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CONVENTIONAL AND NON-CONVENTIONAL EQUIPMENT FOR PAVEMENT SURFACE MACROTEXTURE MEASURING

Abstract

The article deals with the surface macrotexture measurement on various asphalt pavements. For the macrotexture measurement were used two differently working devices. The Profilograph GE is a continually working device owned by Slovak road administration. The ZScanner® 800 is a hand-operated laser 3D scanner, which is the property of University of Zilina. As a characteristic for pavement texture evaluation was chosen the worldwide used parameter MPD.

Keywords

Pavement surface, Macrotexture, Profile, 3D Scanning.

1 INTRODUCTION

The texture of the pavement surface is determined by configuration of single protuberances of wearing course material. The texture is the keystone of the interaction between vehicle tyre and pavement surface. On the world congress [1] was the texture divided to micro- macro and megatexture according to their wavelengths and amplitudes. All of these parts of texture contribute to the interaction between wheel and surface, but with different kind of their influence. Ranges of amplitudes and wavelengths for single parts of texture are showed in the tab.1.

Tab. 1: Ranges of amplitudes and wavelengths for single parts of texture

Textúra	***Wavelength (mm)***	***Amplitude (-)***
Microtexture	0,001 – 0,5	0,001 – 0,5
Macrotexture	0,5 – 50	0,1 – 20
Megatexture	50 – 500	0,1 - 50

The article deals with measurement and evaluation of pavement macrotexture. Macrotecture issues basic drainage of pavement surface. It is expressed by summary of prominences on the pavement surface and describes how single aggregate grains are organized on the pavement surface. It plays essential role by higher speeds over 40 km/h. In [2] the macrotexture is defined as the deviation of a pavement surface from a true planar surface with the characteristic dimensions along

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the surface of 05 mm to 50 mm (corresponding to texture wavelengths with third-octave bands including the range 05 mm to 50 mm of centre wavelengths). For the evaluation of the macrotexture was used parameter *MPD* (Mean Profile Depth). MPD is a worldwide used characteristic for evaluation of macrotexture of pavement surface.

1.1 Mean Profile Depth - *MPD*

The method for calculation of parameter MPD is based on laser measurements of the surface profile with resolution needed for capturing irregularities with wavelengths and amplitudes defined for macrotexture. The next step is the processing of the measured data and calculation of the MPD parameter, which is based on the specified proceeding. The results are evaluated as average values for an interval defined by measurement device operator [2].

The Mean Profile Depth (MPD) is calculated as the average of the two peaks minus the profile average, the latter of which is normally zero as a result of high pass filtering or slope suppression. The peak level of the profile over each half of the baseline shall be identified. This requires that the baseline of 100 mm be divided into two equal parts and that the highest peak in each part be determined. The two peak levels shall be arithmetically averaged. The principle of the MPD parameter calculation is showed in the figure 1.

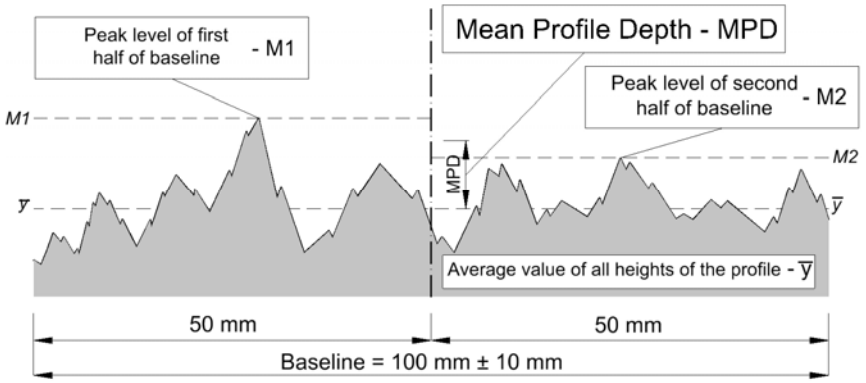

Fig. 1: The principle of the Mean Profile Depth calculation - MPD

The Mean Profile Depth (MPD) for each individual profile is determined as the arithmetically averaged two peak levels minus the average (profile) level.

$$MPD = \frac{M1 + M2}{2} - PP \qquad \text{[mm]}$$

where: $M1$ – the peak level of the first half of the baseline length [mm],
$M2$ – the peak level of the second half of the baseline length [mm],
PP – average level of the profile [mm].

2 MEASUREMENT DEVICES

2.1 Profilograph GE

The device Profilograph GE (fig. 2) is a product of Danish manufacturer Greenwood Engineering A/S, which primarily used for road pavement unevenness measurements but it is able to measure the pavement macrotexture as well. The device has a profiler beam with 15 lasers (16 kHz) for unevenness measurements and 1 laser (64 kHz) for macrotexture measurements. The beam contains inertial systems and gyro for the purpose of beam position balancing. An odometer is mounted on the wheel of the vehicle and in combination with the inertial system it is possible to keep

precise track of the vehicle movement. The vehicle is equipped with the Trimble GPS module for the precise position determination.

