Measurement of the Micro-asperities of the Asphalt Carpet Flat Surface by Means of Virtual Instrumentation

Ştefan Ioniţă, Corneliu Hagiescu, Ştefan Velicu, and Ionel Păunescu

Abstract—**This research paper deals with an adaptation of the virtual instrumentation for measurement of the micro-asperities of a flat surface of an asphalt carpet (road surface), after a certain period of time and the comparison with the values measured during the acceptance of this one.**

The use of virtual instrumentation proves its efficiency at the present moment, when the end-users' requirements are increasingly higher and the management of the information about the asphalt carpet condition is a relevant element for making the decisions regarding the measures to be taken for maintaining it in normal state for safe car traffic. This research used an instrument that measures the temperature of the maximum and minim points of a flat surface (roughness) and compares them (by overlapping) with the initial values measured during acceptance.

Index Terms—**Asphalt, micro-asperities, surface, virtual instrumentation.**

I. Introduction

For determining the size of the micro-asperities of the asphalt surface it is necessary to make an assessment of surface quality and the influence that this one exerts on the adherence of the car tire that runs on the respective surface.

The analysis of the asphalt road surface is a basic element of the optimal management system of the modern road traffic component.

The monitoring of the support coat condition over time leads to the establishment of the maintenance decision to be taken, after technical assessment, for restoring the road surface to its initial quality standard.

Currently, the state of the asphalt coat surface of the road is analyzed in terms of roughness, starting from the following data obtained by using two methods of measurement, namely:

1) SRT roughness (Skid Resistance Test), determined with the help of SRT tester and expressed in SRT units, characterizing the roughness of the bituminous coat;
2) HS roughness (hauteur de sable), determined by analyzing the height of the sand spot and expressed in mm, characterizing the roughness of the road surfaces made of cement concrete and the ones made of bitumen [1].

The acceptable limit values obtained though the determinations performed by means of SRT tester or by sand height method (HS) are governed by STAS 8849-43 [2] standards and are listed in Table I.

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TABLE I: Limit of the Acceptable Values of SRT and Hs Roughness

Limit values of roughness determined by:		Characterization of road surface
SRT tester, in SRT units	HS sand height, in mm	
SRT≥70	HS≥0,6	Good surface; it allows the traffic with speeds higher than 80 km/h
55≤SRT<70	0,2≤SRT<0,6	Satisfactory surface; it allows the traffic with speeds up to 80 km/h
SRT<55	HS<0,2	Unsatisfactory surface; danger of skidding

The features of road surface roughness are the result of the analysis of SRT/HS values, taking into account the indicator CD 155-2000 „Departmental Technical Instructions regarding the Determination of the Modern Roads Technical Status" as shown in Table II [1].

TABLE II: Grade of Road Roughness

Grade	Roughness	
	SRT	**HS**
BAD	<55	<0,2
MODERATE	55…70	0,2…0,6
GOOD	70…80	0,6…0,7
VERY GOOD	>80	>0,7

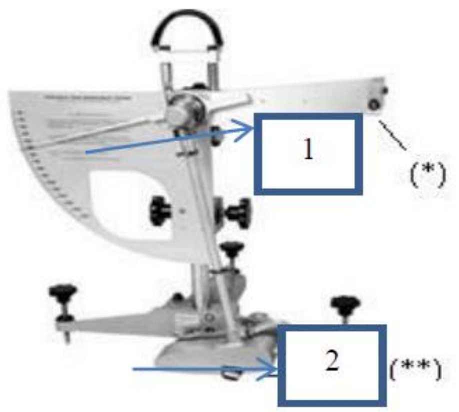

Fig. 1. SRT system for measurement of road coating roughness (1 - pendulum, 2 - support).

II. Equipment Currently Used to Determine the Surface Roughness in Asphalt Coatings

At the present moment, the roughness of the active zone of a public road is determined – for establishing its anti-skid quality - by using the sand height method, HS, in conformity with STAS 8849-83. The testing method consists of transforming the kinetic energy of a pendulum into friction.

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This determination takes into account the lifting height of the pendulum beyond the height of the contact area with the asphalt coating. The pendulum currently used makes measurements in certain points of the asphalt coating. In order to obtain a value correct as possible, it is necessary to make 5 readings at least. The measurement system is shown in Fig. no. 1.

