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PROBLEMS OF ESTIMATION AND MODERNIZATION OF NETWORK AUTOMOBILE ROADS IN UKRAINE

Introduction

The condition of road infrastructure, first of all, affects the economic development of the country and the security of its citizens' lives. A high quality road network is one of the most important factors in improving the socio-economic environment in the country, as well as it is an additional infusion into the GDP potential growth. Therefore, for Ukraine, and especially for the Dnipropetrovsk Oblast, the transport complex of which carries out some extremely important tasks of logistic support of city, long-distance and international transportation, the solution of problems of quality improvement and modernization of transport infrastructure, along with the further development of logistics potential, have an extremely important strategic urgency.

Relevance of the problem

The network of motorways is one of the main components of the transport system in Ukraine, which satisfies the citizens' needs in passenger and freight transportation by roads. But for the time being, according to expert assessments, Ukraine takes one of the last places among the countries of the world in terms of roads pavement quality, which has a very negative impact on the country's development and its socio-economic status. Therefore, in current conditions, the expansion of foreign trade relations together with the integration of Ukraine into the system of international transport corri-

dors and the need to create a system of reliable transport for further development of the domestic economy accentuates that the solutions to the problems of improvement and modernization of quality of transport-operational condition of road network in Ukraine has an extremely urgent importance [1, 2].

Analysis of recent researches and publications

According to experts, unsatisfactory state of highways is a major problem for large cities in Ukraine, and it is 32.8 %. The second position in this ranking is the sanitary condition of the streets, which is 14.7 %, when the third place is given to the problems that are associated with cars parking on sidewalks and lawns, which leaves us with 13.5 % [3]. According to the Corestone Corp analytical group, Ukraine is one of the first countries in the world in terms of mortality in road accidents along with Russia, Georgia, India and Armenia. The mortality rate in our country is 3-4 times higher than in European countries. Thus, the condition of Ukrainian highways became a problem of nationwide scale. According to statistics, an average of 554 car accidents daily takes place in Ukraine. In Ukraine, with a large margin, the number of road accidents is led by Kyiv, where more than 500 thousand accidents occurred over the past 10 years. After the Kyiv Oblast, in the number of accidents, the following places are occupied by Odessa Oblast, Kharkiv Oblast and Dnipropetrovsk oblast [3].

Significant development of the study of monitoring and assessment of the state of roads, planning of repairs and maintenance of roads was reviewed in a number of scientific works [4-9]. Thus in the work [4] the analysis of the influence of market transformations on the development of freight and passenger transportation was carried out and also the trends of world automobile production development were determined. The problems of estimating the state of roads with the use of integral estimates (indexes) were sufficiently highlighted, while the impact of the destruction on the magnitude of these indices and the methods for determining the strength, equality and cohesion indices have been assessed.

The analysis of the current state and problems of the road industry in Ukraine is considered in the work [5] with the determination of the main prospective directions of the road sector modernization. The work [6] covers issues concerning the prospects of the development of highway networks general use, the analysis of problems of development of the domestic road economy as an economic branch and the analysis of the current state of Ukrainian highways. In the work [7], taking into account the state of the development of regional economy, was built the justification for the need to improve the quality of highways in accordance with the technical standards of developed countries and the expansion of their network and length. The problems of increasing the efficiency of the transit potential implementation, the analysis of the capacity of the Ukrainian network of international transport corridors and the perspective directions of development of the corresponding infrastructure are considered in the work [8]. Some modern trends in the development of the transport industry in Ukraine, certain ways of its further development and possible problems of the implementation of infrastructure projects are given in the work [9].

A characteristic feature of modern road management systems in the world is the widespread use of advanced information technology. The introduction of the State Road Service

of Ukraine (Ukravtodor) into the practice of the State Service of Motor Roads of Ukraine (UCSS) and the Automated Expert Bridges Management System (AEBMS) has created the conditions for the development of a system for managing current roads maintenance and reconditioning [10].

The prospects for the development of the network of highways are connected with the existing transport and road complex problems solving. According to the Strategy of Reforming and Development of the Road Industry of Ukraine [10], the Concept of the State Target Economic Program for the Development of Utility Vehicles for 2013-2018, the Transport Strategy of Ukraine for the period up to 2020, the Transport Policy of Ukraine and its approximation to the norms of the European Union (EU) [11], the development of public roads should be directed towards their integration into the European transport network, aimed at bringing the condition of roads in line with international standards requirements.

