EVALUACIJA STANJA RAVNOSTI VOZNE POVRŠINE, NA DEONICE KORIDORA VIII U REPUBLICI MAKEDONIJI

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Rezime: Od površinskih karakteristika vozne površine, ravnost vozne površine nameće se kao jedan od glavnih pokazatelja upotrebljivosti voznih površina, sa aspekta brzog, bezbednog i komfornog transporta.

U okviru eksperimentalnog dela razgledavani su i analizirani način i uzroci stvaranja, uticaj, kriterijumi i metode za merenja uzdužne ravnosti voznih površina kod autoputskih deonica, kao i evaluacija stanja voznih površina.

Rezultati analize i evaluacije vozne površine, potvrdila su dosadašnja saznanja da ravnost voznih površina pretstavlja jedan od najvažnijih parametara za njeno stanje.

Iskustva u svetu govore da je utvrđivanje kriterijuma ravnosti - indeks IRI, doprinelo boljim projektantskim rešenjima i tehnološkom unapređenju u izgradnji puteva, što je rezultiralo sa postizanjem veće ravnosti voznih površina.

Ključne reči: *podužna ravnost, neravnost, Međunarodni indeks ravnosti - IRI.*

EVALUATION OF ROUGHNESS OF PAVEMENT SURFACE ON SECTION ON CORRIDOR VIII IN REPUBLIC OF MACEDONIA

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Abstract: The surface characteristics of the driving surface, impose the level of the driving as one of the main indicators for usability of the driving surfaces, from the aspect of fast, safe and refined transport.

Within the experimental part, we analyzed the manner and causes of creation, the influence, criteria and methods for measuring the longitudinal roughness of the driving area in the highway sections, as well as the evaluation of the condition of the driving surface.

The results of the analysis and the evaluation of the driving surfaces so far confirmed that the level of the driving surface is one of the most important parameter for its condition.

Experience in the world suggests that the setting of roughness criteria - the IRI index, contributed for better design solutions and technological advancement in road construction, resulting in a higher level of evenness on the driving surfaces.

Keywords: longitudinal evenness, unevenness, International Roughness Index - IRI.

1. INTRODUCTION

For the participants in the road traffic, an evenness (the vertical difference between the level of the projected and derived condition of the driving surface) is of particular interest and presents one of the first features of the road that they notice. Depending on the speed and characteristics of the vehicle, an evenness (longitudinal and transverse), significantly increases the oscillations of the vehicle, which cause additional increased dynamic load on the road surface and the vehicles, resulting in an impact on the economy of the transport. At the same time, there is reduced convenience and driving comfort, as well as the most significant - traffic safety. The geometric irregularity of the driving surface is also transferred both to the vehicle and to the driver, in the form of vertical shifts, which the driver feels at the level of its seat.

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The roughness of the driving surface has a great impact, and at the same time changes the conditions of contact between the wheels of the vehicle and the pavement surface, to such an extent that greater irregularities can cause altered wheel suspension conditions. This can lead to a significant reduction in the utilization of the existing abrasion abilities of the pavement, which, even in the dry pavement, may result in certain consequences. According to this it can be concluded that the roughness of the driving surface is imposed as one of the main indicators for usability of the driving surfaces. The influence of longitudinal and transverse unevenness on the vehicle and the driving surface, is shown in Fig. 1 [1].

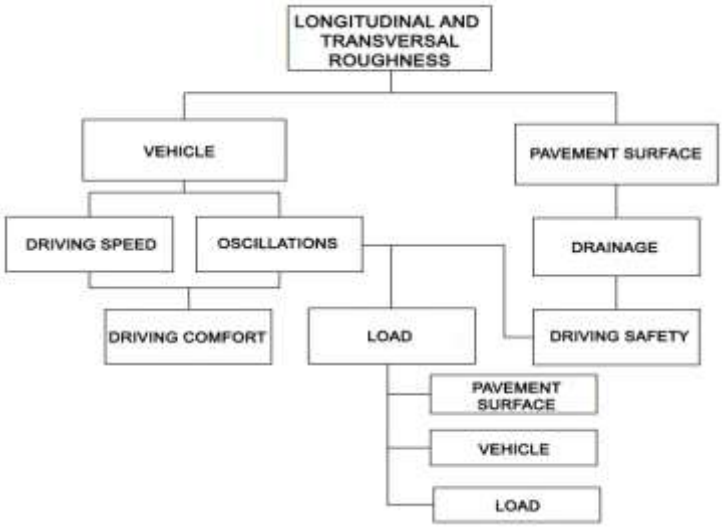

Figure 1. *The influence on the evenness effects, significance and dependence*
*Source: (*Mijoski, G. 2010. *Integral approach to the evaluation of attributes and indicators of pavement surface)*

The unevenness of the pavement surface after traffic load can appear as two different types of deformations: longitudinal and transverse type [2].