Another equipment used for determining the roughness and the friction coefficient is the SCRIM vehicle shown in Fig. 2

Fig. 2. SCRIM system.

The system shown in Fig. 2 examines the asphalt coating on a road section, with the speed of 50km/h. To determine the roughness and the friction coefficient it is necessary to wet the area in front of the testing wheel [3].

A relevant condition of these determinations is the period when the measurements must be done, namely from April to October. The atmospheric temperatures must not exceed 15°C. To make these determinations for a 1 km long section it is necessary to take 3 testing sectors at least and to establish transverse profiles every 5 - 10 m. For a section of 1 - 5 km there are 5 profiles to be taken at least; for a section longer than 5 km it must be determined 1 transverse profile for each kilometer of road. It is worth mentioning that the areas for measurements must be placed on the traffic lanes (wheel tracks) and on the axis. The value of the skid resistance for each traffic zone is calculated as the arithmetical mean of the values of the measured points [2].

III. Research on the Determination of Asphalt Roughness by Means of the Virtual Instrumentation

In the present conditions, when the informatics is used in all the fields of activity, the measurement process underwent important changes, not only metrological ones but methodological changes especially. The main modification consists in the passage from the classic instrumentation, prevailingly analogical one, to the instrumentation mainly numerical, in which the computer has an important role.

In the case of the determination of asphalt roughness, we propose the implementation of an automatic system of measurement that will use programmable numerical instruments controlled by external equipment (operating unit/system with micro-processor). We shall build a virtual instrument, equipped with several recording sensors that govern the measurement process based on an appropriate program. The analysis instruments are connected by means of standardized interfaces. The human operator has a minimum intervention in these systems: his role is only to start and to stop the process of measurement.

The virtual instrumentation of measurement and control is intended to process the information collected by measurement and to elaborate the controls for the execution components that act on the studied process. The system is closed because it generates corrections for maintaining a certain state in a preset evolution (temperature). In our case, the determination of the value of the size to be measured must be performed in controlled environment conditions, as it has characteristics of both instrumentation and control.

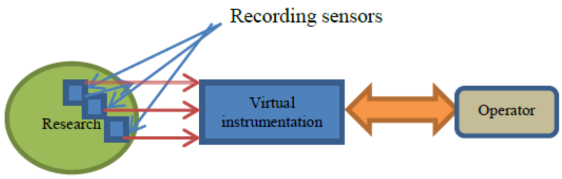

Fig. 3. Using the instrumentation during the measurement process.

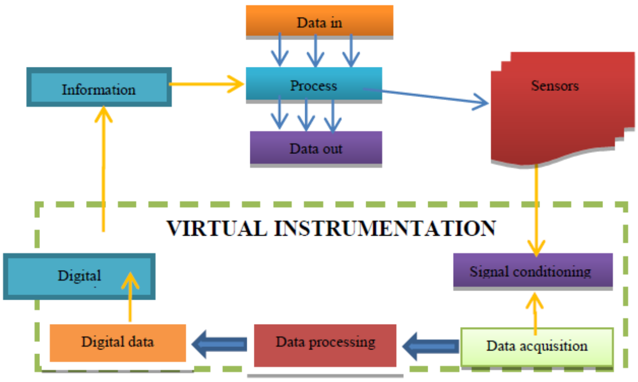

Fig. 4. Block diagram of a virtual instrument

IV. Virtual Instrumentation for Measurement of the Asphalt Carpet Temperature in Order to Establish the Roughness

The research is based on bodies' universal property to emit thermal radiation. The technological equipment includes a hot air unit (turbo blower) with constant temperature of 20ºC. The sensors that capture the asphalt surface temperature are based on an optic system which collects the infrared radiations emitted by the surface and concentrates them on a detector, as shown in Fig. 5.

The infrared sensors capture the natural energy of the invisible infrared radiations; this energy passes through the optic device and is converted by the data acquisition board into an electric signal that is converted afterwards into an output signal.

Advantages of using infrared measurement:

1) The temperature of the asphalt surface is measured without physical contact with this one;
2) The temperature can be measured by scanning the surface with a moving system;
3) The infrared measurements are faster than the contact measurements.

