RUT APPEARANCE ON PAVEMENT SURFACE AND MEASUREMENTS ON MOTORWAY A-4 IN MACEDONIA

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Abstract

Within The Pavement Management System, transversal roughness - the rut depth of pavement surfaces is one of the indicators for assessing the condition of the roads which determines their driving performance. Since the rut collects and retains water (instead drainage), the depth or amount of retained water on the pavement surface has a crucial influence on the creation of aquaplaning and disorder of traffic safety.

The measurements of roughness were made on the motorway A-4 that passes though Republic of Macedonia which is part of the international road E-65 (length 14,2 km) with the measuring apparatus high-speed inertial profiler (The Dynatest Road Surface Profilometer). The evaluation of the condition of the pavement surface in terms of transversal roughness – rut depth was conducted by Slovenian criteria for rut depth (TSC 06.610:2003).

The results from the evaluation of the measurements showed that the pavement surface is heterogeneous represented in all three states: good, satisfactory and poor, which means that certain sections of the motorway require repairmen of pavement surface.

Rut depths and possibility of creating aquaplaning are in proportional dependence; the greater the rut depth, the greater the amount of water that is retained in them, because the amount of water on the pavement surface is creating conditions for the appearance of aquaplaning. Measures for reducing the risk of aquaplaning are: regular measurement and evaluation of the condition of transversal roughness, taking measures for their rehabilitation, improvement of drainage capability of pavement surfaces and improved coefficient of resistance against sliding.

Key words

Aquaplaning; inertial profiler; measurements; pavement surface; rut depth; transversal roughness

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1 INTRODUCTION

1.1 Unevenness on Pavement Surfaces

For road users unevenness of the pavement surfaces is of special interest and one of the first features of the road we perceive. Unevenness depends on the speed and the vehicle features, also significantly acts on the oscillations of the vehicle (excites oscillations) and increases further dynamic loading of road surface and vehicles (which affects the cost of transportation). Unevenness also causes reduced driving comfort, and most important of all reduces traffic safety. It is important to emphasize that unevenness or evenness of the driving surface can appear on the longitudinal and transverse profile of the driving surface [1].

The influence of longitudinal and transversal unevenness on the vehicle and driving surface, is shown schematically in Fig. 1 [2].

