ISSN NO: 2770-0003
Date of Publication: 12-04-2022

Investigation the Network of Highways of International Importance the Republic of Uzbekistan

Aziz Khalmukhamedov,
Kudrat Kutlimuratov*
Doctor of technical science, Professor, Department of Vehicle Engineering, Tashkent State Transport University, Tashkent, Uzbekistan, Phone: +998(71)286-19-03, E-mail: khalmuka@gmail.com
*Senior lecturer, Department of Transport Intellectual Systems Engineering, Tashkent State Transport University, Tashkent, Uzbekistan, Phone: +998(71)286-19-03, E-mail: qudratq@gmail.com

Abstract: The efficiency of a state economy depends on a quality of highways. One of the important indicators of the quality of roads is road roughness, which determines the possible permissible speed of vehicle movements, as well as the associated traffic safety and cost of transportation. In a comprehensive solution to the problem of reducing the cost of transportation on roads play an important role, not only the costs of repairing and maintaining the roads themselves, but also the costs of organizing traffic safety, repairing and maintaining the vehicles themselves.
The lack of data on the actual state of highways does not allow us to determine the rational speed of movement of transports, depending on the specific indicators of the road roughness and the parameters of moving vehicles. The Committee on Roads under the Ministry of Transport of the Republic of Uzbekistan set the task of examining and assessing the entire road network of the country. This study will help establish a list of maintenance priorities and provide reliable data for assessing road performance. At the first stage, the task was set to study the longitudinal road roughness of the network of highways of international importance. Highways of international importance, with a length of slightly more than 9% of the total length of the public road network, provide about 40% of all road transport and 100% of all transit road transport. The paper presents results of a study of the international road roughness the example of the international motor road M39.

Key Words: Transport roads, Highways of international importance, International road roughness, Technical and operational performance of road transport, Efficiency of road transport.

I. Introduction

It is known that the efficiency of the state economy depends on the quality of highways. One of the important indicators of the quality of roads is road roughness, which determines the possible permissible speed of movement of vehicles, as well as the associated traffic safety and cost of transportation. The speed of movement of freight road transport is determined by a number of variable factors, one of the most important among them is the roughness of the surface of the road surfaces. This defect significantly affects the decrease in the speed of trucks and, ultimately, the decrease in the efficiency of road transport. In the studies carried out, the dominant scientific direction was the economic aspect, which does not affect the technical component of the problem - the mechanism of the forced decrease in the speed of trucks due to the presence of irregularities on the surface of the road surfaces. This approach does not allow making the right decisions on the prompt and timely elimination of irregularities and the establishment of a rational speed and efficiency of freight traffic.
In a comprehensive solution to the problem of reducing the cost of transportation on roads, not only the costs of repairing and maintaining the roads themselves, but also the costs of organizing traffic safety, repairing and maintaining the vehicles themselves, that is, directly consumers of communication services, play an important role. Analysis of literature sources shows that the use of well-known methods is no longer enough to create high-quality highways and reduce the cost of their repair and maintenance. Today, a new comprehensive approach to solving this complex technical and economic problem is in demand, requiring the development and application of new scientific principles, including, in particular, virtual modelling of the interaction of trucks with the investigated uneven road section. Insufficient development of such a methodology does not allow determining the rational speeds of movement of trucks, depending on the specific indicators of the road roughness index and the parameters of moving vehicles.

ISSN NO: 2770-0003
Date of Publication: 12-04-2022

Road roughness is an important indicator of the comfort and safety of driving on the road. The roughness of the road surface consists of random multi-frequency waves of many wavelengths and amplitudes. Longitudinal road roughness is defined as "longitudinal deviations of the road surface from a true flat surface with characteristic dimensions that affect vehicle dynamics, ride quality and dynamic load on the road surface" [2-3]. The International Roughness Index (IRI) summarizes the roughness characteristics that affect the response of the vehicle and is most appropriate when a roughness measurement is required that relates to: total vehicle operating costs, overall ride quality, dynamic wheel loads (i.e. heavy road damage by trucks and the braking and turning safety restrictions available to light vehicles) and the general surface condition [4-5]. Performance assessment includes a functional analysis of road surfaces based on a history of ride quality. Ride comfort and road surface characteristics can be conveniently measured in terms of roughness and damage to the road surface. Thus, various models have been developed linking roughness with defects to predict the characteristics of the road surface [6]. The performance of a pavement is a function of its relative ability to handle traffic over a period of time. Typically, an objective measurement system is used to quantify the condition and performance of road surfaces.