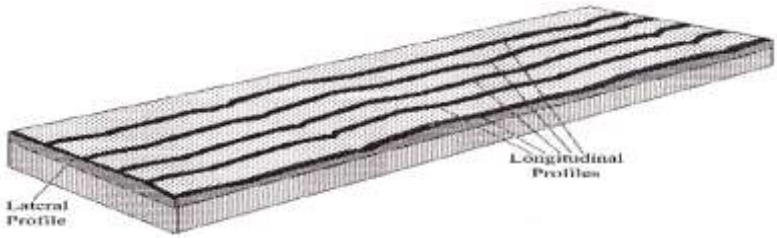

Figure 2. *Types of unevenness of pavement surface*
Source: (Sayers, M.W.; Karamihas, S.M., 1998. The Little Book of Profiling)

The deformations of the pavement surface are most often caused by the heavy traffic load, heavy vehicles, the inadequately selected and dimensioned structure of the pavement structure, the quality of the materials it was built from, as well as the quality of the performed construction work.

2. CRITERIA FOR EVALUATION OF ROUGHNESS

2.1. General criteria

According to the technical regulations for measuring of the level of roughness in the Republic of Macedonia, it is measured with a measuring lath with a length of 4 m, and a criterion or permitted deviation, or the permitted deviation (deviation) is:

- 4 mm for roads with heavy and very heavy traffic and
- 6 mm for roads with light traffic [3].

It is particularly important to point out that this standard does not make a distinction between the newly constructed roads and roads in exploitation.

Based on experiments for roughness conducted on the driving area in Brazil [4,5,6] the International **Roughness Index -** IRI [m / km] set by The World Bank [7], was defined as the main parameter for evaluation of the pavement surface (Figure 3), and then other surveys were conducted in Europe, the United States and Japan [8].

The IRI parameter is used in most countries of the European Union and the United States. The measurement of the IRI level index, is one of the most important parameters used in the computer programs for managing the pavements (for example, HDM-4, The World Bank). The index is monitoring the condition of the road surface from the aspect of road management and planning the maintenance of the pavement construction. It is particularly important to point out that with this standard, there is no distinction between newly constructed roads and roads in exploitation [9].

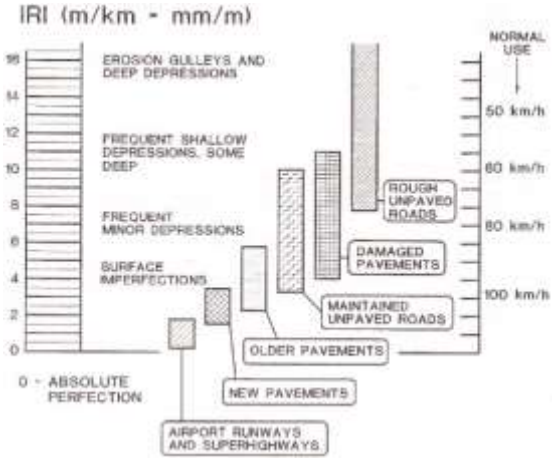

Figure 3. *The IRI Roughness Scale*
*Source: (*Shahin, M.Y. 2005. *Pavement Management for Airports, Roads, and Parking Lots.)*

2.2. Criteria for evaluation of pavement surface

The criteria used for an evaluation of the condition of the driving pavement and its longitudinal evenness in the area of the corridor sections of Corridor VIII, are according to the class - range of roads expressed with annual average daily traffic (AADT) for roads in exploitation. The criteria for evaluation are in relation to the international IRI index [m/km] according to the regulations of the Republic of Slovenia (Table 1).