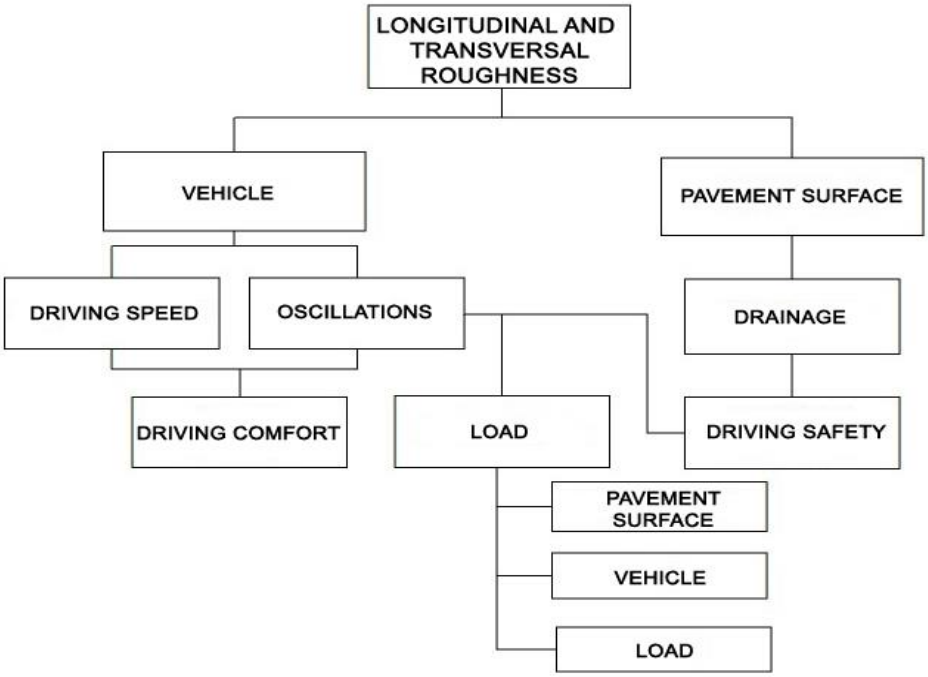

Fig. 1: Scheme of influence of the unevenness, their importance and dependencies

Unevenness of the driving surface has great influence, to that degree that modifies the conditions of the contact between the wheels of the vehicle and the road surface so much, that larger defects that appear can cause altered conditions of reliance of the wheels. It can lead to a significant reduction in the utilization of the existing capacity of the friction of the road that even on dry pavement may result in consequences because of reduced security.

Deformations that occur on the pavement surface are usually caused by the large traffic load, movement of heavy vehicles, poorly chosen and dimensioned structure of road construction, quality of used materials, and the quality of the construction work. It can be concluded that the impact of unevenness reflects on:

- Change - increase of the load;
- Impact on road safety - traffic and
- Impact of comfort - the convenience of driving.

1.2 Transverse Unevenness and Rutting

Transverse evenness of the pavement surfaces is one of the indicators for assessing the condition of the roads, which determines the driving performance. Modern technology for monitoring the roads condition and proper organization of service for maintenance through the Pavement Management System, is of particular relevance to the current state and use of roads, and presents real way for evaluation of the condition of the road surface [3]. To eliminate the unevenness, it is necessary to know the location where they occur, their geometric parameters and their inadequacy of existing norms.

The typical damage detected by measuring the transverse unevenness at pavement constructions is called plastic deformation "rut" [4]. Transverse evenness can manifest consequences that may be the same, and in some cases even larger than the longitudinal evenness. Characteristic effects due to insufficient transverse evenness are [5]:

- Keeping vehicles moving on the same trail;
- Collecting water in the rut;
- Uneven reliance of the vehicle wheels on the road surface.

Extremely important to the safety and driving comfort, as well as assessment of the pavement surfaces is the transverse evenness - rut depth, because the rut collects and retains water (instead drainage), and depth or height of retained water has a crucial influence on the creation of aquaplaning and disruption of traffic safety [6].

The main factors in the appearance of road ruts are: traffic load, the temperature of the road surface, quality and type of used materials and the quality of road construction [7].

Depending on where the deformation occurs in the road structure and what is the reason for the ruts emergence, we distinguish [8]:

- Deformation in the lower formation - insufficient loads of road structure (occurs due to lack of surface loads or pallet; insufficient thickness and / or loads of layers and poor drainage etc. Ruts the appearance in the lower layers, then reflects on the pavement surface) fig. 2.

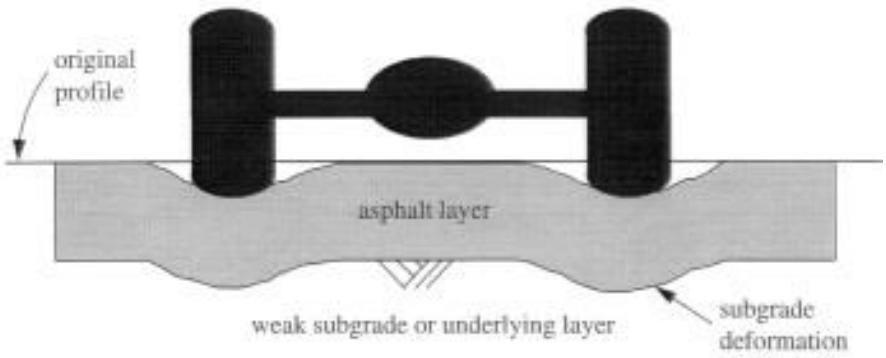

Fig. 2: Rutting in subgrade or base

Deformation in the asphalt layers (occurs because of poor size distribution, too much connective agent - bitumen or filler, the wrong type of bitumen, water damage, heavy traffic and high temperatures on the pavement surface) fig. 3.

