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Inhomogeneity of low-noise wearing courses evaluated by tire/road noise measurements using the close-proximity method

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ABSTRACT

Performing numerous analyses of tire/road noise measurements on low-noise pavements during the last several years, the authors observed significant inhomogeneity of the wearing course in numerous cases, while similar problems were almost non-existent when dense pavements were measured.

Three main causes of low-noise pavement inhomogeneity can be defined. The first one is imperfections in the technology used for asphalt mix production and/or errors made during the laying process of the wearing course. The second one is clogging that takes place during the pavement's service life. The third reason is related to uneven and/or excessive wear of the pavement (raveling and stripping of the aggregate may appear in this case). Findings of analyses of noise data acquired from low-noise pavements (based on 10 m long segments), using the close-proximity (CPX) method, are presented and discussed herein.

Significant differences in measured averaged noise levels, up to 1.7 dB, between test sections of open-graded wearing courses that were the same in principle, located on the same road but in different lanes were found when performing CPX measurements. At the same time the test sections of a dense pavement differed by max. 0.5 dB only. The calculated A-weighted sound pressure level variability index Scpx, considered to be an indication of pavement homogeneity, reached the value of 1.69 dB over a 500 m long test section of the porous pavement while the Scpx values for dense pavements were much below 0.5 dB.

1. Introduction

A pavement is considered to be low-noise when it produces lower noise readings when trafficked than a standard or reference pavement. According to Sandberg and Ejsmont [1], it should produce at least a 3 dB (half power) lower vehicle noise than that obtained on conventional and "most common" pavements. In most industrialized countries, the conventional and "most common" pavements, also considered as standard or reference ones, are dense asphalt concrete (DAC) and stone mastic asphalt (SMA) pavements with a maximum chipping size between 11 and 16 mm [2]. Nowadays, porous pavements (single and double layer) and thin asphalt layers are considered to be noise-reducing pavements [3].

The macrotexture and used aggregate size determine noise characteristic of dense asphalt pavements (DAC, SMA) [4]. In case of low-noise pavements primarily the porosity and texture influence on their noise properties. Existing low-noise pavements are generally characterized by a relatively high volume of open and interlinked voids (open-graded pavements – e.g. porous asphalt concrete) and/or by an optimized texture where aggregate is graded without one or more intermediate sizes (gap-graded pavements – e.g. thin asphalt layer). Acoustic properties of porous pavements have been and still are the focus of research in many countries. However, opinions regarding their noise reduction effectiveness, particularly in cases of long-term use, are divided [5]. The problems of pore clogging, less structural durability, the need to modify the binder and the effect of maximum aggregate size have been highlighted [6,7].

Asphalt mix can be produced in either continuous plants (stationary or mobile) or in drum-mixing facilities. The constituent components of the mix (aggregate, binder, filler, and additives), as well as the composition parameters (production temperature, mixing time), all have a significant influence on the characteristics and properties of the final low-noise pavement, including its homogeneity. To achieve a homogeneous low-noise pavement special care should be taken at all stages of mix production and during the laying process.

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During the service life of low-noise open-graded pavement, the pores of the wearing course tend to be clogged by dirt, dust and general detritus arising from the wear of the pavement and vehicle tires. The problem of clogging is more prevalent on minor roads and streets in cities than on highways. Likewise, it has a greater effect on low-speed lanes than on high-speed ones. Usually the clogging of the porous pavement is invisible to the eyes of the CPX measuring system operator, as the dirt was deep inside the pores. However, sometimes clogging is clearly visible. An example of such a case may be clogging caused by agricultural vehicles entering the road directly from a field with mud and soil stuck to their tires (result – see Fig. 1).

Porous pavements, due to their open-graded structure, are more exposed to the atmosphere in comparison to other dense pavements. Thus, the binder is more susceptible to oxidation that leads to brittleness, pavement cracking and loss of aggregate. When the pavement is exposed to dense traffic, especially when that traffic consists of a high percentage of heavy vehicles, excessive wear of porous pavement usually takes place, which may cause raveling of the aggregate and finally damage to the pavement. First, however, inhomogeneity due to excessive wear appears (result – see Fig. 2).

The aim of this paper is to present and discuss possible problems that may appear while taking noise measurements and evaluating acquired data on low-noise wearing courses, which can finally lead to improper estimation of tire/road noise produced by particular pavements.

Fig. 2. Inhomogeneous porous pavement due to uneven and excessive wear (and close-up of the wearing course).

2. Measurement method

There are two standardized methods dedicated to measuring the influence of pavement characteristics on tire/road noise. The first one – Statistical Pass-By (SPB) method [8] – is mainly intended to classify pavements in typical and good condition according to their influence on traffic noise and/or to evaluate the influence of different pavements at particular sites - irrespective of condition and age – on traffic noise. The Close-Proximity (CPX) method [9] is intended to check a pavement's noise characterization compliance at almost any site according to particular specifications (e.g. for conformity of production) and/or to check the acoustic effect of maintenance and condition (e.g. wear of and damage to pavement, clogging and the effect of cleaning porous pavement) and/or to check the homogeneity of a wearing course of road section.

All measurements reported in this paper were performed according to the CPX method. A special test trailer named Tiresonic Mk3 [10], designed and built at the Gdansk University of Technology in Poland, was used. During measurements tire/road noise emission (SPL and 3rd octave bands) was acquired using two

Fig. 1. Mud and soil on a porous pavement brought from fields by agricultural vehicles (*photo by M. Motylewicz*).