The above problems show that problems of the development of a highways network of Ukrainian general use were considered exclusively within the context of the problems of the transport-road complex being an economic branch of the Ukrainian economy. Thus, the attention to the studies of actual improvement of the quality of the above-mentioned roads and their compliance with modern requirements was not given to its full at the moment, although this issue is one of the key terms. It is also worth noting that a specific feature of such studies is the relatively rapid change of the information regarding the current highway roads network condition, which requires constant monitoring and updating of a large amount and great scope of coverage of the data of an array of source data.

Purpose of the article

The purpose of this study is to consider the modern methods of assessing the roads condition and to determine the directions of their modernization in accordance with world standards for solving problems of improving the

transport infrastructure quality of the state as a whole, and especially for the Dnipropetrovsk Oblast, since the roads of the Dnipropetrovsk Oblast cover a significant amount of transportation in different directions, in particular a significant part of the international traffic.

To achieve the above-stated goals, the following tasks need to be addressed:

- The analysis of the current state of roads in Ukraine and in the Dnipropetrovsk Oblast;
- The systematization of methods for diagnosing the highways operational condition;
- The development of a criterion for roads ranking and classification according to the road pavement condition.

Main research material

The motorways roads in Ukraine are a network of roads on the territory of Ukraine, which unites the settlements and separated objects between them and is intended for vehicles traffic, which transport passengers and goods. The network of public roads includes 169.6 thousand kilometres of roads, of which the hard cover roads are 165.8 thousand kilo-

metres (excluding municipal, departmental, internal economic roads). Almost all Ukrainian highways pass through settlements that do not meet the requirements for international transport corridors, as it limits the speed of road transport.

The transport-operational condition of highways is unsatisfactory: about 39 % of Ukrainian public highways do not meet modern requirements for strength and 51 % of them – for flatness [15]. According to Ukravtodor, by the end of 2016, more than 50 % of highways needed overhaul and rebuilding and 70% of them were in the need of some urgent repairs. Since such a tendency of deterioration persisted in 2017, the current condition of highways network is characterized by a significant physical deterioration degree. To a large extent, it can be said that this is more due to the wear of the roadblock, caused by an increase in the traffic flow and the maximum weight of trucks.

The general characteristics of the Ukrainian highways network of general use are given in Table 1.

Table 1

The characteristics of highways network of general use in Ukraine

Indicator		Road category					Total	
		I		II	III	IV		V
		I-a	I-b					
Average daily traffic intensity in both directions, car / day		More than 7000	More than 7000	3000-7000	1000-3000	100-1000	<100	
Speed, km / h	Basic	150	120	120	100	80	60	
	On complex sites	120/80	100/60	100/60	80/50	60/40	40/30	
Width of the road, m		15–30		7,5–9	7-8	6	4,5	
The thickness of the canvas, cm		20		8-12		5		
Axle load, t		11,5		10,6		7		
Maximum weight of the car, t		40		36		24		
Length of roads, thousand km		2,7		13,3	28,7	109,6	15,3	169,6
Share of road distribution, %		1,6		7,8	17	64,6	9	100

Thus, it can be seen that the largest share of the road network of general use, according to the given data, is the roads of the IV category (64.6 %), which according to the European definition of quality are among the most unsuitable for the efficient functioning and development of both the transport-road complex and the economy of the country. It is worth noting that it is the roads of the I category that are, according to their technical characteristics, close to European norms [11], but for today the share of such roads in Ukraine is only 1.6 %, which is an extremely low indicator of the estimation of transport infrastructure, in comparison with the statistical parameters of the developed countries.

In addition, it should be noted that according to the analytical data of the research carried out by The Global Economy electronic service [12], the quality of the road surface in Ukraine is extremely low and takes one of the last places (with a quality index of 2.44 while the best indicator is 6, 61, which may be seen in the UAE), bypassing only Moldova, Mauritania, Haiti, Burma, Mozambique, Paraguay, Madagascar and Guinea (with the worst indicator of 1.94).