In 2021, the Committee on Roads under the Ministry of Transport of the Republic of Uzbekistan set the task of examining and assessing the entire road network of the country. This study will help establish a list of maintenance priorities and provide reliable data for assessing road performance. The total length of public highways, in total - 42695 km, including: - highways of international importance - 3981 km; highways of national importance - 14,100 km; motor roads of local importance - 24614 km. At the first stage, the task was set to study the longitudinal road roughness of highways of international importance. Highways of international importance (Fig. 1, Table 1), make up slightly more than 9% of the total length of the public road network, providing about 40% of all road transport and 100% of all transit road transport.

Fig 1. Highways of international importance of the Republic of Uzbekistan

Table 1. Information about highways of international importance of the Republic of Uzbekistan

N	Highway number	Name of the roads	Length, km
1.	**M34**	**Tashkent - Dushanbe** (Tashkent - Yangiyul - Chinoz - Syrdarya - Gulistan - Khavas - Dushanbe, on the territory of the Republic of Uzbekistan)	160
2.	**M37**	**Samarkand - Bukhara - Turkmenbashi** (Samarkand - Ishtikhon - Kattakurgan - Karmana - Bukhara - Alat - Chorjoi, on the territory of the Republic of Uzbekistan) Transport outlets:	365
		a) Samarkand ring road	46
		b) Navoi Free industrial-economic Zone "	2
		Included all outlets	413

ISSN NO: 2770-0003
Date of Publication: 12-04-2022

N	Highway number	Name of the roads	Length, km
3.	**M39**	**Almaty - Bishkek - Tashkent - Shakhrisabz - Termez** (Shymkent, border of the Republic of Kazakhstan - Gishtkoprik - Tashkent - Chinaz - Jizzakh - Samarkand - Shahrisabz - Guzar - Termez, on the territory of the Republic of Uzbekistan)	628
		Outlets:	
		a) Hayraton entrance road (on the territory of the Republic of Uzbekistan)	30
		b) Tashkent ring road	67
		Included all outlets	725
4.	**M41**	**Bishkek - Dushanbe - Termez** (Osh and Khorog, border of the Republic of Tajikistan - Denau - Jarqurghon - Termez)	191
5.	**A373**	**M39 highway - Gulistan - Boka - Angren - via Kokand and Andijan - Osh** (M39 highway (918 km) - Sardoba - Buka - Ahangaron - Angren - Kokand - Shahrihan - Andijan - Osh, on the territory of the Republic of Uzbekistan)	475
		Outlets:	
		a) to Tashkent city	45
		б) to Kokand city (208 - 274 km)	66
		Included all outlets	586
6.	**A376**	**Kokand - Jizzakh** (Kokand - Besharik - the territory of the Republic of Tajikistan, via Konibodom and Khojand, Bekabad - Khavas - Jizzakh)	168
7.	**A377**	**Samarkand - Ayniy** (On the territory of the Republic of Uzbekistan)	37
8.	**A378**	**Samarkand - Guzar**	152
9.	**A379**	**Navoi - Uchkuduk** (Through the city of Zarafshan)	289
10.	**A380**	**Guzar - Bukhara - Nukus - Beyneu** (Guzar - Karshi - Mubarek - Bukhara - Toprakkala - Beruni - Nukus - Khojaly - Kungrad - the border of the Republic of Kazakhstan, Beyneu)	1204
		Outlets:	
		a) Bukhara rong road	42
		Included all outlets	1246
11.	**A381**	**Khujayli – Toshovuz** (On the territory of the Republic of Uzbekistan)	12
		Total highways of international importance	3979

II. Method and Methodology

2.1. Road roughness

Road roughness is one of the most important indicators of the characteristics of the road surface and most often the factor determining the road surface as a candidate for maintenance, restoration and reconstruction [10]. Comprehensive measurement of the condition of the pavement will require data on other indicators of pavement performance, such as deflection, traction and deflection.