Table 1. *Criteria for evaluation of the pavement roughness*
Source: (Technical specifications for public roads – TSC 06.610 - R. Slovenia)

Separation by size of traffic	**Evaluation of the situation**				
	Very good	**Good**	**Average**	**Bad**	**Very bad**
	Size of the index of roughness IRI_{100}				
Medium or high density of traffic (AADT > 2.000 vehicles/day) **and medium or heavy traffic** (> 80 NOO 82 KN/day)	< 1,2	1,2 - 1,5	1,5 - 2,2	2,2 - 3,1	> 3,1
Low density of traffic (AADT ≤ 2.000 vehicles/day) **and light traffic** (≤ 80 NOO 82 KN/day)	< 2,6	2,6 - 3,5	3,5 - 4,3	4,3 - 4,9	> 4,9

We already said that the existing criteria for evaluation of the pavement roughness in the Republic of Macedonia are outdated and not applicable [10]. As a criteria for evaluation, medium or high density of traffic (AADT>2.000 vehicle/day) and medium or heavy traffic (> 80 NOO 82 KN/day), had been used (Table 1).

3. MATERIALS AND METHODS

Measuring the roughness of the road surface was carried out by PE for State Roads, with a measuring device such as high speed inertial profile, Dynatest Road Surface Profilometer [11]. According to a survey conducted in the United States by the Texas Department of Transportation (TX DOT), for the accuracy and quality of the damped Roughness, several measuring instruments have been analysed, and it has been found that high-speed inertial Profilometer are the best measuring devices [12].

Figure 4. *High speed inertial profiler The Dynatest Road Surface Profilometer 5051 Mark II*
Source: (Own Figure)

When performing the measurements for the roughness of the pavement surface on certain sections, we calculated the following statistical sizes:

- Minimum value of the index of roughness IRI_{100} (Min)
- Maximum value of the index of roughness IRI_{100} (Max)
- The average value of the index of roughness IRI100 (Med)
- 80% appearance of the index of roughness IRI100 (0,80)
- 95% appearance of the index of roughness IRI100 (0,95).

4. RESULTS

4.1. Measuring of the roughness on the Motorway A2 section: Hipodrom - Miladinovci

The analyzed section of the A2 motorway is long 10,4 km and extends between the two interchanges. The results from the measurement are shown in Fig. 5 and 6, and the evaluation of the roughness is shown on the circular diagram on Figure 7.