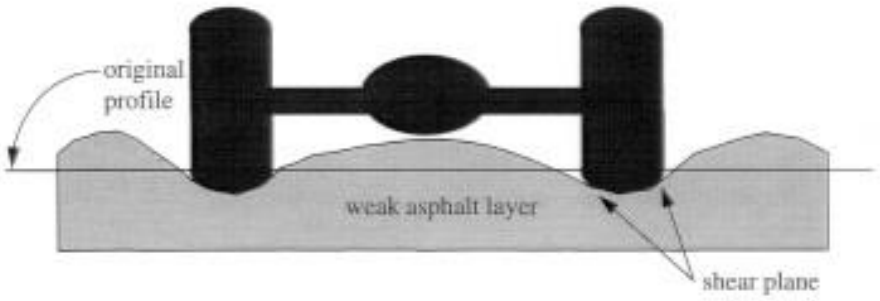

Fig. 3: Rutting in asphalt layers

2 MEASURING THE DEPTH OF THE RUTS ON MOTORWAYS A-4/E-65

Measurements of evenness were done on the motorway A-4, as part of the international road E-65 at 15 km length with the measuring apparatus, high-speed inertial profiler, The Dynatest Road Surface Profilometer, which according to studies conducted in the United States, represents the most precise measurement apparatus for measuring evenness of the pavement surface (Fig. 4) [9].

Fig. 4: Inertial profilometer type: The Dynatest Road Surface Profilometer 5.051 Mark II

The scheme of the measuring apparatus and its operation [10] is shown on the following Figure 5.

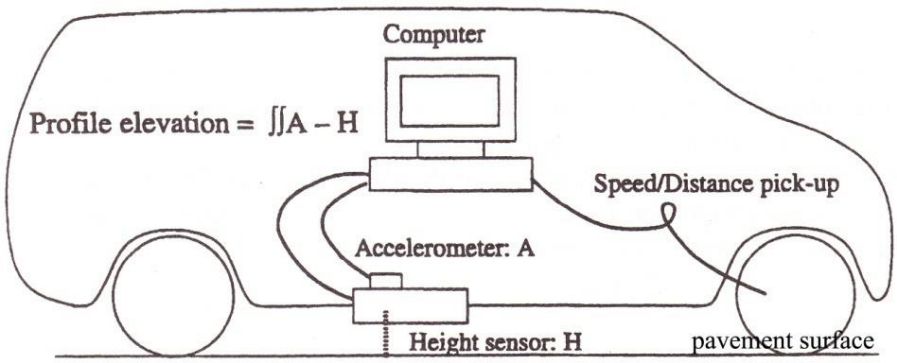

Fig. 5: The scheme of the measuring apparatus The Dynatest Road Surface Profilometer

The evaluation of the condition of the pavement surface in relation to the transverse evenness - "rut depth" was made by Slovenian criteria for rut depth (TSC 06.610:2003) [11] as a function of the speed of movement, according to tab. 1

Tab. 1: Criteria for assessing the condition of evenness of the transverse A-4/ E-65

Limit driving speed on the road	Measurement unit	Depth of water retention	
		Limit H_g	High limit H_{gg}
V ≤ 70 km/h	mm	8	10
V > 70 km/h	mm	4	6

Analyzed and presented data from motorway A-4, refer to its two sections as follows:

- Section M301D (consisting of three sections C10, C20 and C30): Petrovec interchange (overpass No. 32R) - interchange Hipodrom, with a total length of 10,4 km;
- Section M303D (consisting of one section C10): Chento interchange (overpass No. 12) - End of motorway with a total length of 4,6 km;

Road construction on motorway A-4 was designed in 1985 and is dimensioned with the following pavement construction [12]:

- 6,5 cm .... AB 16 C (wearing course of asphalt concrete)
- 7,5 cm .... AB 22 (binding course - Binder)
- 10,0 cm .... BPU 32 (bituminous bearing course)
- 30,0 cm .... mechanically stabilized crashed stone

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54,0 cm .... Overall thickness of road structure with improved liner of 30,0 cm and CBR> 10.