Table 2 shows the required values of the road roughness index for the motor road of the Republic of Uzbekistan in accordance with the normative document rules for diagnostics and assessment of road conditions [14]

ISSN NO: 2770-0003
Date of Publication: 12-04-2022

Table 2. Required values of road surface roughness for highways

Highway category	Maximum permissible values of IRI m/ km	
	upon commissioning	during operation
I A+I B	1,4-1,6	3,0
II	1,7-1,8	3,5
III	2,0	4,5-5,0
IV	2,6	5,0-5,5
V		6,0

The PKR-2 device is a World Bank class 1 roughness measuring device installed on the mobile road laboratory (MRL) "Trassa" (Fig. 2). This study used the test procedures established by the World Bank in TP-46 and ASTM E950 [11-12]. The MRL "Trassa" test system can collect a wide range of information, ranging from ride quality measurements (International Roughness Index and trip number) to high accuracy lateral and longitudinal inertial profiles, as well as geometric information such as lateral and longitudinal pitch, and curve radius or angle of the curve. MRL "Trassa" calculates, displays and stores the longitudinal and transverse profile, as well as road roughness index, and cross-section measurements in real time and at highway speeds. MRL "Trassa" can measure the texture of the road surface and defects. In the middle of the vehicle, 2 laser sensors, 2 accelerometers and an inertial motion sensor were installed. MRL "Trassa" can collect data at speeds up to 110 km/h (recommended speed, 70 km / h).

Fig 2. The IRI system for measuring the road roughness and operation of the PKR-2 laser profilometer at the MRL "Trassa"

2.2 Road measurements

The roads were measured using the PKR-2. Road roughness measurements were carried out for the right traffic lanes. For split two-lane roads, both directions were surveyed. The measurements are taken at normal driving speed (70 km / h), located using DGPS (satellite support) and supplemented with digital photographs of the road situation and the surface.

2.3 Data analysis

Doroga-PRO special measuring computer program software was used to analyze the data. The computer program has the meaning of GPS coordinates and Google Earth Map. It was used to analyze roughness data. IRI is calculated from the track profile of the left and right wheels. In Fig. 3 shows the example of results of the Doroga-PRO program with a length of 20 m. (This length of 20 m is optional).