There are some infrared measurement systems that can record the temperature of one point or several points. The data obtained can be directly incorporated into the process or monitored for further adjustments. The equipment for infrared measurement with multi-point linear scanning (Fig. 6) can create graphical profiles of the temperature. This equipment can be associated /switched to a system of data acquisition able to analyze in real time the temperature of asphalt surface micro-asperities, leading to roughness analysis by extrapolation of temperature values in the maximum and minimum points (equivalence of temperature and roughness) in real time.

During the period with temperatures of 18-20 ºC, the scanning system can be placed on a GPS guided remote control drone flown by an operator.

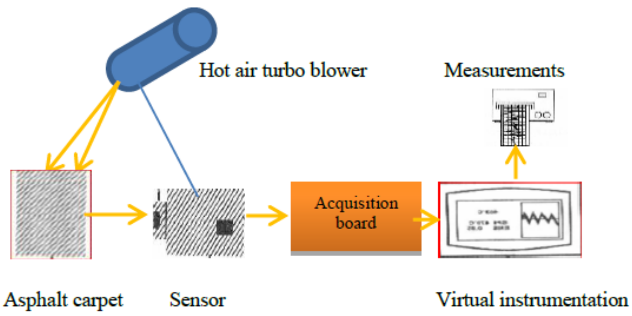

Fig. 5. Measurement system of asphalt roughness.

The data correlation is made by localization and scanning of a surface whose characteristics are known. The scanning is performed by means of the temperature measurement system and is correlated with the characteristics of the surface (roughness). In this case, the surface image is acquired with the help of a HD camera, coupled to a microscope for low magnification (maximum ×100) and to an infrared scanning system; the roughness analysis is made by image processing techniques and methods of texture analysis (Fig. 6).

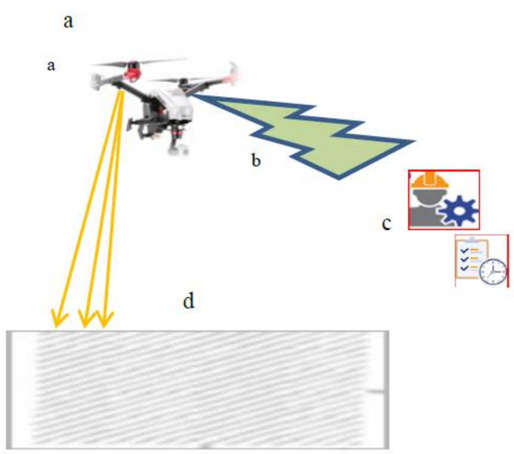

Fig. 6. Equipment placed on a drone (a-drone, b- GSM system, c- operator, d- asphalt).

The research was conducted using a TESTO 876 thermal imaging camera. This one stores automatically and simultaneously both thermal and real image. The device is provided with a special function that superposes the two images by means of the software (IRSoft). Thus, the information provided by the thermal image and the real one are displayed together, in a single image. Tips have maximum temperature (T1) (Fig. 7).

If we monitor the images recorded by scanning with thermal imaging camera and analyze the contrast / contrast ratio which is represented by the ratio of the brightest zones to the darkest ones forming the images captured in the two moments (initial/ after a period of use), we notice that there are different color tones at the work acceptance and then close tones after a period of use of the asphalt carpet. The number of color tones that can be identified by the naked eye or by means of the color tone scales must be 8 at most.

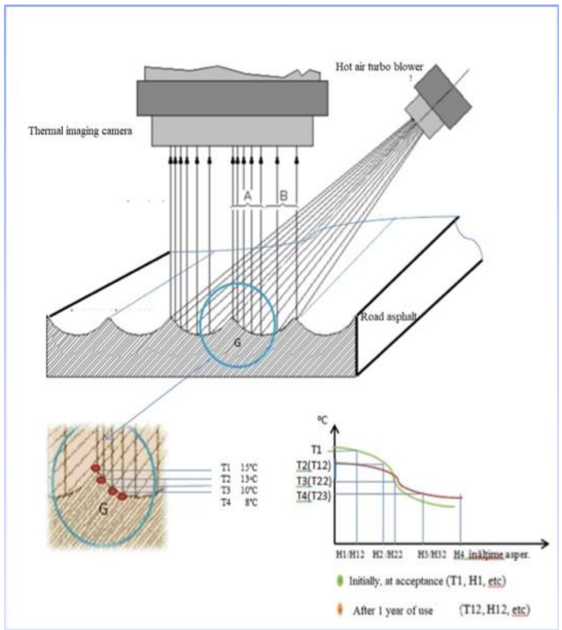

Fig. 7. Surface section measured by means of a thermal imaging camera.