One of the decisive parameters of the transport network is its structure by importance and the type of road surface. Such a

distribution of Ukrainian highways is given in the Table 2 and the Table 3 [15].

The results of the analysis of the condition of the Ukrainian highways network show that most of them, about 90 %, are characterized by a high degree of physical deterioration and do not provide the necessary conditions for the traffic safety. Such a state of the transport network is associated with insufficient funding for repairs and maintenance of roads, as well as a significant increase in the traffic volume of vehicles and their actual mass. In recent years the financing for the restoration of the highways operational condition and the condition of general-purpose bridges is 20...30 % of the need [10]. According to the Ministry of Infrastructure, of the 16,191 bridges only 7,471 correspond to the current rates and standards, whilst 1,865 bridge transitions require some urgent repairs [15].

Not less important factor of unsatisfactory transport-operational condition of roads is the poor quality of constructive and repairing works, the main reasons of which are: non-compliance with production technologies, non-compliance with modern requirements of a considerable quantity of materials, unsatisfactory level of technical equipment of road works, low level of qualification and low responsibility of road builders.

Table 2

The structure and the length of Ukrainian highways by its significance

Roads		Marking	Length, thousand km	Share of total length, %
State significance	international*	M	8,7	5,2
	national	H	4,8	2,8
	regional	P	10,1	5,9
	territorial	T	28,5	16,8
Total			52,1	30,7
Local significance	in oblast	O	50,0	29,5
	in rayon		67,5	39,8
	Total		117,5	69,3
Total			169,6	100

* According to the international highway agreement (ADR) of 1975, the main European highways are marked with the letter "E".

At the same time, the service infrastructure of Ukrainian highways of the general use, according to its characteristics, equipment, the enumeration and the quality of the offered services, also does not meet most common modern requirements [11].

It should be noted that one of the main parameters characterizing the quality and the safety of motorways is the road surface flatness. Both traffic safety and speed, alongside with transport-economic costs, depend on this index. Therefore, the non-conformity of highways with the established norms of equality of road surface is one of the negative factors of influence, both on a vehicle, and on all participants of a transport process. The use of this parameter allows to analyse the current state of highways road pavement and identify effective measures to improve it.

For analysis of the road pavement coverage of the highway, three main methods are used: the flatness index R; International Roughness Index IRI; the integral index of the mean-square deviation of the profile I [16]. It should be noted that the method of the International Roughness Index (IRI), which is the main parameter of estimating roads quality in a number of European countries, is quite widely used practically. The application of this indicator with sufficient reliability allows us to assess the operational properties of the road surface of the roadway and to objectively characterize the level of traffic safety [7]. From a physical point of view, the IRI roughness index determines the ratio of the total displacement of the submerged mass of the vehicle (wheels) relative to the submersible (body of the vehicle) to the length of the road, measured in [m / km] or [mm / m]. In this case, the IRI measurement methods are divided into four categories based on the used equipment and measurement technology [13].

At present, different regulatory requirements for the equality of road categories according to the IRI index are applied in different countries, and there is currently no single standard that would be common for all different categories of roads. The standards that ap-

ply in a number of European countries are presented in Table 4.

For comparison, it should be noted that according to the calculations of independent companies, the IRI index for the best Ukrainian roads is below the average in European countries, and their greater share is beyond this limit. Thus, at present, there is an urgent need to modernize and improve Ukrainian roads. Respectively, roads monitoring according to the parameters of their state and the level of road coverage should allow, based on objective data, to develop measures aimed at improving the network of Ukrainian highways and improving quality and safety of public highways traffic.

Table 3

Structure of Ukrainian roads by type of road surface

Road surface type	Length, thousand km	Share of total length, %
Asphalt concrete	56,8	33,5
Black highway	71,7	42,3
Cement concrete	2,9	1,7
Pavement	8,5	5,0
White-gravel	25,9	15,3
Soil	3,8	2,2
Total	169,6	100

In order to improve the condition of highways during modernization and construction, it is expedient to use much more modern methods and materials. It is proposed to significantly increase the construction of concrete roads, which have several advantages over the asphalt concrete road [17]. For example, in the USA concrete roads make up 60 % of all highways in the country, and in European countries – about 40 %. In this case, the technology of paving concrete roads constantly improves. Thus, the widespread usage of steel anchor fibre is gaining its momentum during paving some new motorways and modernization of already existing road surfaces, which improves the characteristics of concrete after

its use and thus performs power functions. First of all, the fibre provides the concrete slab strength. Metal fibre, connecting with concrete, forms a single fibrous concrete mass. Steel fibre concrete is a kind of reinforced concrete, in which the role of reinforcement is made of steel fibres, evenly distributed throughout the volume of concrete.