ISSN NO: 2770-0003
Date of Publication: 12-04-2022

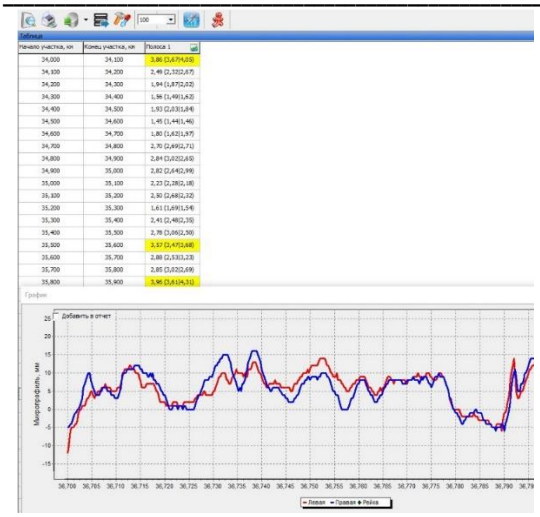

Fig 3. Example of Doroga-PRO software view

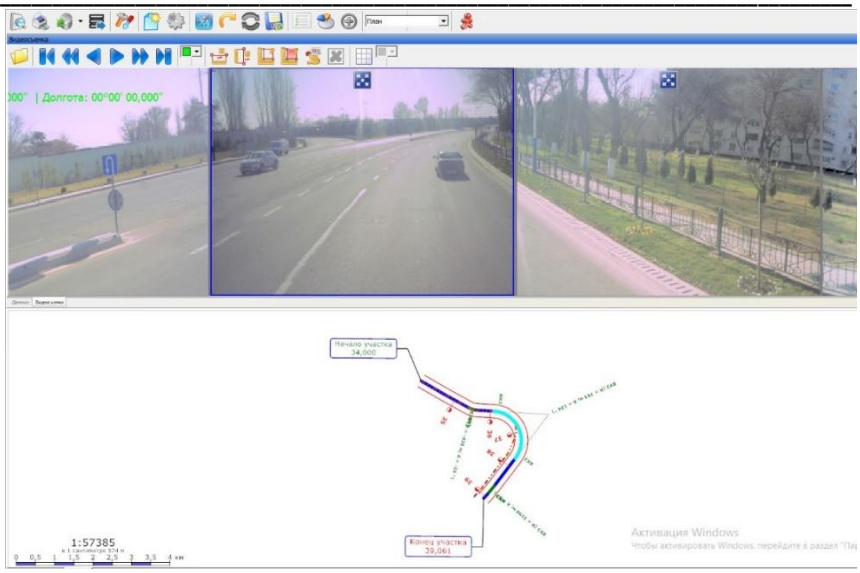

Fig 4. Software Doroga-PRO view

The program Doroga-PRO was used to view inventory and surface images, as well as road roughness values for a length of 20 m. Fig.4 shows the view of the software, which contain the IRI profile, global coordinate and map. Measurements were taken every 20 meters and stored in digital format. Unitary Enterprise "Yul loiha expertise" processed the obtained data, combined them into longer homogeneous sections and implemented them in the road database module for the road surface management system.

III. Experimental Results

In 2016, studies of the road roughness on the international highways were carried out. They are: M34 “Toshkent – Dushanbe” (90.66 km); A373 “M39 highway - Guliston - Buka - Angren - Kokon and Andijon – Ush” corridor (82.2 km); M39 “Almaty - Bishkek - Tashkent - Shakhrisabz – Termiz” corridor (65 km); A373a from A373 road to Tashkent city outlet (44 km); M39b “Tashkent ring road” (83.5 km), with a total length of 363 km of the international road network. The results of the study are shown in Table. 3.

Table 3. Summary data of the road roughness of highways of international importance.

ISSN NO: 2770-0003
Date of Publication: 12-04-2022

№	Road	Road category	Studied length	Maximum permissible indicators of longitudinal roughness according to the IRI indicator during operation, m / km	Average value of longitudinal roughness index according to IRI index, m / km	The share of the route where the permissible values of longitudinal roughness are fixed according to the IRI indicator, %	The share of the route where inadmissible values of longitudinal roughness were recorded according to the IRI indicator, %
1	M34 "Tashkent – Dushanbe" 160 km	I	59 km	3.0	5,8	39,38 km (43%)	51,28 km (57 %)
		II	39 km	3,5	5,93		
		III	7 km	4,5-5,0	6,66		
2	A373 "M39 - Guliston - Buka - Angren - Kokon and Andijon- Ush" 475 km.	I	78 km	3,0	4,09	32,8 km (40 %)	49,4 km (60 %)
3	M39 Almaty - Bishkek - Tashkent - Shakhrisabz - Termez 628 km.	I	65 km	3,0	3,92	20,6 km (32 %)	44,4 km (68 %)
4	A373a from A373 road to Tashkent city outlet 45 km.	I	45 km	3,0	4,11	13,80 (31 %)	30,2 km (69 %)
5	M39b Tashkent rign road 67 km.	I	70 km	3,0	3,38	46,5 km (56 %)	37,0 km (44 %)
	In total, along the surveyed highways of international importance of the Republic of Uzbekistan	I	317	3,0	4,26	153,08 km (42 %)	212,28 km (58 %)
		II	39 km	3,5	5,93		
		III	7 km	5,0-5,5	6,66		

The analysis of the data obtained in the course of this study on the longitudinal roughness of the road surface according to the IRI indicator showed that:

