding is a good alternative to exposed aggregate concrete for construction of low-noise pavements (Izevbekhai and Khazanovich, 2013; Skarabis and Stockert, 2015).

Single layers of the porous asphalt concrete (PAC), the double porous asphalt concrete (DPAC), the porous cement concrete (PCC) and very thin asphalt concrete (VTAC) and ultra thin asphalt concrete UTAC) layers are qualified as the low noise pavements. According to Sandberg and Ejsmont low noise pavement should produce at least 3 dB lower vehicle noise than that obtained on reference surface. In the case of porous surfaces their noisiness is determined by the thickness and number of layers, porosity and their exploitation lifetime. Praticò (2014) assessed the effect of the tortuosity on the absorption coefficient of a pavement layer.

The first sections of porous pavement were built in Europe in the 70 s of the twentieth century (Sandberg and Ejsmont, 2002). In the 90 s of the twentieth century in the Netherlands, Italy, France and Germany emerged solutions composed of two layers of porous asphalt. These surfaces show higher acoustic effectiveness in relation to single layers of porous asphalt. They are less durable than the very thin layers of asphalt and single layers of porous asphalt.

The main advantages of thin asphalt concrete layers with a thickness of 10–30 mm in comparison with the dense asphalt concrete and the SMA are, apart from improved noise reduction, higher coefficients of friction (from low to medium speeds), lower construction costs and shorter completion time. Their main disadvantages include greater susceptibility to the loss of grains and delamination, reduced resistance to low temperatures, a shorter lifetime, a greater decrease in acoustic effectiveness in service and larger dependence of the friction coefficient on the qualities of the materials used.

One of the future-oriented solutions in the fight against excessive road noise are poroelastic road surfaces. They are characterised with air void contents from 20% to 40% and at least a 20% proportion of granulated rubber. Research on the use of poroelastic surface were conducted in Norway, Japan and Sweden, but most attempts ended in failure. The main causes of failures was the lack of appropriate bonding of poroelastic layer with the base course and too low coefficient of friction under wet conditions (Sandberg and Ejsmont, 2002). Currently, the PERSUADE (Poro-Elastic Road Surfaces for the Advanced Defence of the Environment) – a research project is being carried out, whose main objective is to develop a poroelastic road pavement, durable and safe, and able to lower the level of sound emitted by 10–15 dB compared with the reference surface (Ejsmont et al., 2014; Sandberg and Goubert, 2011; Bendtsen et al., 2013). An important aspect of the application of poroelastic surface is flammability (Swieczko-Zurek et al., 2014).

In Poland, the first experimental sections of porous pavement were built in 1985-86. Between 1999 and 2009 individual roads sections with low-noise pavements (e.g.: COLSOFT, RUGOSOFT, NANOSOFT – wearing courses produced in cooperation with the company COLAS; GUFI – wearing course produced by Road and Bridge Research Institute in Warsaw) were constructed. They differed in air void contents, rubber amount addition, maximum aggregate size and thickness. In subsequent years SMA LA was applied in order to reduce noise. In 2010, a test section with porous asphalt concrete PAC 8 and a test section with thin asphalt concrete VTAC 8 were built on the regional road DW 780. In the same year a test section of road with porous asphalt (PAC 11) was made on the national road DK50. In 2014, the first section with double porous asphalt concrete (DPAC 8 + 16) in Poland was built on the regional road DW967. The thickness of the upper layer of PAC 8 was 4 cm with the void contents 23.6%, thickness of the lower layer of PAC 16 is 6 cm with the void content of 25.5%.

Vehicle traffic load and weather conditions lead to significant changes in the characteristics of the materials used to build the wearing course. Clogging of the pores, changes in the characteristics of the binder and the damage to parts of the wearing course influence changes in the acoustic performances of the surface over time. This applies especially to surfaces with a larger amount of void contents. The influence of type of pavements, their characteristics and the influence of period of exploitation, wetness of surface and climatic conditions on noise level were tested by many researchers (Anfosso-Lédée and Pichaud, 2007; Anfosso-Lédée and Brosseaud, 2009; Bendtsen et al., 2010b, 2012; Freitas, 2012; Gardziejczyk, 2007).

In many countries, various measures are taken to maintain the increased acoustic durability of porous layers as long as possible during their lifetime. Special cleaning equipment has been developed to remove detritus from pores of the low noise pavements.

In Poland, there is a lack of adequate experience in construction and maintaining of pavements with high volume of open and interlinked voids. The aim of this article is to demonstrate changes of the acoustic properties of road surfaces over time, depending on their characteristics, location of the road section, and to show how important is the appropriate maintenance during exploitation.