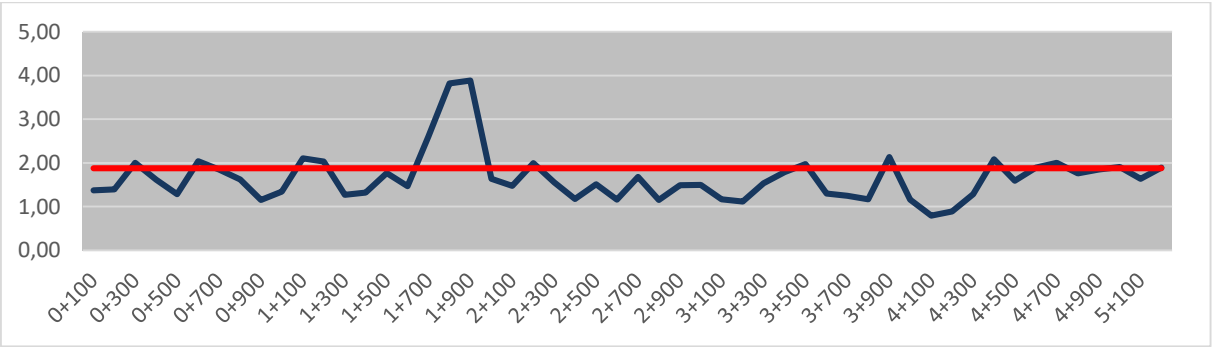

Figure 5. *Results on section L1=5, 2 Km*

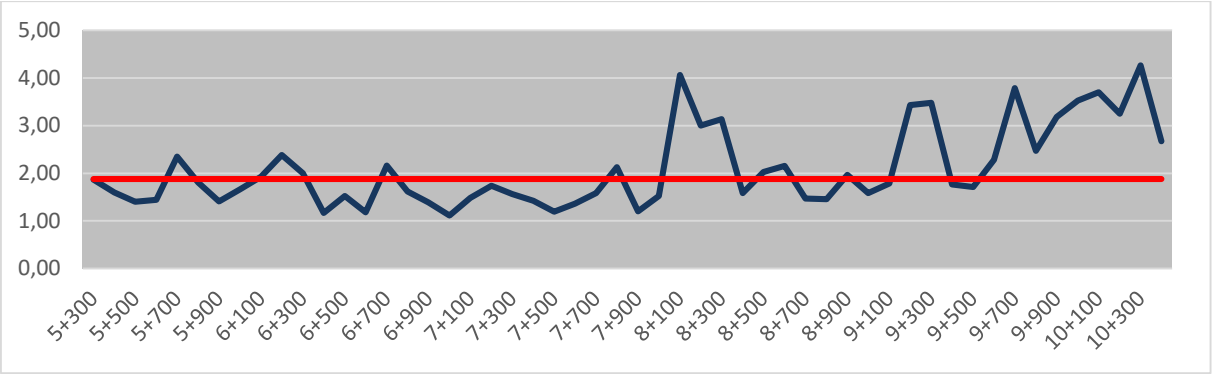

Figure 6. *Results on section L2=5, 2 Km*

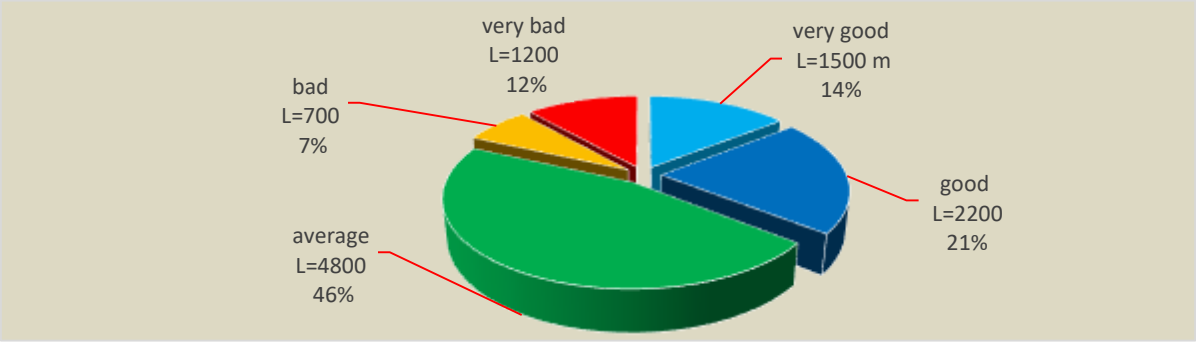

Figure 7. *Evaluation of the roughness of the Motorway A2 with length L = 10, 4 km*

Table 2. *Statistic value of the measured section*

	Min.	Avg.	Max.	St. Dev.	80%	95%	Number of data
IRI_{100}	0,80	1,88	4,27	0,75	2,14	3,67	104

4.2. Measuring of the roughness on the State road A2 section: Kumanovo - border crossing Deve Bair

The analyzed section of the state road A2 with the length L = 73,5 km is at the level of the national road. The results from the measurement are shown in Figures 8-17, and the evaluation of the roughness is present on the circular diagram of Fig. 18.