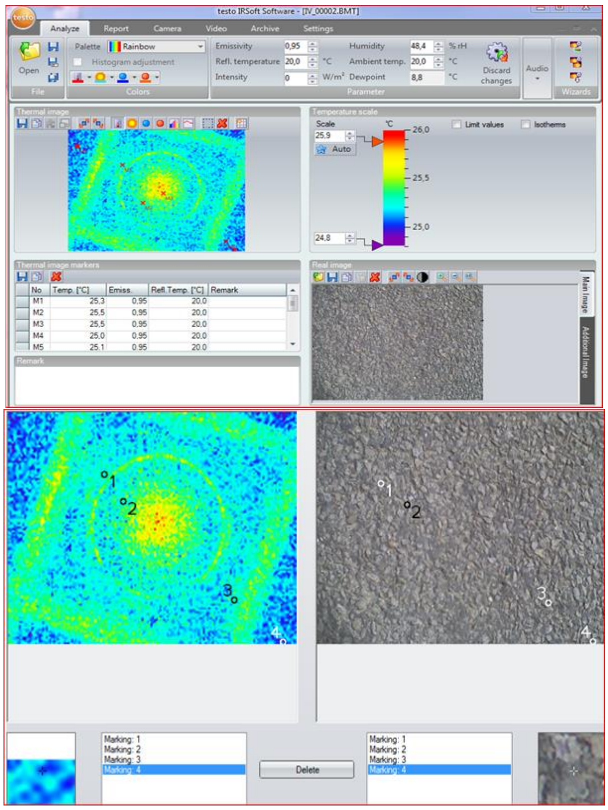

Fig. 8. Initial visualization of asphalt surface T0.

The features of the contrast depend on the evenness of the spectral signatures, on the radiation diffusion due to atmospheric conditions and on the sensitivity of the equipment used for measurements. An image has a good contrast when the number of color tones identifiable by the naked eye is not higher than 8. The contrast can be expressed quantitatively by the contrast ratio, using the formula below: CR = Bmax/ Bmin, where CR – contrast ratio, Bmax, Bmin – maximum (T max. ºC) and minimum (T min. ºC) brightness of the points in the same image (Fig. 8.)

At the completion of the asphalt coating works, the carpet has a roughness complying with the technical regulations in force. The real image and the image given by the temperatures of the micro-irregularities of the asphalt coat are recorded by scanning (points 1,2,3,4).

The scanned surface was viewed at an interval of 120 days approximately. We notice concentrations of the points of maximum brightness where the temperature is close to the temperature of the air of the turbo blower ~ / (around the value of 25ºC), figure 10. Therefore, we identify a reduced number of color tones - namely 4 - on almost the entire scanned surface. So we can draw the conclusion that the roughness is low (the temperature of the micro-irregularities peaks is almost equal to the temperature of the air transmitted by the turbo blower, points 1,2,3,4) (Fig. 9).

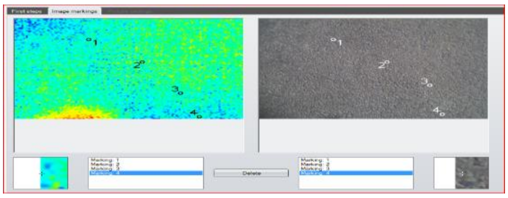

Fig. 9. Asphalt surface at T1 (120 days).

V. Conclusion

The roughness of the roads decreases over time, proportional to the destruction of the aggregate particles of poor quality. The current solution for roughness analysis involves investments for the acquisition of complex equipment and devices and also the training of skilled personnel. By adapting a suitable virtual instrumentation and by measuring the temperature of the micro-asperities of the flat surface of the asphalt carpet (road surface) after a certain period of time compared to the values measured during the acceptance of this one, we acquire sufficient data to make an intervention decision.

In this paper we completed a study for the efficient analysis of the roughness of asphalt surface with minimum costs and long-term benefic results for the preservation/maintenance of an asphalt surface.

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