- on the M34 highway - 43% of the measurements meet the requirements, 57% of the measurements do not meet the requirements;
- on the M39 highway - 32% of the measurements meet the requirements, 68% of the measurements do not meet the requirements;
- on the A373 highway - 40% of measurements meet the requirements, 60% of the measurements do not meet the requirements;
- on the A373a highway - 31% of measurements meet the requirements, 69% of the measurements do not meet the requirements

ISSN NO: 2770-0003
Date of Publication: 12-04-2022

- on the M39b highway - 56% of measurements meet the requirements, 44% of the measurements do not meet the requirements;

- all along the surveyed highways of international importance - 42% of the measurements meet the requirements, 58% of the measurements do not meet the requirements;

- the smallest average value of the longitudinal roughness indicator according to the IRI 3.38 indicator was recorded on the M39b highway;

- the highest average value of the longitudinal roughness index in terms of IRI 6.66 was recorded on the M34 motorway;

- the smallest share of the route where unacceptable longitudinal roughness indicators were recorded according to the IRI indicator of 44% was recorded on the M39b highway;

- the largest share of the route where unacceptable longitudinal roughness indicators were recorded according to IRI 69% was recorded on the A373a highway.

In 2021, studies of the roughness of the road surface of the entire network of international highways began.

Let us consider the results of a study of the longitudinal roughness of the road surface of the M39 Almati - Bishkek - Tashkent - Shahrisabz - Termiz corridor road of international importance, namely, the 806-871 km section with a length of 65 km, in 2016 and 2021. Table 4 shows summary data on the study of the road roughness of the M39 international highways in 2016 and 2021.

Table 4. Summary data on the study of the road roughness of the M39 international road.

№	Name of road	Road category	Sector	Maximum permissible indicators of longitudinal roughness according to the IRI indicator during operation, m / km	Average value of longitudinal roughness index according to IRI index, m / km		The share of the route where the permissible values of longitudinal roughness are fixed according to the IRI indicator, %		The share of the route where inadmissible values of longitudinal roughness were recorded according to the IRI indicator, %	
					2016	2021	2016	2021	2016	2021
1	M39 Almaty - Bishkek - Toshkent - Shakhrisabz – Termiz 628 km.	I	806-871 km (65 km)	3,0	3,61	4,49	20,6 km (32 %)	7,15 km (11 %)	44,4 km (68 %)	57,85 km (89 %)

In 2016, the average indicators of the road roughness on the M39 highway amounted to 3.61 m/km (Table 4). It was found that, average road roughness does not meet the requirements of IKN GOST R 50597-93 (3 m/km) for 32% of the route length. In 2021, repeated studies were carried out on that section of the road to reveal the dynamics of changes in the road roughness. It was found that average values of the road roughness of the highway road increased to 4.49 m / km, and the admissible values of the road roughness were exceeded by 89% of the entire length of the routes (Fig. 5).

A similar analysis was carried out for all sections of highways of international importance. The road roughness indicator in 2021 compared to 2016 increased on all sections, which increased the length of sections requiring repairs by almost 4 times. In Table 5, Fig. 5-7 show the distribution histograms of the experimental probabilities of the road roughness indicator and the theoretical Weibull distribution curves that smooth them out. With a confidence level of 95%, the interval of the theoretical mathematical expectation of the road roughness indicator in 2016 was 3.61 m / km, and in 2021 was 4.49 m/km.