Traffic was measured in 1985 with AADT (Annual Average Daily Traffic) with 10.861 vehicles per day, with the following structure: 6.832 passenger vehicles (PV); 363 vehicles with trailer (OR); 606 light commercial vehicles (LTV); 2.378 heavy trucks (TTV) and 682 buses (BUS).

Traffic measurement with automatic traffic counters type "Sterela" showed that there is a constant increase in traffic and an increase of heavy traffic, as one of the main causes of ruts, despite climatic conditions. In fact, according to the annual report about the size of the traffic on the road network from the Agency for State Roads, a section of motorway A-4 (entrance in Skopje) is with the largest registered traffic loading on the road network in the Republic of Macedonia, with AADT of about 20,000 vehicles per day [13].

2.1 Measured Values of the Depth of the Ruts at the Section M301D

The results of the measured values, and their evaluation according to previously stated standard, for M301D section consists of three sections C10 (Tab.2; Fig.6), C20 (Tab.3; Fig.7) and C30 (Tab.4; Fig.8) from Petrovec interchange to interchange Hipodrom, are presented separately for each section as well as cumulatively for the section M301D [14].

Tab. 2: Measured values of the section M301D C10

Minimum	Average	Maximum	St.Dev.	80%	95%	Data
0.00	0.93	5.80	0.81	1.52	2.16	310

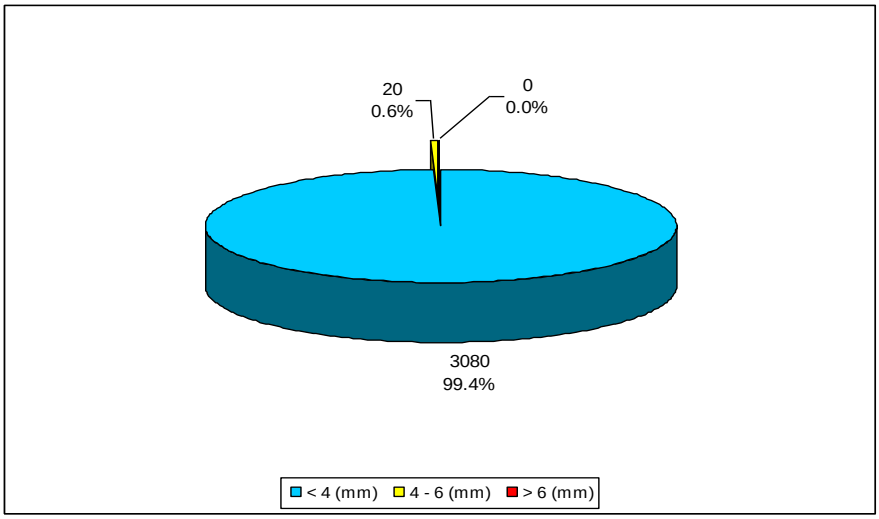

Fig. 6: Evaluation of the condition of pavement surface

Tab. 3: Results from measurements of section M301D C20

Minimum	Average	Maximum	St.Dev.	80%	95%	Data
0.00	4.09	9.60	2.07	6.00	7.41	400

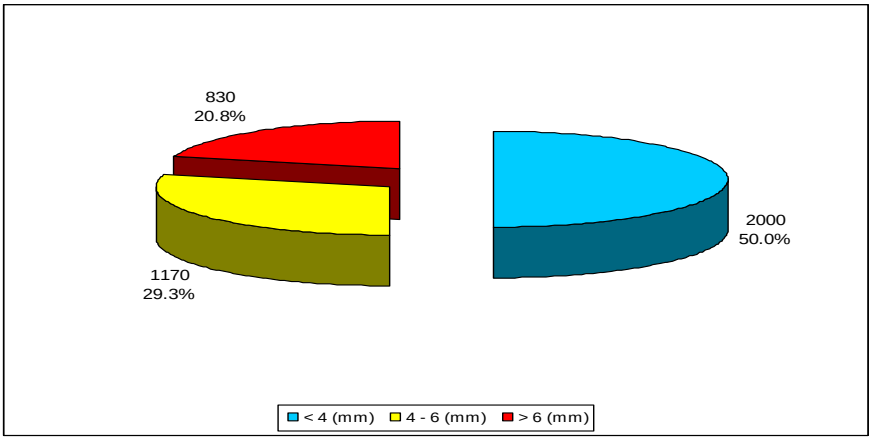

Fig. 7: Evaluation of the condition of pavement surface

Tab. 4: Results from measurements of section M301D C30

Minimum	Average	Maximum	St.Dev.	80%	95%	Data
0.00	8.51	18.70	3.50	11.30	13.26	330

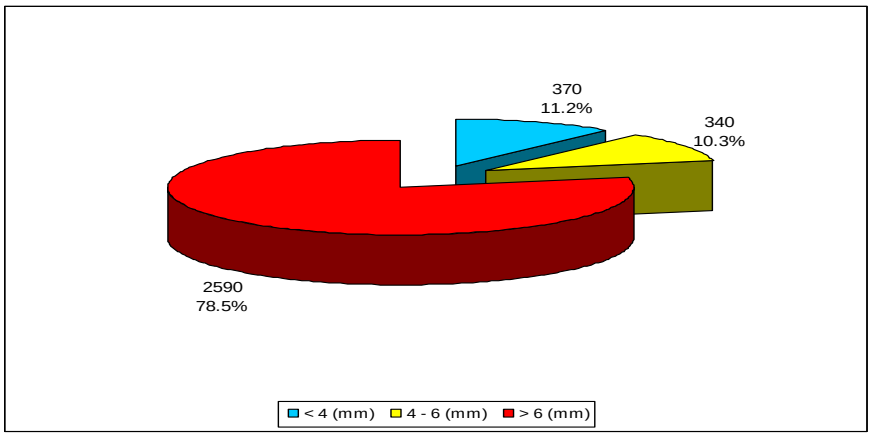

Fig. 8: Evaluation of the condition of pavement surface

Cumulative evaluation of the condition of the pavement surface on section M301D, is presented in Fig. 9

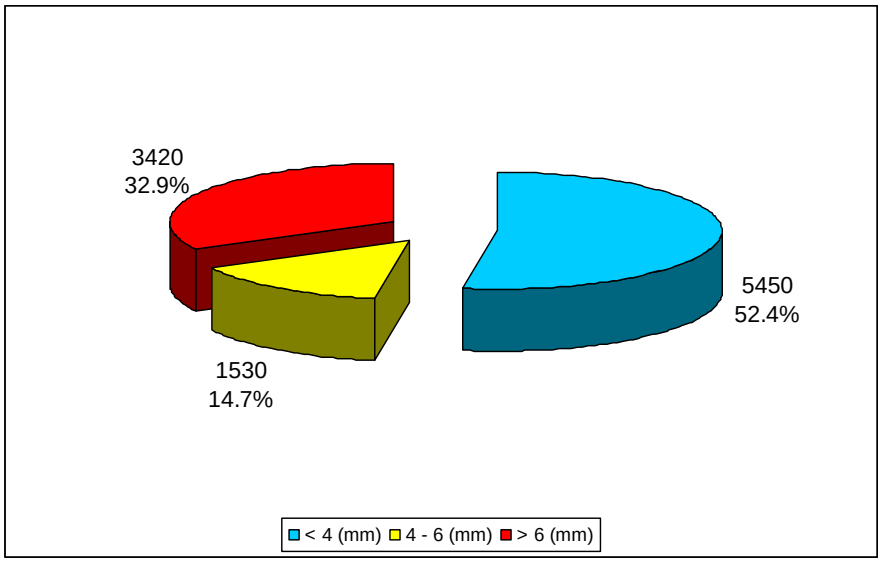

Fig. 9: Evaluation of the condition of total pavement surface M301D

2.2 Measured Values of the Depth of the Ruts at the Section M303D

The results of the measured values, and their evaluation according to previously stated standards, for M303D section consists of one section C10, the interchange Cento - end of the motorway, which are presented in Tab. 5 and Fig. 10 [14].