The use of steel fibre concrete reinforced with steel fibres, in some cases, makes it possible to exclude part of the fittings from the design, and in some cases completely abandon the traditional rod fittings with the subsequent replacement of its fibres. The effectiveness of using steel-concrete structures in these cases can be achieved by reducing labour costs for reinforcing works, reducing the cost of steel and concrete (by reducing the thickness of

structures), the combination of technological operations for the preparation of concrete mix and its reinforcement, which ultimately leads to reducing the complexity of manufacturing structures by 25...27 % and saving construction materials per 1 cubical meter of finished product.

Made from such material and according to the defined technology, the road pavements would be characterized by increased durability to stretching and bending, higher limiting compressibility, crack resistance, high impact strength, water resistance, corrosion resistance and durability; reduced deformations of creep and shrinkage; high parameters of freezing, thermal and fire resistance, and also high abrasion resistance.

Table 4

Roads flatness standards according to the IRI index in European countries

No.	Country, the year of use of the IRI index	Characteristics of flatness	IRI index value, m / km
1	Belgium, 1984	Class A. High flatness	Up to 2
		Class B. Satisfactory flatness	2-4
		Class C. Satisfactory flatness	4-6
		Class D. Bad flatness	6-8
		Class E. Very bad flatness	Over 8
		Intervention threshold	Over 6
2	Sweden, 1988	Very satisfactory flatness	Up to 1,5
		Satisfactory flatness	1,5-2,5
		Average flatness	2,5-3,5
		Flatness below average	3,5-4,5
		Poor flatness	Over 4,5
3	Finland, 2000	Motorways	Up to 1,7
		Other 2-way state and national routes	Up to 1,9
		Other roads of general use	Up to 2,1
4	International experiment (World Bank, Brazil, 1982)	Runways at airports and high-speed motorways	0,8-1,3
		New road pavements	1,3-3,3
		Roads in operation	2,3-5,5
5	International experiment FILTER (PIARC, Netherlands, Germany, 1998)	Satisfactory equality	Up to 1,5
		Average equality	1,5-3,5
		Bad equality	Over 3,5

The use of such modern materials, as well as the theoretical development and practical application of the newest methods for improving the quality of the state of public roads, would be able to solve most of the above-mentioned problems related to the functioning of Ukraine transport system and significantly improve the socio-economic situation of the country.

Conclusions and further researches directions

According to international experts, Ukraine takes one of the last positions among the countries of the world in terms of road pavement, which has a very negative impact on the development of the country and its socio-economic status. Particular attention should be paid to the construction of new and modernization of existing high-speed highways with asphalt cover of the first category (and the use of more modern technology, such as using steel anchor fibres of different types). From the use of pit repairs it is necessary to switch to systematic and automated work on modernization of existing and construction new highways of European level with modern infrastructure, using international standards and bases. The implementation of the proposed measures would significantly improve the economic efficiency of using the potential of the transport and the road complex of the country at both domestic and international levels.