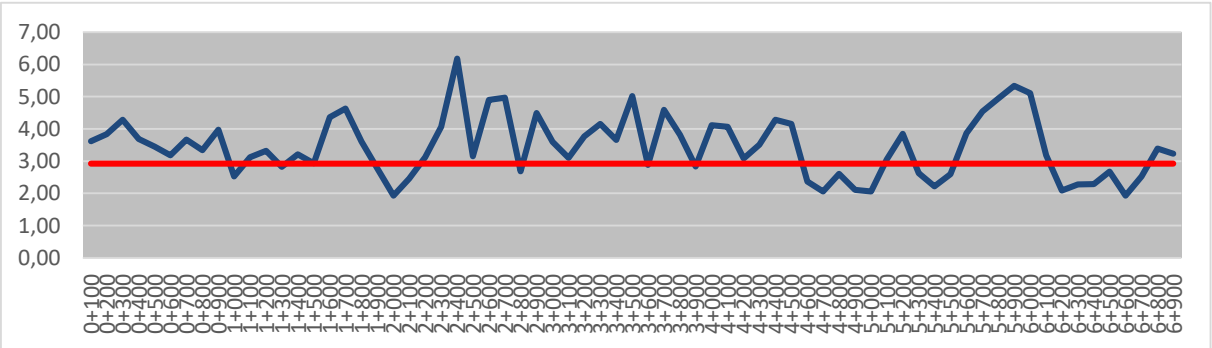

Figure 8. *Roughness at km 0,0 to km 7,0 km with L_1=7,0 km*

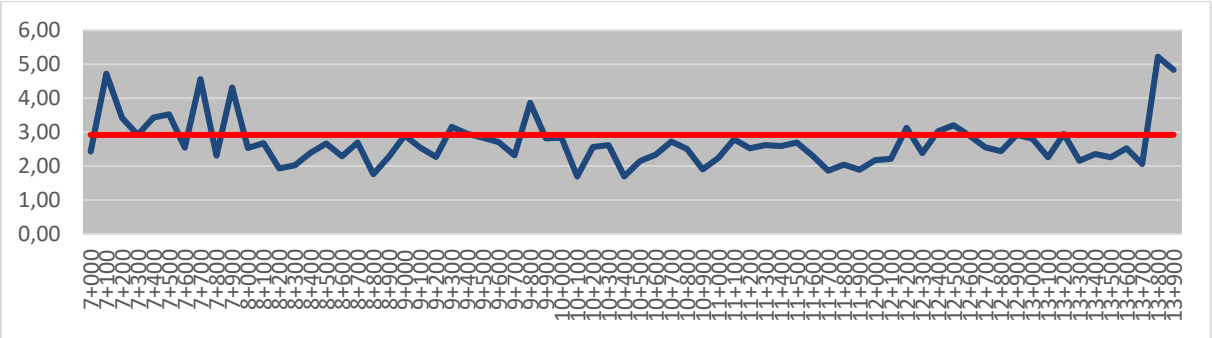

Figure 9. *Roughness at km 7,0 to km 14,0 km with L_2=7,0 km*

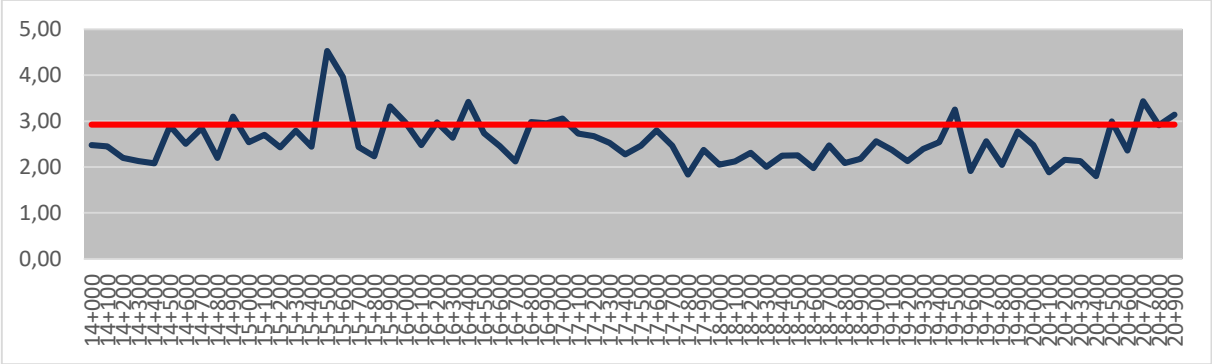

Figure 10. *Roughness at km 14,0 to km 21,0 km with L_3=7,0 Km*

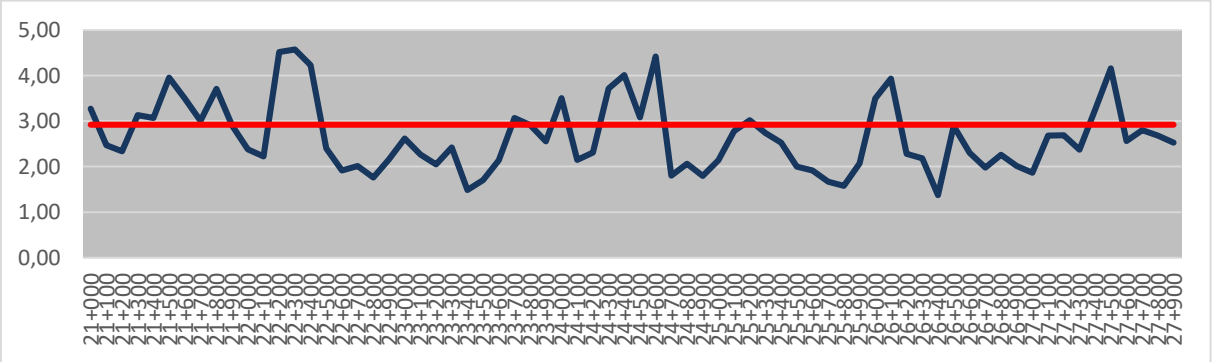

Figure 11. *Roughness at km 21,0 to km 28,0 km with L_4=7,0 Km*

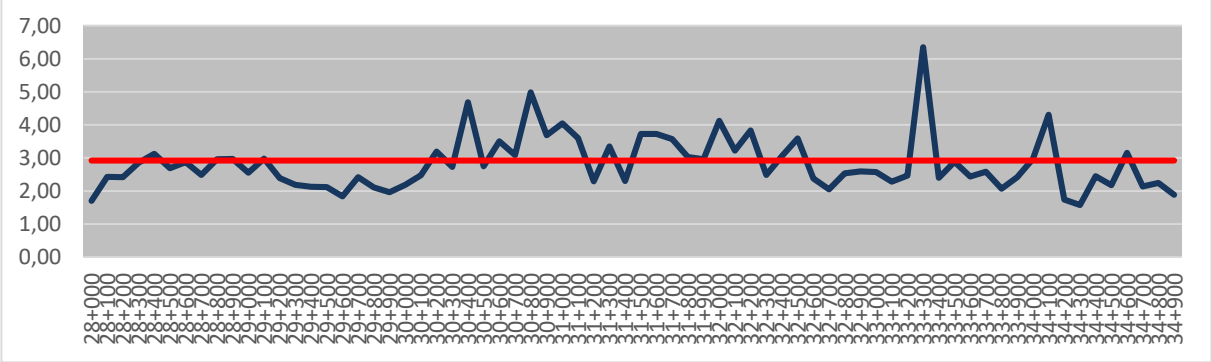

Figure 12. *Roughness at km 28,0 to km 35,0 km with L_5=7,0 km*

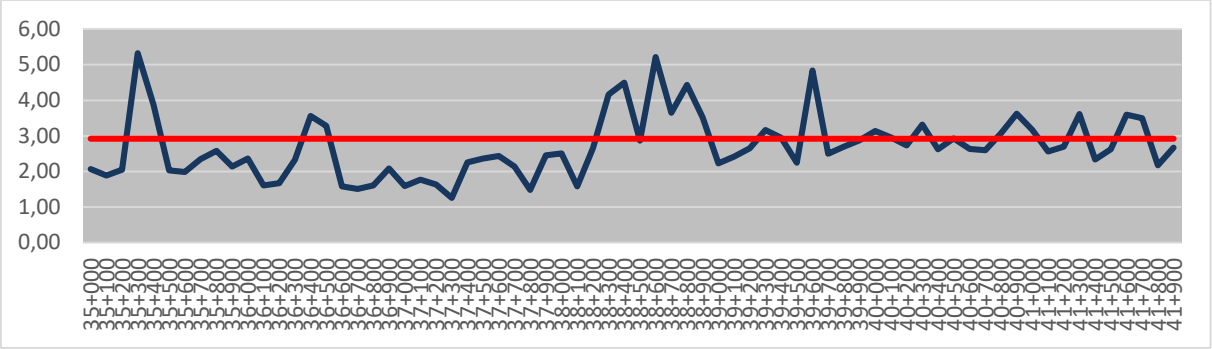

Figure 13. *Roughness at km 35,0 to km 42,0 km with L_6=7,0 km*

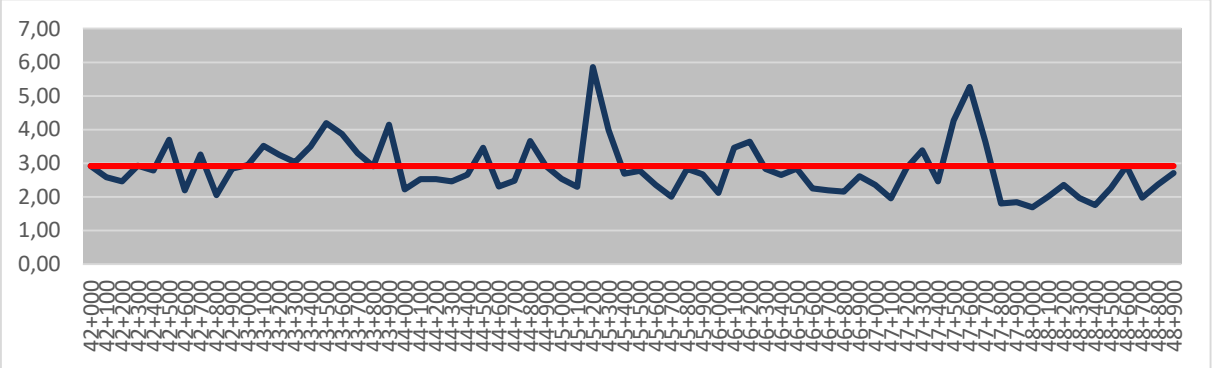

Figure 14. *Roughness at km 42,0 to km 49,0 km with L_7=7,0 km*

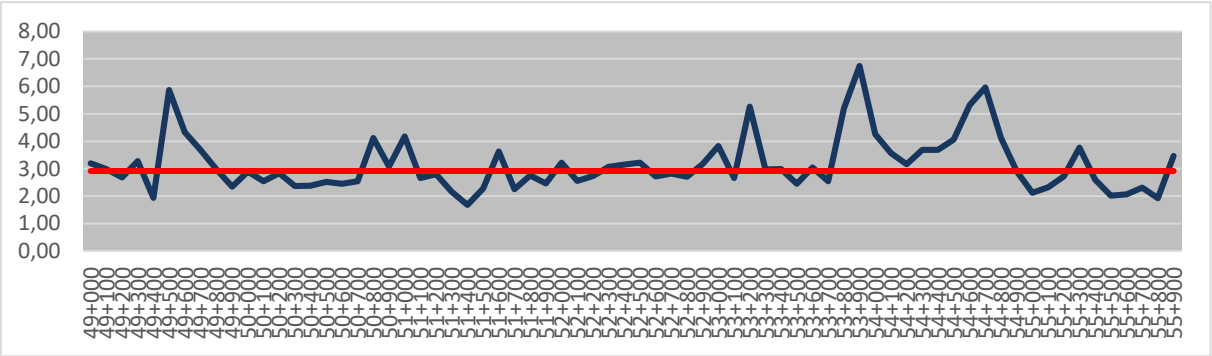

Figure 15. *Roughness at km 49,0 to km 56,0 km with L_8=7,0 km*