ISSN NO: 2770-0003
Date of Publication: 12-04-2022

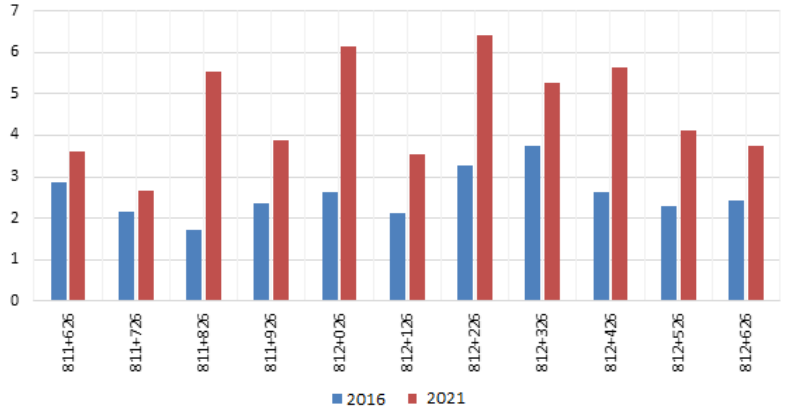

Fig 5. The results of statistical processing of the indicators of the road roughness of the international motor road M39 in 2016 and 2021.

Table 5. The results of statistical processing of the indicators of the roughness of the road surface of the M39 international road in 2016 and in 2021

Statistical characteristic	Arithmetic mean	Standard deviation	Coefficient of variation
Date of examination	Lane 1		
2016 г.	3,61	1,12	0,31
2021 г.	4,49	1,39	0,31

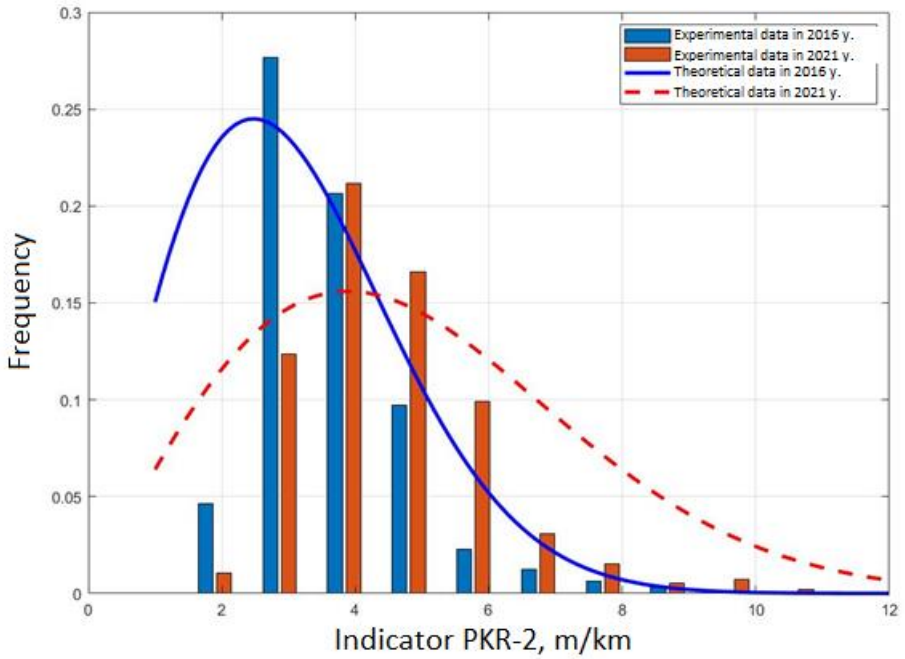

Fig. 6. The results of statistical processing of the indicators of the road roughness for the international highway road M39 in 2016 and 2021.

ISSN NO: 2770-0003
Date of Publication: 12-04-2022

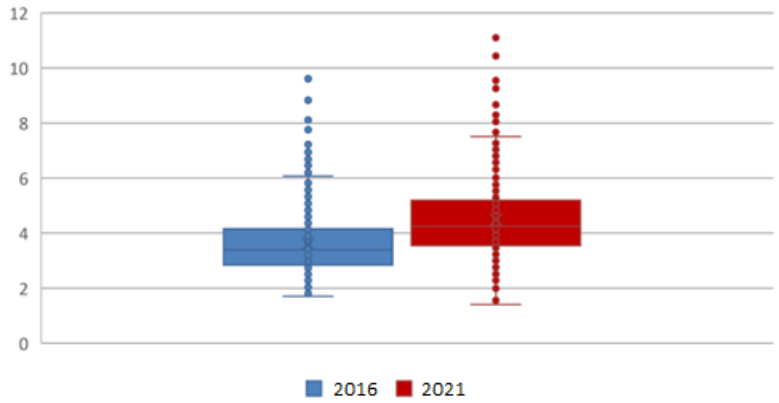

Fig. 7 Results of statistical processing of road roughness indicators for M39 international road in 2016 and 2021.