Fig. 2: Profilograph GE

The device allows to perform measurements at traffic flow speeds, e.g. 20 – 110 km/h on dry and clean surfaces. The measuring speed doesn't have to be constant during the measuring process. The measurements and evaluation is realized by use of provided software Profilograph for Windows.

Tab. 2: Technical specification of the laser for macrotexture - LMI SELCOM type 2207

Sampling frequency:	62.5 kHz
Signal Bandwidth:	20 kHz
Distance from surface:	260 mm
Measuring range:	155 mm

2.2 ZScanner®800

ZScanner® 800 is a laser handheld self-orienting 3D scanner (fig.3, on the left) with high resolution developed by the company Creaform Inc. This type of scanner allows relative movement of the scanned object surface and the scanner during measurement. The scanning is performed by use of three cameras, which are shooting the laser cross (fig.3, on the right). It displayed a real-time on-screen image of the surface being scanned. The process with real-time surfacing shows the scanning progress as you go, revealing hidden spots and ensuring a complete scan the first time. The scanner is provided with the „VXelements- 3D Digitizing Software" (fig.3, on the right). Technical specifications of the 3D scanner is showed in the table 3.

Fig. 3: 3D scanner with measuring set and the VXelements- 3D Digitizing Software

The scanning process begins with pre-scanning of the reflective positioning targets. The system is creating the coordinate system according the position of scanned target points. After that, the pavement surface is scanned. The principle of the surface scanning is based on the triangulation process. If the „trinocular" cameras are capturing at least 4 reflective points, the system is able to determine the position of the points of the scanned surface. Every point has the unique X, Y, Z coordinates. The polygon mesh of the scanned surface is automatically recalculated according to captured position of all points and according to selected resolution. The scanning resolution is possible to change, for example the high resolution mode can be engaged during scanning for areas of high detail. The VXelements software provided with the device is able to capture all following scanning, which allow to get scanning process more precise and comprehensive. The software allows to export data of measured surface in several data format (.dae, .fbx, .ma, .obj, .ply, .stl, .txt, .wrl, .x3d, .x3dz, .zp), which are used as a input data in the next processing and evaluation.

Tab. 3: Technical specifications of 3D ZScanner 800®

Weight/ Dimensions:	1.25 kg/171 x 260 x 216 mm	***Resolution X,Y,Z:***	up to 50 microns
Measurements:	25 000 *Measurements* /s	***Accuracy XY:***	up to 40 microns
Laser class:	II (eye safe)	***Data transfer:***	FireWire
Number of cameras:	3	***Field Depth:***	30 cm

3 THE PROCESSING AND THE DATA ANALYSIS

All macrotexture measurements were performed on five selected road pavements with different type of wearing course. Measured road sections were 100m long. This length is possible to consider as satisfactory for getting the objective information about macrotexture level of investigated surface by device Profilograph GE. By 3D Zscanner were performed measurements on 10 points in the same wheel path as the measurements performed by Profilograph GE.

Data processing for measurements performed by Profilograph GE was done using the Profilograph for Windows software (Fig.4). The software evaluates pavement macrotexture by MPD parameter based on average level of results interval, which should be bigger than 100mm following the definition of the MPD parameter calculation.

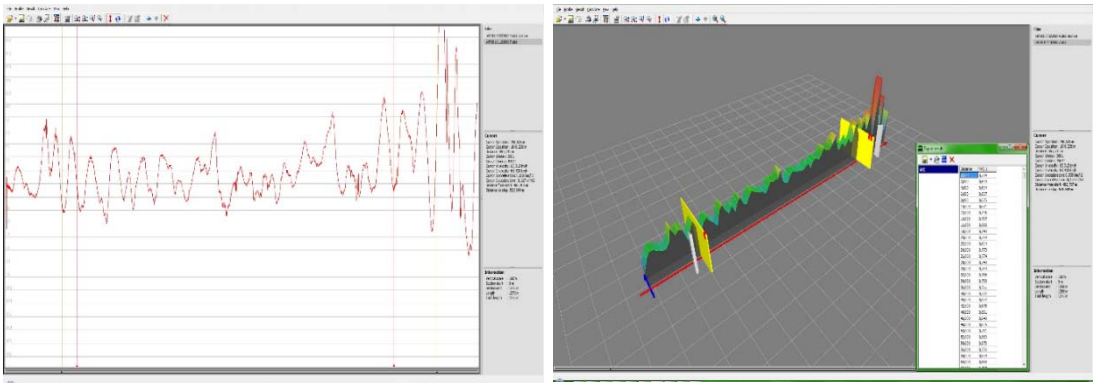

Fig. 4: The example of a profile of which is the *MPD* calculated in Profilograph for Windows

The processing of all collected data measured by 3D scanner was performed in the MATLAB® software [4]. MATLAB provides a range of numerical computation methods for analyzing data, developing algorithms, and creating models. The MATLAB language includes mathematical functions that support common engineering and science operations. [5]. The scanning process was performed with resolution 0,2 mm, and the scanned surface area was limited by the

template wit dimensions of 200x60 mm, which means that there were scanned 300 profiles with length 200 mm. The MPD parameter was calculated over baseline 100 mm long, what represents 600 values of mean profile depth per one measurement point. An example of the output from the MATLAB® environment are showed in the fig. 5.