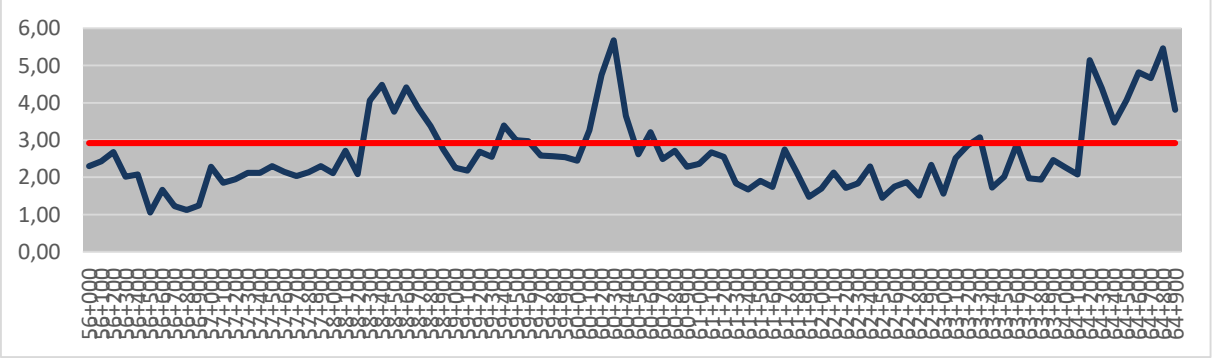

Figure 16. *Roughness at km 56,0 to km 65,0 km with L_9=9,0 km*

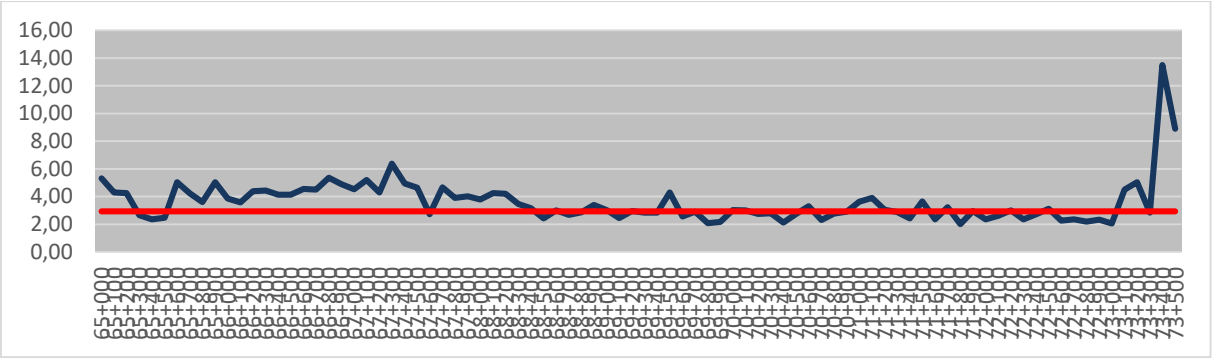

Figure 17. *Roughness at km 65,0 to km 73,5 km with L_{10}=8,5 km*

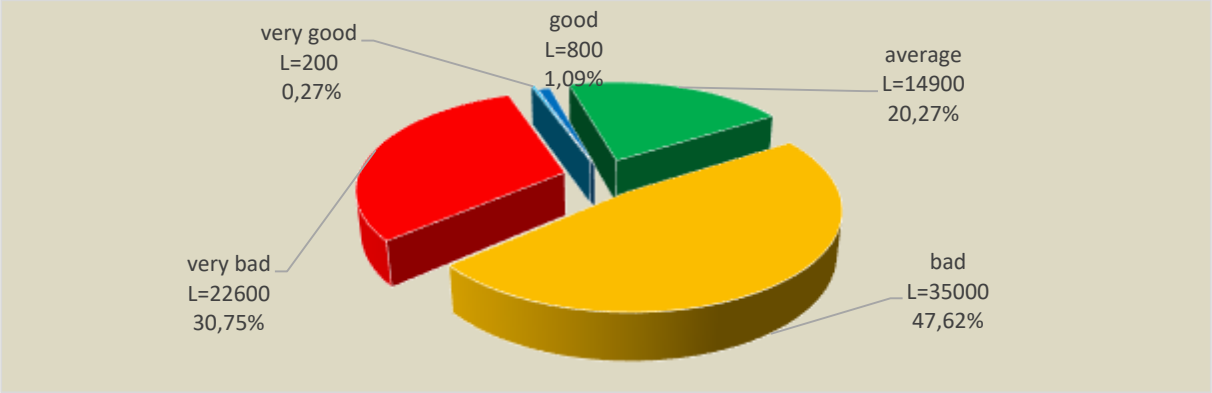

Figure 18. *Evaluation of roughness on State road A2 with length L=73,5 km*

Table 3. *Statistic value of the measured section*

	Min.	Avg.	Max.	St. Dev.	80%	95%	Number of data
IRI_{100}	1,05	2,92	13,51	1,02	3,60	4,77	735

5. CONCLUSION

The adoption of effective decisions in managing road networks requires competent authorities for roads in the country, as well as their managers, to have enough knowledge of surface and structural condition of the roads at all times. Information on the level of service, constructive capacity, surface conditions and road safety should be assessed and properly used within the relevant model for pavement management system (PMS), as well as economic analyzes. It is not possible to do quality control only with possession of the proper monitoring equipment. Caring out a quality assessment of the condition of the road requires accurate and reasonable criteria, as well as professionals - civil engineers specialized for roads. They will lead the process of monitoring and assessing the situation, and afterwards carry out the expertise and deliver quality decisions in the road management system.

It can be concluded that with the new technical regulations for public roads roughness, it is necessary to define: the basic measurement procedures; measuring equipment; the methods of measurement and criteria for assessment of the situation.

As a general evaluation tool for assessing driving comfort, in EU countries it is recommended to measure 100 meters sectors, and with its acceptance it would be compatible with European standards. The criteria should be in accordance with the road class and the level of traffic for newly built road sections, and criteria for road sections in exploitation and road sections should be prepared after the end of the warranty period. So far, for the assessment of the roughness of the driving surfaces it can be suggested:

- Measurement of 20 meter road sections (IRI_{20}) in newly built roads;
- Measurement of 20 meter road sections (IRI_{20}) in newly built roads after the end of the warranty period;
- Measurement of 100 meter road sections (IRI_{100}) on roads in exploitation.

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