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Methods of Assessment of Accuracy of Road Surface Roughness Measurement with Profilometer

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Abstract

The paper presents comparative characteristics of the main types of profilometers used for measuring of longitudinal roughness of the road surface. Certain issues related to accuracy of road roughness measurement with profilometers are considered.

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Keywords: road surface roughness; microprofile; profilometer; measurement accuracy; difference in elevation points; three-meter rod

1. Main text

Assessment of longitudinal roughness of the road surface is based on a number of various indicators, which, in their turn, are obtained with the help of various instruments and devices. The profilometer stands out of the range of measuring devices [Moscow Automobile and Road Construction State Technical University (MADI) (2006)]; it allows obtaining longitudinal microprofile of the road surface, enabling to define other indicators of roughness: such integrated indices as IRI, RN [Standartinform (2014)], as well as the difference in elevation points and the clearance under a three-meter rod [Lushnikov and Lushnikov (2010)].

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The paper presents comparative characteristics of the main types of profilometers. Certain issues related to accuracy of measurements with profilometers are considered.

Profilometers applied for measurement of road surface roughness can be conventionally divided into three groups.

The first and the most numerous group consists of profilometers applying a laser sensor and an accelerometer as measuring devices placed in the same housing on the front or rear bumper of the car. They are compact, easy to use and provide high accuracy of measurements. Such measuring devices can be used for measurement of transverse roughness.

Among disadvantages of this group of profilometers the following can be mentioned: limited speed range of a vehicle with a profilometer (as a rule, ranging from 20 to 100 km/h) and sensitivity to weather conditions (rain, snow, etc.). Such profilometers do not provide the required accuracy of measurements on a broken stone road and some other types of the road surface, which means that they cannot always be used to measure roughness of lower layers of the road surface.

The second group consists of profilometers with measuring elements in the form of two accelerometers placed on the wheel and the body of a car or hitch. Such profilometers have quite sufficient measurement accuracy for practical purposes, a lower cost, and allow measurements in adverse weather conditions and on road surfaces of various types.

Disadvantages of this group of profilometers include rather complex configuration, a limited speed range of a vehicle equipped with a profilometer and rather low measurement accuracy as compared to the first group of devices.

The third group includes profilometers using lasers, arranged in the longitudinal direction (towards the travel direction), as measuring elements. Their main feature is the ability to produce high-precision measurements at low speeds or even when driving with stops, which is very convenient, for example, when working in the urban environment. However, along with this, they have a number of shortcomings: complex structure, high price, sensitivity to weather conditions and inability to be used for all types of road surfaces, like profilometers of the first group.

Table 1 shows comparative characteristics of the above stated types of profilometers.

In order to assess measurement accuracy of profilometers, a road section with a stated reference longitudinal profile is used. This profile is selected, as a rule, by measuring elevations with a leveling unit. Then, a microprofile is specified from the reference profile with the help of filtration [Moscow Automobile and Road Construction State Technical University (MADI) (2006)], i.e. by removal of long-wave irregularities (for example, ascents and descents) and ultra-short wave irregularities (for example, surface roughness) from the profile, which, actually, do not affect vibrations of a vehicle moving on the road. In order to compare measured and reference microprofiles, assessment of amplitude-frequency responses (AFR) of the profilometer, average spectral power density of measured and reference microprofiles, as well as their correlation coefficients and standard deviations are commonly used [Moscow Automobile and Road Construction State Technical University (MADI) (2006), Khachaturov, Aphanasiev and Vasiliev (1976)].

Table 1. Comparative characteristics of profilometers.

Profilometer type	1	2	3
Low-level sensitivity to weather conditions	–	∨	–
Low-level sensitivity to the type of road surface	–	∨	–
Relatively simple configuration	∨	–	–
Relatively low cost	–	∨	–
Availability of transverse roughness measurement	∨	–	–
High accuracy of measurements	∨	–	∨
Measurements at low speed	–	–	∨