Tab. 5: Results from measurements of section M303D C10

Minimum	Average	Maximum	St.Dev.	80%	95%	Data
0.00	8.78	29.90	5.68	12.90	20.61	460

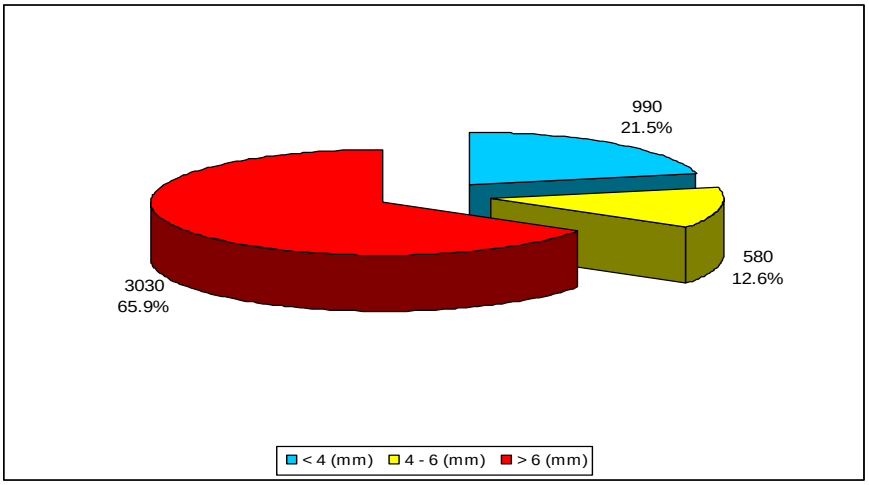

Fig. 10: Evaluation of the condition of total pavement surface M303D

3 PHOTOS FROM THE MEASURED SECTION OF THE MOTORWAY A-4

Several taken photos (Fig. 11 - 16) of the characteristic places on the motorway are presented below. Deformations like ruts with different sizes, are visible on all sections of the motorway [15].

Fig. 11: Beginning of the motorway A-4

Fig. 12: Ruts appearance

Fig. 13: More evident ruts on climb

Fig. 14: Ruts appearance

Fig. 15: Max. ruts size

Fig. 16: End of motorway

4 CONCLUSION

From the measured values, as well as from the conducted evaluation of the pavement surface condition, we may note that the plastic deformations - ruts have appeared on all sections, and situation is quite heterogeneous. The ruts depth ranges from 0,00 mm to 29,90 mm (on the M301D).

It can be concluded that the factors with significant influence on the appearance of transverse unevenness - ruts depth are: traffic load, climatic conditions, the quality of the pavement surface and quality of the used materials. Adding the additives (such as Polymers) in the composition of the asphalt mixture - modified asphalt concrete, contributes to improved endurance, and these asphalt mixtures have greater resistance to ruts appearance at specified temperature, than conventional asphalt mixtures [16].

Added additives in the bitumen can increase longevity of the pavement structure and ruts resistance. Size of the mineral aggregate is also very important. Asphalt mixtures with greater aggregate grain, have the greater resistance to the creation of plastic deformations - ruts [17].

Also, it can be concluded that ruts and possibility of creating aquaplaning are in proportional dependence, because the greater rut depth is, the greater amount of water is retained in them. The amount of water on the driving surface is precondition for creating aquaplaning [1].

The danger of aquaplaning is important because once it occurs, it does not stop, even if it come to a significant reduction of the thickness of the aqueous layer.

As recommendations for improvement of the road network in Macedonia within the Pavement Management System, the following measures can be proposed: adoption of criteria for determining the ruts depth, regular measurements of unevenness - rut depth, evaluation of the condition of transverse evenness and measures for their rehabilitation, use of modified asphalt concrete, improving the drainage capability of driving areas. These are important factors that affect the creation of plastic deformation on the road surface which will finally result in reduction of the potential aquaplaning and increase in the road safety.

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