References

1. Kudryts'ka, N. V. Transportno-dorozhniy kompleks Ukrainy: suchasnyy stan, problemy ta shlyakhy rozvytku: [monohrafiya] / N. V. Kudryts'ka. – K. : NTU, 2010. – 338 p.
2. Pasichnyk A. M. Suchasni transportno-mytни tekhnolohiyi mizhnarodnykh pereve-zen' tovariv: [monohrafiya] / za red. A. M. Pasichnyka. – Dnipro : AMSU, 2012. – 288 p.
3. World Media About Ukraine [Electronic resource]. Mode access: www.corestone.expert/en.
4. Avtomobil'nyy transport Ukrainy: stan, problemy perspektyvy rozvytku: [monohrafiya] / Derzhavnyy avtotransportnyy naukovodoslidnyy i proektnyy insty-tut; za zah. red. A. M. Redzyuka. – K. : DP «Derzhavtotrans NDI proekt», 2005. – 400 p.
5. Halushko, V. O. Problemy ta perspektyvy rozvytku dorozhn'oyi haluzi / V. O. Halushko // Dorozhnya haluz'. 2011. – № 2. – P. 12–15.
6. Dmytriyeu, I. A. Suchasnyy stan ta perspektyvy rozvytku merezhi avtomobil'nykh dorih zahal'noho korystuvannya / I. A. Dmytriyeu, M. M. Burmaka // Problemy i perspektyvy rozvytku pidpryyemnytstva : zb. nauk. prats' KHNADU. – 2013. – № 1(4). – P. 64–72.
7. Miklovda, V. P. Suchasnyy stan ta riven' rozvytku avtomobil'noyi infrastruktury Ukrainy / V. P. Miklovda, YA. V. Shevchuk // Naukovyy visnyk Uzhhorods'koho univertsytetu. Seriya «Ekonomika». Vypusk 32. – Uzhhorod : Vyd-vo Uzhhorods'koho natsional'noho univertsytetu, 2011. – P. 6–13.
8. Pasichnyk, A. M. Doslidzhennya propusknoyi spromozhnosti ukraiyins'koyi merezhi mizhnarodnykh transportnykh korydoriv / A. M. Pasichnyk, V. S. Mal'nov, O. M. Klen // Visnyk AMSU. – 2012. – № 1 (41). – P. 28–36.
9. Remyha, YU. S. Analiz tendentsiy rozvytku transportnoyi infrastruktury Ukrainy // Zbirnyk naukovykh prats' NAU. – 2008. – №20. – P. 263-273.
10. Ministry of Infrastructure of Ukraine [Electronic resource]. Mode access: <http://mtu.gov.ua/files/Ministry%20of%20Infrastructure%20%20Road%20Sector%20Reforms%20-20v.pdf>.
11. Transportna polityka Ukrainy ta yiyi nablyzhennya do norm Yevropeys'koho Soyuzu / za red. Marchina Svyenchitski; T. Syryychyk, A. Furhal's'ki, CH. Klimkevych, M. Kamola ta in. – K. : Analityko-doradchyy tsentr Blakytynoyi strichky, 2010. – 102 p.
12. The Global Economy Ranking [Electronic resource]. Mode access: www.theglobaleconomy.com/rankings/roads-quality.
13. The International Road Roughness Experiment. Establishing Correlation and a Calibration Standard for Measurements: World Bank Technical Paper Number 45. WTP-45 / M. W. Sayers, T. D. Gillespie,

- C. A. V. Queiroz / THE WORLD BANK. Manufactured in the United States of America. 1986. – 453 p.
14. Pasichnyk, A. M. Problemy otsinky transportno-eksploatatsiynoho stanu ta napryamky modernizatsiyi merezhi avtomobil'nykh dorih v Ukraini / A. M. Pasichnyk, YE. M. Lebid', O. M. Klen, S. V. Miroschnichenko // Visnyk skhidnoukrayins'koho natsional'noho universytetu im. V. Dalya, 2017. – №3 (233). – P. 150–158.
 15. Tekhnichnyy stan avtomobil'nykh dorih zahal'noho vykorystannya [Electronic resource]. Mode access: <https://mtu.gov.ua/content/tehnichniy-stan-avtomobilnih-dorig-avtomobilnih-dorig-zagalnogo-vikorystannya.html>.
 16. Horb, A. O. Vyznachennya indeksu rivnosti metodom nazemnoho lazernoho skanuvannya / A. O. Horb, O. I. Horb // Suchasni dosyahnennya heodezychnoyi nauky ta vyrobnytstva, 2011. – №1 (21). – P. 145–149.
 17. Tekhnolohycheskaya karta na ustroystvo osnovanyya yz lytoho betona dlya vnutrykvartal'nykh doroh s asfal'tobetonnyy

pokrytyem [Electronic resource]. Mode access: http://ohranatru.da.ru/ot_biblio/normativ/data_normative/46/46314/.

Ключові слова: плавність руху, дефекти покриття, оцінка рівності автодоріг, модернізація автодоріг.

Ключевые слова: плавность движения, дефекты покрытия, оценка ровности автодорог, модернизация автодорог.

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