From the given intervals of mathematical expectation, it follows that over 5 years the intervals have shifted towards large values, as a result, the theoretical curve of the probability density distribution of the road roughness indicator has moved towards large numerical values of the road roughness indicator (Fig. 6). Thus, based on the analysis of the research results of 2016 and 2021. It was found that the value of road roughness on an international highway road increased by an average of 0.88 m/km, and the share of sections with unacceptable road roughness values reached 89%.

IV. Conclusion

1. The determining factor of the transit potential of the country is the condition of highways of international importance. The observed decrease in vehicle speed is the result of a decrease in the quality of roads. Only 42% of international road quality measurements, as measured by the road roughness index, meet the requirements.
2. In 2016 and 2021, studies were carried out on the road roughness index of the M39 highway of international importance “Almaty - Bishkek - Tashkent - Shahrisabz – Termiz” (806-871 km) with a length of 65 km, in 2016 and 2021. Based on the analysis of the research results of 2016 and 2021. it was found that the value of road roughness on an international motor road increased by an average of 0.88 m / km, and the share of sections with unacceptable road roughness values reached 89%.
3. A decrease in the speed of movement leads to a chain of negative consequences: lengthening the time of transportation, increasing fuel consumption, accelerating the physical deterioration of the rolling stock of cars, increasing tariffs for the transportation of goods, reducing the competitiveness of road transport.
4. To mitigate the negative impact of a decrease in the speed of vehicles, it is necessary to conduct large-scale studies of the roughness of highways to develop measures to bring them in line with international requirements.

References

1. R.B. Ivut, A.F. Zubritskiy, A.S. Zinevich, Transit capacity development in the Republic of Belarus in the context of its transport-logistical system formation, News of Science and Technology. –2015. - No. 1. - P. 19-33.
2. Shain, M.Y., Pavement Management for Airports, Roads, and Parking Lots, United States of Amerika, 1994.
3. Janoff, M., Nick, J., David, P., and Hayhoe, G., Pavement Roughness and Rideability, NCHRP Report 275, 1975.
4. Sayers, M. and Karamihas, S., The Little Book of Profiling, The Regent of the University of Michigan, Michigan. 1998.
5. Al-Rousan,T., Asi, I. , and Baker, A., Roughness Evaluation Of Jordan Highway Network, 24th ARRB Conference, Australia, 2010.

ISSN NO: 2770-0003
Date of Publication: 12-04-2022

6. Attoh- Okine, N.O., Grouping Pavement Condition Variables for Performance Modeling Using Self-Organizing Maps, Computer- Aided Civil and Infrastructure Engineering, 16: 112–125. 2001.
7. Hicks and Mahoney, Pavement Evaluation, Evaluation Categories, WAPA Asphalt Pavement Guide, 1981.
8. Abdul Hamid Isa. et al., Pavement Performance Model for Federal Roads, Lt Col Proceeding of the Eastern Asia Society for Transportation Studies, Vol.5, pp. 428-440, 2005.
9. Ullidtz, P., Forlag, P., Modelling Flexible Pavement Response and Performance, Technical University of Denmark, 1998.
10. Basic Asphalt Recycling Manual, ARRA, Project Evaluation, Page 4, USA, 2001.
11. Sayers, M., Gillespie, T. and Paterson, W., Guidelines for Conducting and Calibrating Road Roughness Measurements, World Bank Technical Paper Number 46. The World Bank, Washington, 1986.
12. ASTM E 950/E950M-09 Standard Test Method for Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference.
13. Resolution of The President of The Republic of Uzbekistan on approval of the Strategy for the development of the transport system of the Republic of Uzbekistan until 2035
14. IKN 05-2011 Rules for the diagnosis and assessment of the condition of roads. GAK Uzavtoyul. Tashkent. 2011.