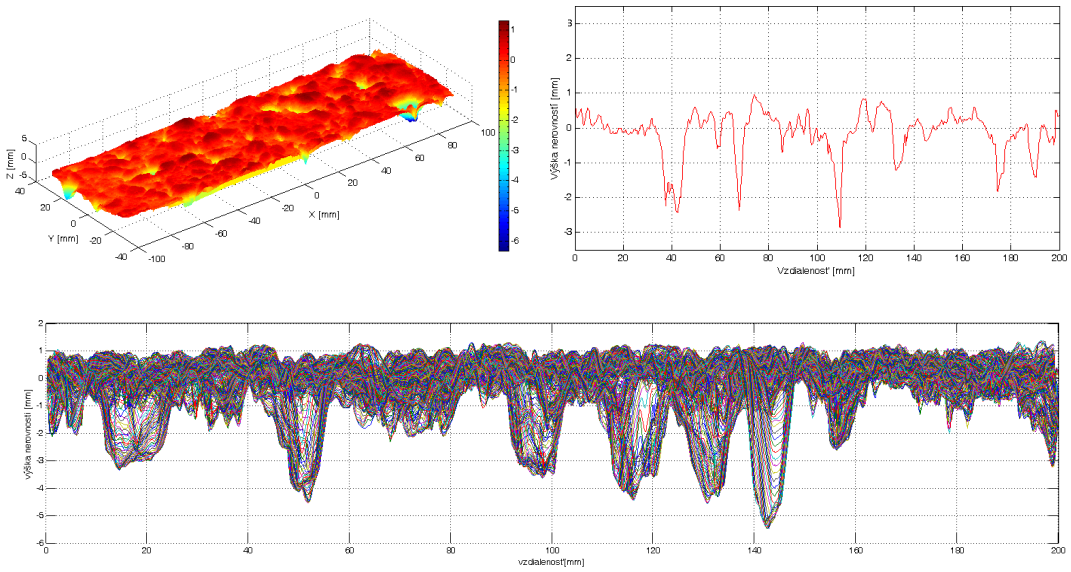

Fig. 5: Outputs from MATLAB®: a) scanned surface, b) texture profile, c) all measured profiles

After processing of measured data we are able to compare results gained of both measuring methods. According to reached vale of coefficient of correlation *(r)* representing the relationship between *MPD* parameters measured by 3D scanner and Profilograph $r = 0{,}993$ it can be concluded that there is a very high degree of correlation. The relationship is showed in the fig. 6.

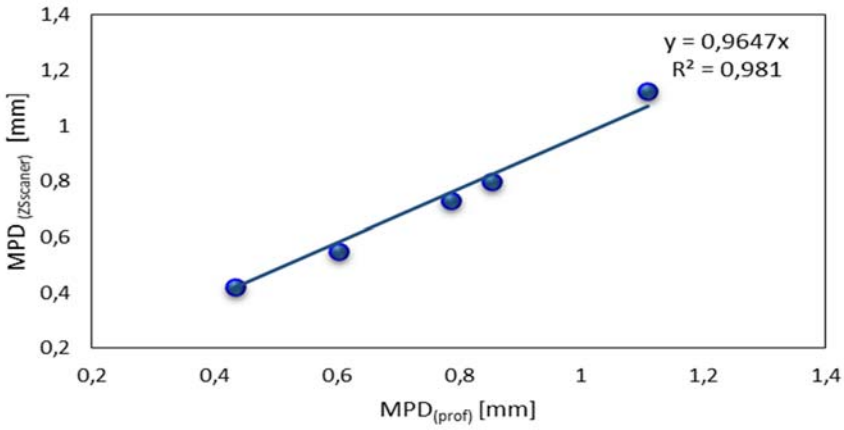

Fig. 6: The comparison of MPD parameter gained by two different methods

4 CONCLUSION

The article was primarily concerned with comparison of two different devices for pavement surface macrotexture measurements. The greatest advantage of the laser scanning of the texture is that measurements are not influenced by test conditions as it is by other skid resistance measurements. Profilograph GE is a continually working device which allows to measure the pavement surface macrotextue in one line (profile). The 3D scanner provide a three dimensional scanning of surfaces, which allows opportunities for better capturing of macrotexture properties. Downside of the method is that the scanning process takes a much longer time and the measurement process is not continuous. However, the 3D data from scanning is possible to process according many different characteristics (amplitude, wavelength, and hybrid) for the purpose of evaluating the influence of the surface texture not only on skid resistance, but on rolling resistance, and noise emission production, as well. Three dimensional texture scanning can help to objective assessment of the road surface quality. There is a hope that with the progress of development of laser technics, we will be able to perform 3D scanning on the continual basis, and not only measurements of macrotexture, but also measurements of microtexture of the pavement surface.

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